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About O Level

(PURE) PHYSICS

(TOPICAL)

About **Thinking Process**

When solving problems, we first analyse the questions and then gather relevant information until we are able to determine the answers. But for presentation reason, we need to organise, rearrange and then present ONLY the required workings and solutions.

Thinking process reveals the extra but relevant information which is not required as part of the solutions.

About **MCQ with HELPs**

Explanations are given so that students know exactly why the answer is the right one.

period	2006 to 2019
contents	June & November, Paper 1 & 2, Worked Solutions
form	Topic By Topic
compiled for	O Levels
special features	Thinking Process, MCQ with HELPs

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CONTENTS

MCQ questions solutions
THEORY questions solutions

Revised Syllabus

UNIT A MECHANICS

- **Topic 1** Mass, Weight, Density and Volume
- **Topic 2** Kinematics
- **Topic 3** Force, Vector and Scalar Quantities
- **Topic 4** Work, Energy and Power
- **Topic 5** Principles of Moments
- **Topic 6** Pressure

UNIT B THERMAL PHYSICS

- **Topic 7** Heat Capacity, Expansion
- **Topic 8** Transfer of Heat
- **Topic 9** Temperature
- **Topic 10** Gas Laws and Particles of Matter
- **Topic 11** Change of State

UNIT C WAVES

- **Topic 12** Longitudinal Waves
- **Topic 13** Transverse Waves

UNIT D LIGHT

- **Topic 14** Dispersion of Light
- **Topic 15** Lenses
- **Topic 16** Refraction
- **Topic 17** Reflection
- **Topic 18** Electromagnetic Waves

UNIT E ELECTRICITY AND MAGNETISM

- **Topic 19** Static Electricity
- **Topic 20** Current Electricity
- **Topic 21** Magnetism
- **Topic 22** Magnetic Effect
- **Topic 23** Electromagnetic Induction

UNIT F MODERN PHYSICS

- **Topic 24** Electronics, CRO
- **Topic 25** Radioactivity

REVISIONS

- June **2016** Paper 1 & 2
- December **2016** Paper 1 & 2
- June **2017** Paper 1 & 2
- December **2017** Paper 1 & 2
- June **2018** Paper 1 & 2
- December **2018** Paper 1 & 2

REVISED SYLLABUS

O LEVEL PHYSICS 5054

All candidates enter for **three** papers – Papers 1 and 2 and either Paper 3 or 4.

Paper 1: Multiple choice	1 hour
40 compulsory multiple choice questions of the direct choice type. The questions involve four response items. 40 marks	

Paper 2: Theory	1 hour 45 minutes
This paper has two sections. Section A has a small number of compulsory, structured questions of variable mark value. 45 marks in total are available for this section. Section B has three questions. Each question is worth 15 marks. Candidates must answer **two** questions from this section. There is no compulsory question on Section 25 of the syllabus (Electronics systems). Questions set on topics within Section 25 appear only in Paper 2 and are always set as an alternative within a question. 75 marks	

Paper 3: Practical test	2 hours	Paper 4: Alternative to practical	1 hour
This paper has two sections. Section A has three compulsory questions each carrying five marks and each of 20 minutes duration. Section B has one question of 15 marks and is of one hour's duration. 30 marks		A written paper of compulsory short-answer and structured questions designed to test familiarity with laboratory practical procedures. 30 marks.	

Aims

The aims of the science curricula are the same for all students. These are set out below and describe the educational purposes of an O Level/School Certificate course in Physics. They are not listed in order of priority.

The aims are to:

1. provide, through well-designed studies of experimental and practical science, a worthwhile educational experience for all students, whether or not they go on to study science beyond this level and, in particular, to enable them to acquire sufficient understanding and knowledge

    1.1 to become confident citizens in a technological world, able to take or develop an informed interest in matters of scientific import;

    1.2 to recognise the usefulness, and limitations, of scientific method and to appreciate its applicability in other disciplines and in everyday life;

    1.3 to be suitably prepared for studies beyond O Level in pure sciences, in applied sciences or in science-dependent vocational courses.

2. develop abilities and skills that
   2.1 are relevant to the study and practice of science;
   2.2 are useful in everyday life;
   2.3 encourage efficient and safe practice;
   2.4 encourage effective communication.
3. develop attitudes relevant to science such as
   3.1 concern for accuracy and precision;
   3.2 objectivity;
   3.3 integrity;
   3.4 enquiry;
   3.5 initiative;
   3.6 inventiveness.
4. stimulate interest in and care for the local and global environment.
5. promote an awareness that:
   5.1 the study and practice of science are co-operative and cumulative activities, that are subject to social, economic, technological, ethical and cultural influences and limitations;
   5.2 the applications of sciences may be both beneficial and detrimental to the individual, the community and the environment.

Assessment Objectives

The assessment objectives describe the knowledge, skills and abilities that candidates are expected to demonstrate at the end of the course. They reflect those aspects of the aims that are assessed.

AO1 Knowledge with understanding

Candidates should be able to demonstrate knowledge with understanding in relation to:

1. scientific phenomena, facts, laws, definitions, concepts, theories;
2. scientific vocabulary, terminology, conventions (including symbols, quantities and units);
3. scientific instruments and apparatus, including techniques of operation and aspects of safety;
4. scientific quantities and their determination;
5. scientific and technological applications with their social, economic and environmental implications.

The subject content defines the factual knowledge that candidates may be required to recall and explain. Questions testing these objectives will often begin with one of the following words: ***define, state, describe, explain or outline.*** (See the glossary of terms in this syllabus.)

AO2 Handling information and solving problems

Candidates should be able, in words using symbolic, graphical and numerical forms of presentation, to:

1. locate, select, organise and present information from a variety of sources, including everyday experience;
2. translate information from one form to another;
3. manipulate numerical and other data;
4. use information to identify patterns, report trends and draw inferences;
5. present reasoned explanations for phenomena, patterns and relationships;
6. make predictions and hypotheses;
7. solve problems.

These assessment objectives cannot readily be fully specified in the syllabus content. Questions testing skills in physics may be based on information (given in the question paper) that is unfamiliar to the candidates or is based on everyday experience. In answering such questions, candidates are required to use principles and concepts that are within the syllabus and to apply them in a logical manner. Questions testing these objectives will often begin with one of the following words: *predict, suggest, calculate,* or *determine*. (See the glossary of terms in this syllabus.)

AO3 Experimental skills and investigations

Candidates should be able to:

1. follow instructions;
2. carry out techniques, use apparatus, handle measuring devices and materials effectively and safely;
3. make and record observations, measurements and estimates with due regard to precision, accuracy and units;
4. interpret, evaluate and report upon observations and experimental data;
5. identify problems, plan and carry out investigations, including the selection of techniques, apparatus, measuring devices and materials;
6. evaluate methods and suggest possible improvements.

Weighting of Assessment objectives

Theory Papers (Papers 1 and 2)

AO1 Knowledge with understanding is weighted at approximately 65% of the marks for each paper, with approximately half allocated to recall..

AO2 Handling information and solving problems is weighted at approximately 35% of the marks for each paper.

Practical Assessment (Papers 3 and 4)

This is designed to test appropriate skills in assessment objective AO3 and will carry approximately 20% of the marks for the qualification..

Syllabus content

It is expected that any course in physics will be based on experimental work. Teachers are encouraged to develop appropriate practical work for candidates to facilitate a greater understanding of the subject.
Candidates should be aware of the appropriate safety precautions to follow when carrying out practical work.
Certain learning outcomes of the syllabus have been marked with an asterisk (*) to indicate the possibility of the application of IT.

SECTION I: GENERAL PHYSICS

1. Physical Quantities, Units and Measurement

Content

1.1 Scalars and vectors
1.2 Measurement techniques
1.3 Units and symbols

Learning Outcomes

Candidates should be able to:

(a) define the terms *scalar* and *vector*.
(b) determine the resultant of two vectors by a graphical method.
(c) list the vectors and scalars from distance, displacement, length, speed, velocity, time, acceleration, mass and force.
(d) describe how to measure a variety of lengths with appropriate accuracy using tapes, rules, micrometers and calipers. (The use of a vernier scale is **not** required.)
(e) describe how to measure a variety of time intervals using clocks and stopwatches.
(f) recognise and use the conventions and symbols contained in 'Signs, Symbols and Systematics', Association for Science Education, 2000.

SECTION II: NEWTONIAN MECHANICS

2. Kinematics

Content

2.1 Speed, velocity and acceleration
2.2 Graphical analysis of motion
2.3 Free-fall

Learning Outcomes

Candidates should be able to:

(a) state what is meant by *speed* and *velocity*.
(b) calculate average speed using distance travelled/time taken.
(c) state what is meant by *uniform acceleration* and calculate the value of an acceleration using change in velocity/time taken.
(d) discuss non-uniform acceleration.
(e) *plot and *interpret speed-time and distance-time graphs.
(f) *recognise from the shape of a speed-time graph when a body is

(1) at rest,
(2) moving with uniform speed,
(3) moving with uniform acceleration,
(4) moving with non-uniform acceleration.

(g) calculate the area under a speed-time graph to determine the distance travelled for motion with uniform speed or uniform acceleration.

(h) state that the acceleration of free-fall for a body near to the Earth is constant and is approximately 10 m/s^2.

(i) describe qualitatively the motion of bodies with constant weight falling with and without air resistance (including reference to terminal velocity).

3. Dynamics

Content

3.1 Balanced and unbalanced forces

3.2 Friction

3.3 Circular motion

Learning Outcomes

Candidates should be able to:

(a) state Newton's third law.

(b) describe the effect of balanced and unbalanced forces on a body.

(c) describe the ways in which a force may change the motion of a body.

(d) do calculations using the equation *force* = *mass* × *acceleration*.

(e) explain the effects of friction on the motion of a body.

(f) discuss the effect of friction on the motion of a vehicle in the context of tyre surface, road conditions (including skidding), braking force, braking distance, thinking distance and stopping distance.

(g) describe qualitatively motion in a circular path due to a constant perpendicular force, including electrostatic forces on an electron in an atom and gravitational forces on a satellite. ($F = mv^2/r$ is not required.)

(h) discuss how ideas of circular motion are related to the motion of planets in the solar system.

4. Mass, Weight and Density

Content

4.1 Mass and weight

4.2 Gravitational fields

4.3 Density

Learning Outcomes

Candidates should be able to:

(a) state that mass is a measure of the amount of substance in a body.

(b) state that mass of a body resists change from its state of rest or motion.

(c) state that a gravitational field is a region in which a mass experiences a force due to gravitational attraction.

(d) calculate weight from the equation *weight* = *mass* × *gravitational field strength*.

(e) explain that weights, and therefore masses, may be compared using a balance.

(f) describe how to measure mass and weight by using appropriate balances.

(g) describe how to use a measuring cylinder to measure the volume of a liquid or solid.

(h) describe how to determine the density of a liquid, of a regularly shaped solid and of an irregularly shaped solid which sinks in water (volume by displacement).

(i) make calculations using the formula *density* = *mass/volume*.

5. Turning Effect of Forces

Content

5.1 Moments

5.2 Centre of mass

5.3 Stability

Learning Outcomes

Candidates should be able to:

(a) describe the moment of a force in terms of its turning effect and relate this to everyday examples.

(b) state the principle of moments for a body in equilibrium.

(c) make calculations using *moment of a force = force × perpendicular distance from the pivot* and the principle of moments.

(d) describe how to verify the principle of moments.

(e) describe how to determine the position of the centre of mass of a plane lamina.

(f) describe qualitatively the effect of the position of the centre of mass on the stability of simple objects.

6. Deformation

Content

6.1 Elastic deformation

Learning Outcomes

Candidates should be able to:

(a) state that a force may produce a change in size and shape of a body.

(b) *plot, draw and interpret extension-load graphs for an elastic solid and describe the associated experimental procedure.

(c) *recognise the significance of the term "limit of proportionality" for an elastic solid.

(d) calculate extensions for an elastic solid using proportionality.

7. Pressure

Content

7.1 Pressure

7.2 Pressure changes

Learning Outcomes

Candidates should be able to:

(a) define the term *pressure* in terms of force and area, and do calculations using the equation *pressure = force/area.*

(b) explain how pressure varies with force and area in the context of everyday examples.

(c) describe how the height of a liquid column may be used to measure the atmospheric pressure.

(d) explain quantitatively how the pressure beneath a liquid surface changes with depth and density of the liquid in appropriate examples.

(e) do calculations using the equation for hydrostatic pressure $p = \rho gh$.

(f) describe the use of a manometer in the measurement of pressure difference.

(g) describe and explain the transmission of pressure in hydraulic systems with particular reference to the hydraulic press and hydraulic brakes on vehicles.

(h) describe how a change in volume of a fixed mass of gas at constant temperature is caused by a change in pressure applied to the gas.

(i) do calculations using $p_1V_1 = p_2V_2$.

SECTION III: ENERGY AND THERMAL PHYSICS

8. Energy Sources and Transfer of Energy

Content

8.1 Energy forms

8.2 Major sources of energy

8.3 Work

8.4 Efficiency

8.5 Power

Learning Outcomes

Candidates should be able to:

(a) list the different forms of energy with examples in which each form occurs.

(b) state the principle of the conservation of energy and apply this principle to the conversion of energy from one form to another.

(c) state that kinetic energy $E_k = \frac{1}{2}mv^2$ and that gravitational potential energy $E_p = mgh$ and use these equations in calculations.

(d) list renewable and non-renewable energy sources.

(e) describe the processes by which energy is converted from one form to another, including reference to

(1) chemical/fuel energy (a re-grouping of atoms),

(2) hydroelectric generation (emphasising the mechanical energies involved),

(3) solar energy (nuclei of atoms in the Sun),

(4) nuclear energy,

(5) geothermal energy,

(6) wind energy.

(f) explain nuclear fusion and fission in terms of energy releasing processes.

(g) describe the process of electricity generation and draw a block diagram of the process from fuel input to electricity output.

(h) discuss the environmental issues associated with power generation.

(i) calculate work done from the formula *work = force × distance moved in the line of action of the force.*

(j) calculate the efficiency of an energy conversion using the formula *efficiency = energy converted to the required form/total energy input.*

(k) discuss the efficiency of energy conversions in common use, particularly those giving electrical output.

(l) discuss the usefulness of energy output from a number of energy conversions.

(m) calculate power from the formula *power = work done/time taken.*

9. Transfer of Thermal Energy

Content

9.1 Conduction

9.2 Convection

9.3 Radiation

Learning Outcomes

Candidates should be able to:

(a) describe how to distinguish between good and bad conductors of heat.

(b) describe, in terms of the movement of molecules or free electrons, how heat transfer occurs in solids.

(c) describe convection in fluids in terms of density changes.

(d) describe the process of heat transfer by radiation.

(e) describe how to distinguish between good and bad emitters and good and bad absorbers of infra-red radiation.

(f) describe how heat is transferred to or from buildings and to or from a room.

(g) state and explain the use of the important practical methods of thermal insulation for buildings.

10. Temperature

Content

10.1 Principles of thermometry

10.2 Practical thermometers

Learning Outcomes

Candidates should be able to:

(a) explain how a physical property which varies with temperature may be used for the measurement of temperature and state examples of such properties.

(b) explain the need for fixed points and state what is meant by the *ice point* and *steam point*.

(c) discuss sensitivity, range and linearity of thermometers.

(d) describe the structure and action of liquid-in-glass thermometers (including clinical) and of a thermocouple thermometer, showing an appreciation of its use for measuring high temperatures and those which vary rapidly.

11. Thermal Properties of Matter

Content

11.1 Specific heat capacity

11.2 Melting and boiling

11.3 Thermal expansion of solids, liquids and gases

Learning Outcomes

Candidates should be able to:

(a) describe a rise in temperature of a body in terms of an increase in its internal energy (random thermal energy).

(b) define the terms *heat capacity* and *specific heat capacity*.

(c) calculate heat transferred using the formula *thermal energy = mass × specific heat capacity × change in temperature*.

(d) describe melting/solidification and boiling/condensation in terms of energy transfer without a change in temperature.

(e) state the meaning of *melting point* and *boiling point.*

(f) explain the difference between boiling and evaporation.

(g) define the terms *latent heat* and *specific latent heat.*

(h) explain latent heat in terms of molecular behaviour.

(i) calculate heat transferred in a change of state using the formula *thermal energy* = *mass* × *specific latent heat.*

(j) describe qualitatively the thermal expansion of solids, liquids and gases.

(k) describe the relative order of magnitude of the expansion of solids, liquids and gases.

(l) list and explain some of the everyday applications and consequences of thermal expansion.

(m) describe qualitatively the effect of a change of temperature on the volume of a gas at constant pressure.

12. Kinetic Model of Matter

Content

12.1 States of matter

12.2 Molecular model

12.3 Evaporation

Learning Outcomes

Candidates should be able to:

(a) state the distinguishing properties of solids, liquids and gases.

(b) describe qualitatively the molecular structure of solids, liquids and gases, relating their properties to the forces and distances between molecules and to the motion of the molecules.

(c) describe the relationship between the motion of molecules and temperature.

(d) explain the pressure of a gas in terms of the motion of its molecules.

(e) describe evaporation in terms of the escape of more energetic molecules from the surface of a liquid.

(f) describe how temperature, surface area and draught over a surface influence evaporation.

(g) explain that evaporation causes cooling.

SECTION IV: WAVES

13. General Wave Properties

Content

13.1 Describing wave motion

13.2 Wave terms

13.3 Wave behaviour

Learning Outcomes

Candidates should be able to:

(a) describe what is meant by wave motion as illustrated by vibrations in ropes and springs and by experiments using a ripple tank.

(b) state what is meant by the term *wavefront.*

(c) define the terms speed, frequency, wavelength and amplitude and recall and use the formula *velocity* = *frequency* × *wavelength.*

(d) describe transverse and longitudinal waves in such a way as to illustrate the differences between them.

(e) describe the use of a ripple tank to show
   (1) reflection at a plane surface,
   (2) refraction due to a change of speed at constant frequency.

(f) describe simple experiments to show the reflection and refraction of sound waves.

14. Light

Content

14.1 Reflection of light

14.2 Refraction of light

14.3 Thin converging and diverging lenses

Learning Outcomes

Candidates should be able to:

(a) define the terms used in reflection including *normal, angle of incidence* and *angle of reflection.*

(b) describe an experiment to illustrate the law of reflection.

(c) describe an experiment to find the position and characteristics of an optical image formed by a plane mirror.

(d) state that for reflection, the angle of incidence is equal to the angle of reflection and use this in constructions, measurements and calculations.

(e) define the terms used in refraction including *angle of incidence, angle of refraction* and *refractive index.*

(f) describe experiments to show refraction of light through glass blocks.

(g) do calculations using the equation $\sin i / \sin r =$ constant.

(h) define the terms critical angle and total internal reflection and recall and use the formula $\sin c = 1/n$.

(i) describe experiments to show total internal reflection.

(j) describe the use of optical fibres in telecommunications and state the advantages of their use.

(k) describe the action of thin lenses (both converging and diverging) on a beam of light.

(l) define the term *focal length.*

(m) *draw ray diagrams to illustrate the formation of real and virtual images of an object by a converging lens, and the formation of a virtual image by a diverging lens.

(n) define the term linear magnification and *draw scale diagrams to determine the focal length needed for particular values of magnification (converging lens only).

(o) describe the use of a single lens as a magnifying glass and in a camera, projector and photographic enlarger and draw ray diagrams to show how each forms an image.

(p) draw ray diagrams to show the formation of images in the normal eye, a short-sighted eye and a long-sighted eye.

(q) describe the correction of short-sight and long-sight.

15. Electromagnetic Spectrum

Content

15.1 Dispersion of light

15.2 Properties of electromagnetic waves

15.3 Applications of electromagnetic waves

Learning Outcomes

Candidates should be able to:

(a) describe the dispersion of light as illustrated by the action on light of a glass prism.

(b) state the colours of the spectrum and explain how the colours are related to frequency/wavelength.

(c) state that all electromagnetic waves travel with the same high speed in air and state the magnitude of that speed.

(d) describe the main components of the electromagnetic spectrum.

(e) discuss the role of the following components in the stated applications:

(1) radiowaves – radio and television communications,

(2) microwaves – satellite television and telephone,

(3) infra-red – household electrical appliances, television controllers and intruder alarms,

(4) light – optical fibres in medical uses and telephone,

(5) ultra-violet – sunbeds, fluorescent tubes and sterilisation,

(6) X-rays – hospital use in medical imaging and killing cancerous cells, and engineering applications such as detecting cracks in metal,

(7) gamma rays – medical treatment in killing cancerous cells, and engineering applications such as detecting cracks in metal.

16. Sound

Content

16.1 Sound waves

16.2 Speed of sound

16.3 Ultrasound

Learning Outcomes

Candidates should be able to:

(a) describe the production of sound by vibrating sources.

(b) describe the longitudinal nature of sound waves and describe compression and rarefaction.

(c) state the approximate range of audible frequencies.

(d) explain why a medium is required in order to transmit sound waves and describe an experiment to demonstrate this.

(e) describe a direct method for the determination of the speed of sound in air and make the necessary calculation.

(f) state the order of magnitude of the speeds of sound in air, liquids and solids.

(g) explain how the loudness and pitch of sound waves relate to amplitude and frequency.

(h) describe how the reflection of sound may produce an echo.

(i) describe the factors which influence the quality (timbre) of sound waves and how these factors may be demonstrated using a CRO.

(j) define *ultrasound*.

(k) describe the uses of ultrasound in cleaning, quality control and pre-natal scanning.

SECTION V: ELECTRICITY AND MAGNETISM

17. Magnetism and Electromagnetism

Content

17.1 Laws of magnetism

17.2 Magnetic properties of matter

17.3 Electromagnetism

Learning Outcomes

Candidates should be able to:

(a) state the properties of magnets.

(b) describe induced magnetism.

(c) state the differences between magnetic, non-magnetic and magnetised materials.

(d) describe electrical methods of magnetisation and demagnetisation.

(e) describe the plotting of magnetic field lines with a compass.

(f) state the differences between the properties of temporary magnets (e.g. iron) and permanent magnets (e.g. steel).

(g) describe uses of permanent magnets and electromagnets.

(h) explain the choice of material for, and use of, magnetic screening.

(i) describe the use of magnetic materials in audio/video tapes.

(j) describe the pattern of the magnetic field due to currents in straight wires and in solenoids and state the effect on the magnetic field of changing the magnitude and direction of the current.

(k) describe applications of the magnetic effect of a current in relays, circuit-breakers and loudspeakers.

18. Static Electricity

Content

18.1 Laws of electrostatics

18.2 Principles of electrostatics

18.3 Applications of electrostatics

Learning Outcomes

Candidates should be able to:

(a) describe experiments to show electrostatic charging by friction.

(b) explain that charging of solids involves a movement of electrons.

(c) state that there are positive and negative charges and that charge is measured in coulombs.

(d) state that unlike charges attract and like charges repel.

(e) describe an electric field as a region in which an electric charge experiences a force.

(f) state the direction of lines of force and describe simple field patterns.

(g) describe the separation of charges by induction.

(h) discuss the differences between electrical conductors and insulators and state examples of each.

(i) state what is meant by *"earthing"* a charged object.

(j) describe examples where charging could be a problem e.g. lightning.

(k) describe examples where charging is helpful e.g. photocopier and electrostatic precipitator.

19. Current Electricity

Content

19.1 Current

19.2 Electromotive force

19.3 Potential difference

19.4 Resistance

Learning Outcomes

Candidates should be able to:

(a) state that a current is a flow of charge and that current is measured in amperes.

(b) do calculations using the equation *charge = current* × *time*.

(c) describe the use of an ammeter with different ranges.

(d) explain that electromotive force (e.m.f.) is measured by the energy dissipated by a source in driving a unit charge around a complete circuit.

(e) state that e.m.f. is work done/charge.

(f) state that the volt is given by J/C.

(g) calculate the total e.m.f. where several sources are arranged in series and discuss how this is used in the design of batteries.

(h) discuss the advantage of making a battery from several equal voltage sources of e.m.f. arranged in parallel.

(i) state that the potential difference (p.d.) across a circuit component is measured in volts.

(j) state that the p.d. across a component in a circuit is given by the work done in the component/ charge passed through the component.

(k) describe the use of a voltmeter with different ranges.

(l) state that *resistance = p.d./current* and use the equation *resistance = voltage/current* in calculations.

(m) describe an experiment to measure the resistance of a metallic conductor using a voltmeter and an ammeter and make the necessary calculations.

(n) discuss the temperature limitation on Ohm's Law.

(o) *use quantitatively the proportionality between resistance and the length and the cross-sectional area of a wire.

(p) calculate the net effect of a number of resistors in series and in parallel.

(q) describe the effect of temperature increase on the resistance of a resistor and a filament lamp and draw the respective sketch graphs of current/voltage.

(r) describe the operation of a light-dependent resistor.

20. D.C. Circuits

Content

20.1 Current and potential difference in circuits

20.2 Series and parallel circuits

Learning Outcomes

Candidates should be able to:

(a) *draw circuit diagrams with power sources (cell, battery or a.c. mains), switches (closed and open), resistors (fixed and variable), light-dependent resistors, thermistors, lamps, ammeters, voltmeters, magnetising coils, bells, fuses, relays, diodes and light-emitting diodes.

(b) state that the current at every point in a series circuit is the same, and use this in calculations.

(c) state that the sum of the potential differences in a series circuit is equal to the potential difference across the whole circuit and use this in calculations.

(d) state that the current from the source is the sum of the currents in the separate branches of a parallel circuit.

(e) do calculations on the whole circuit, recalling and using formulae including $R = V/I$ and those for potential differences in series, resistors in series and resistors in parallel.

21. Practical Electricity

Content

21.1 Uses of electricity

21.2 Dangers of electricity

21.3 Safe use of electricity in the home

Learning Outcomes

Candidates should be able to:

(a) describe the use of electricity in heating, lighting and motors.

(b) recall and use the equations power = voltage × current, and energy = voltage × current × time.

(c) define the kilowatt-hour (kWh) and calculate the cost of using electrical appliances where the energy unit is the kWh.

(d) state the hazards of damaged insulation, overheating of cables and damp conditions.

(e) explain the use of fuses and circuit breakers and fuse ratings and circuit breaker settings.

(f) explain the need for earthing metal cases and for double insulation.

(g) state the meaning of the terms *live*, *neutral* and *earth*.

(h) describe how to wire a mains plug safely. Candidates will not be expected to show knowledge of the colours of the wires used in a mains supply.

(i) explain why switches, fuses and circuit breakers are wired into the live conductor.

22. Electromagnetism

Content

22.1 Force on a current-carrying conductor

22.2 The d.c. motor

Learning Outcomes

Candidates should be able to:

(a) describe experiments to show the force on a current-carrying conductor, and on a beam of charged particles, in a magnetic field, including the effect of reversing (1) the current, (2) the direction of the field.

(b) state the relative directions of force, field and current.

(c) describe the field patterns between currents in parallel conductors and relate these to the forces which exist between the conductors (excluding the Earth's field).

(d) explain how a current-carrying coil in a magnetic field experiences a turning effect and that the effect is increased by increasing (1) the number of turns on the coil, (2) the current.

(e) discuss how this turning effect is used in the action of an electric motor.

(f) describe the action of a split-ring commutator in a two-pole, single coil motor and the effect of winding the coil onto a soft-iron cylinder.

23. Electromagnetic Induction

Content

23.1 Principles of electromagnetic induction

23.2 The a.c. generator

23.3 The transformer

Learning Outcomes

Candidates should be able to:

(a) describe an experiment which shows that a changing magnetic field can induce an e.m.f. in a circuit.

(b) state the factors affecting the magnitude of the induced e.m.f.

(c) state that the direction of a current produced by an induced e.m.f. opposes the change producing it (Lenz's Law) and describe how this law may be demonstrated.

(d) describe a simple form of a.c. generator (rotating coil or rotating magnet) and the use of slip rings where needed.

(e) *sketch a graph of voltage output against time for a simple a.c. generator.

(f) describe the structure and principle of operation of a simple iron-cored transformer.

(g) state the advantages of high voltage transmission.

(h) discuss the environmental and cost implications of underground power transmission compared to overhead lines.

24. Introductory Electronics

Content

24.1 Thermionic emission

24.2 Simple treatment of cathode-ray oscilloscope

24.3 Action and use of circuit components

Learning Outcomes

Candidates should be able to:

(a) state that electrons are emitted by a hot metal filament.

(b) explain that to cause a continuous flow of emitted electrons requires (1) high positive potential and (2) very low gas pressure.

(c) describe the deflection of an electron beam by electric fields and magnetic fields.

(d) state that the flow of electrons (electron current) is from negative to positive and is in the opposite direction to conventional current.

(e) describe in outline the basic structure and action of a cathode-ray oscilloscope (c.r.o.) (detailed circuits are not required).

(f) describe the use of a cathode-ray oscilloscope to display waveforms and to measure p.d.s and short intervals of time (detailed circuits are not required).

(g) explain how the values of resistors are chosen according to a colour code and why widely different values are needed in different types of circuit.

(h) discuss the need to choose components with suitable power ratings.

(i) describe the action of thermistors and light-dependent resistors and explain their use as input sensors (thermistors will be assumed to be of the negative temperature coefficient type).

(j) describe the action of a variable potential divider (potentiometer).

(k) describe the action of a diode in passing current in one direction only.

(l) describe the action of a light-emitting diode in passing current in one direction only and emitting light.

(m) describe the action of a capacitor as a charge store and explain its use in time-delay circuits.

(n) describe and explain the action of relays in switching circuits.

(o) describe and explain circuits operating as light-sensitive switches and temperature-operated alarms (using a relay or other circuits).

25. Electronic Systems

Note: There is no compulsory question set on Section 25 of the syllabus. Questions set on topics within Section 25 are always set as an alternative within a question

Content

25.1 Switching and logic circuits

25.2 Bistable and astable circuits

Learning Outcomes

Candidates should be able to:

(a) describe the action of a bipolar npn transistor as an electrically operated switch and explain its use in switching circuits.

(b) state in words and in truth table form, the action of the following logic gates, AND, OR, NAND, NOR and NOT (inverter).

(c) state the symbols for the logic gates listed above (American ANSI Y 32.14 symbols will be used).

(d) describe the use of a bistable circuit.

(e) discuss the fact that bistable circuits exhibit the property of memory.

(f) describe the use of an astable circuit (pulse generator).

(g) describe how the frequency of an astable circuit is related to the values of the resistive and capacitative components.

SECTION VI: ATOMIC PHYSICS

26. Radioactivity

Content

26.1 Detection of radioactivity

26.2 Characteristics of the three types of emission

26.3 Nuclear reactions

26.4 Half-life

26.5 Uses of radioactive isotopes including safety precautions

Learning Outcomes

Candidates should be able to:

(a) describe the detection of alpha-particles, beta-particles and gamma-rays by appropriate methods.

(b) state and explain the random emission of radioactivity in direction and time.

(c) state, for radioactive emissions, their nature, relative ionising effects and relative penetrating powers.

(d) describe the deflection of radioactive emissions in electric fields and magnetic fields.

(e) explain what is meant by *radioactive decay.*

(f) explain the processes of fusion and fission.

(g) describe, with the aid of a block diagram, one type of fission reactor for use in a power station.

(h) discuss theories of star formation and their energy production by fusion.

(i) explain what is meant by the term *half-life.*

(j) make calculations based on half-life which might involve information in tables or shown by decay curves.

(k) describe how radioactive materials are handled, used and stored in a safe way.

(l) discuss the way in which the type of radiation emitted and the half-life determine the use for the material.

(m) discuss the origins and effect of background radiation.

(n) discuss the dating of objects by the use of ^{14}C.

27. The Nuclear Atom

Content

27.1 Atomic model

27.2 Nucleus

Learning Outcomes

Candidates should be able to:

(a) describe the structure of the atom in terms of nucleus and electrons.

(b) describe how the Geiger-Marsden alpha-particle scattering experiment provides evidence for the nuclear atom.

(c) describe the composition of the nucleus in terms of protons and neutrons.

(d) define the terms *proton number* (atomic number), Z and *nucleon number* (mass number), A.

(e) explain the term *nuclide* and use the nuclide notation $^{A}_{Z}X$ to construct equations where radioactive decay leads to changes in the composition of the nucleus.

(f) define the term *isotope*.

(g) explain, using nuclide notation, how one element may have a number of isotopes.

Paper 3: Practical test

Introduction

This paper is designed to assess a candidate's competence in those practical skills which can realistically be assessed within the context of a formal test of limited duration. The best preparation for this paper is for candidates to pursue a comprehensive course in practical Physics throughout the time during which they are being taught the theoretical content. It is not expected that all the experiments and exercises will follow the style of the Practical Test, but candidates should regularly be made aware of the points examiners will be looking for when marking this paper.

The questions in the Practical Test cover most of the Objectives outlined above. In particular, candidates should be prepared to make measurements or determinations of physical quantities such as mass, length, area, volume, time, current and potential difference. Candidates should be aware of the need to take simple precautions for safety and/or accuracy. The questions are not necessarily restricted to topics in the curriculum content. The test does not involve the use of textbooks, nor will candidates need access to their own records of laboratory work carried out during the course. Candidates are required to follow instructions given in the question paper. Candidates may use an electronic calculator, which complies with the current version of the Regulations: alternatively, mathematical tables may be used. Examiners assume that an electronic calculator will be used when they are setting the papers and judging the length of time required for each question. Candidates answer on the Question Paper.

Paper 4: Alternative to Practical paper

This paper is designed for those Centres for whom the preparation and execution of the Practical Test is impracticable.

The Alternative to Practical Paper consists of four or five questions relating to practical Physics: candidates answer on the question paper.

The best preparation for this paper is a thorough course in experimental Physics. Candidates are unlikely to demonstrate their full potential on this paper unless they have become fully familiar with the techniques and apparatus involved by doing experiments for themselves. Questions may involve the description of particular techniques, the drawing of diagrams, or the analysis of data. The examiners expect the same degree of detail as for Paper 3 and candidates should be taught to adopt practices which satisfy the same general marking points. In addition, candidates should be able to draw, complete and label diagrams of apparatus and to take readings from diagrams of apparatus given in the question paper. Where facilities permit, demonstration experiments by the teacher can be very useful in the teaching of particular techniques, and can be the source of useful data for candidates to analyse.

Appendix

Summary of key quantities, symbols and units

Candidates should be able to state the symbols for the following physical quantities and, where indicated, state the units in which they are measured. Candidates should be able to define the items indicated by an asterisk (*).

Quantity	*Symbol*	*Unit*
length	l, h	km, m, cm, mm
area	A	m^2, cm^2
volume	V	m^3, cm^3
weight	W	N*
mass	m, M	kg, g, mg
time	t	h, min, s, ms
density*	ρ	g/cm^3, kg/m^3
speed*	u, v	km/h, m/s, cm/s
acceleration	a	m/s^2
acceleration of free fall	g	
force*	F, P	N
moment of force*		N m
work done	W, E	J*, kW h*
energy	E	J
power*	P	W*
pressure*	p, P	Pa*, N/m^2
atmospheric pressure		use of millibar
temperature	θ, t, T	°C, K
heat capacity	C	J/°C, J/K
specific heat capacity*	c	J/(g °C), J/(g K)
latent heat	L	J
specific latent heat*	l	J/kg, J/g

Quantity	Symbol	Unit
frequency*	f	Hz
wavelength*	λ	m, cm
focal length	f	m, cm
angle of incidence	i	degree (°)
angles of reflection, refraction	r	degree (°)
critical angle	c	degree (°)
potential difference*/voltage	V	V*, mV
current*	I	A, mA
charge		C, A s
e.m.f.*	E	V
resistance	R	Ω

Glossary of terms used in Physics Papers

The glossary (which is relevant only to Science subjects) will prove helpful to candidates as a guide but it is not exhaustive. The glossary has been deliberately kept brief, not only with respect to the numbers of terms included but also to the descriptions of their meanings. Candidates should appreciate that the meaning of a term must depend, in part, on its context.

1. *Define (the term(s) ...)* is intended literally. Only a formal statement or equivalent paraphrase, such as the defining equation with symbols identified, being required.
2. *Explain/What is meant by ...* normally implies that a definition should be given, together with some relevant comment on the significance or context of the term(s) concerned, especially where two or more terms are included in the question. The amount of supplementary comment intended should be interpreted in the light of the indicated mark value.
3. *State* implies a concise answer with little or no supporting argument, e.g. a numerical answer that can be obtained 'by inspection'.
4. *List* requires a number of points with no elaboration. Where a given number of points is specified, this should not be exceeded.
5. *Describe* requires candidates to state in words (using diagrams where appropriate) the main points of the topic. It is often used with reference either to particular phenomena or to particular experiments. In the former instance, the term usually implies that the answer should include reference to (visual) observations associated with the phenomena. The amount of description intended should be interpreted in the light of the indicated mark value.
6. *Discuss* requires candidates to give a critical account of the points involved in the topic.
7. *Deduce* implies that candidates are not expected to produce the required answer by recall but by making a logical connection between other pieces of information. Such information may be wholly given in the question or may depend on answers extracted in an earlier part of the question.
8. *Suggest* is used in two main contexts. It may either imply that there is no unique answer or that candidates are expected to apply their general knowledge to a 'novel' situation, one that formally may not be 'in the syllabus'.

9. *Calculate* is used when a numerical answer is required. In general, working should be shown.
10. *Measure* implies that the quantity concerned can be directly obtained from a suitable measuring instrument, e.g. length, using a rule, or angle, using a protractor.
11. *Determine* often implies that the quantity concerned cannot be measured directly but is obtained by calculation, substituting measured or known values of other quantities into a standard formula, e.g. the Young modulus, relative molecular mass.
12. *Show* is used when an algebraic deduction has to be made to prove a given equation. It is important that the terms being used by candidates are stated explicitly.
13. *Estimate* implies a reasoned order of magnitude statement or calculation of the quantity concerned. Candidates should make such simplifying assumptions as may be necessary about points of principle and about the values of quantities not otherwise included in the question.
14. *Sketch*, when applied to graph work, implies that the shape and/or position of the curve need only be qualitatively correct. However, candidates should be aware that, depending on the context, some quantitative aspects may be looked for, e.g. passing through the origin, having an intercept, asymptote or discontinuity at a particular value. On a sketch graph it is essential that candidates clearly indicate what is being plotted on each axis.

    Sketch, when applied to diagrams, implies that a simple, freehand drawing is acceptable: nevertheless, care should be taken over proportions and the clear exposition of important detail.

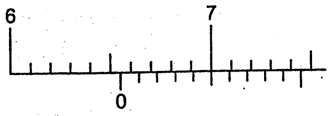
Thinking Process

MCQ Answers

Topic 1 Mass, Weight, Density And Volume

MCQ Section

1. The diagram shows a vernier scale.



What is the reading on the vernier scale?

A 6.50 cm **B** 6.55 cm

C 7.00 cm **D** 7.05 cm

[J06/P1/Q3]

2. The inertia of a body is its resistance to changes in motion.
Which property is a measure of the body's inertia?

A its density

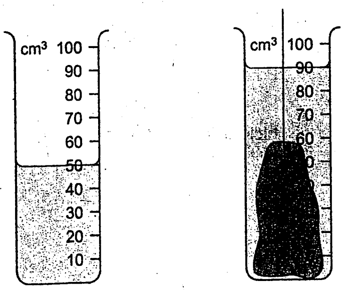
B its mass

C the height of its sides

D the size of its base

[J06/P1/Q6]

3. An object of mass 100g is immersed in water as shown in the diagram.



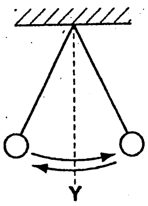
What is the density of the material from which the object is made?

A 0.4 g/cm³ **B** 0.9 g/cm³

C 1.1 g/cm³ **D** 2.5 g/cm³

[J06/P1/Q7]

4. A pendulum swings backwards and forwards passing through **Y**, the middle point of the oscillation.



The first time the pendulum passes through **Y**, a stopwatch is started. The twenty-first time the pendulum passes through **Y**, the stopwatch is stopped. The reading is *T*.

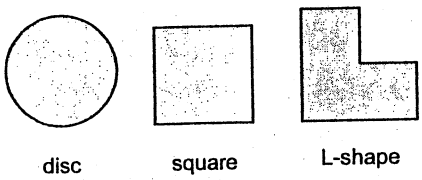
What is the period of the pendulum?

A *T*/40 **C** *T*/20

B *T*/21 **D** *T*/10

[N06/P1/Q1]

5. Three objects are cut from the same sheet of steel. They are different shapes but they all have the same mass.



Which object has the greatest density?

A the disc

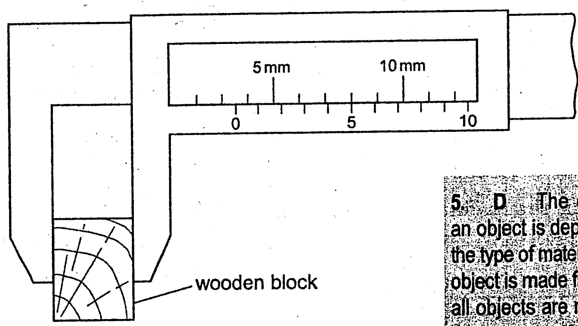
B the L-shape

C the square

D all have the same density

[N06/P1/Q6]

6. The width of a wooden block is measured using vernier calipers.



What is the width of the block?

A 3.5 mm **B** 5.3 mm

C 8.0 mm **D** 8.5 mm

[J07/P1/Q1]

1. B main scale reading = 6.5 cm
Vernier scale reading = 0.05 cm
Final reading = 6.55 cm

2. B It is a fact that inertia ∝ mass.

3. D $\text{density} = \frac{\text{mass}}{\text{volume}}$
$= \frac{100}{40} = 2.5 \text{ g/cm}^3$

4. D The period is the time taken for the pendulum to complete one oscillation. The shortest time taken for pendulum to go from Y to Y again is half a period. Since the counting started at 1, the total no of half-periods is (21 − 1) = 20. So total no. of periods is 10.

5. D The density of an object is dependent on the type of material that the object is made from. Since all objects are made from the same material, all 3 objects have the same density.

6. A Reading = main reading + vernier reading = 3 + 0.5 = 3.5 mm

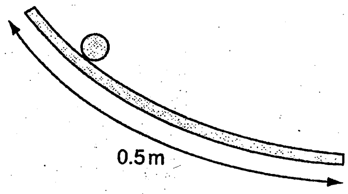
7. A student does an experiment to estimate the density of an irregularly-shaped stone.

Which items of equipment are needed?

A a balance and a measuring cylinder containing water
B a balance and a ruler
C a ruler and a measuring cylinder containing water
D only a measuring cylinder containing water

[J07/P1/Q6]

8. In an experiment, a ball is rolled down a curved track that is about half a metre long.



Which measuring device should be used to measure the length accurately?

A metre rule
B micrometer
C tape measure
D vernier calipers

[N07/P1/Q1]

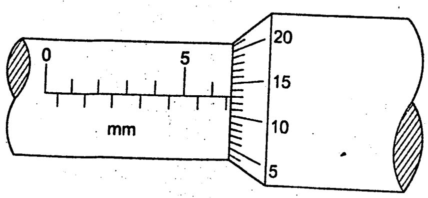
9. A body of mass 10 kg falling freely in the gravitational field close to the Moon's surface has an acceleration of 1.6 m/s².

What is the gravitational field strength on the Moon?

A 0 N/kg **B** 1.6 N/kg
C 10 N/kg **D** 16 N/kg

[N07/P1/Q6]

10. What is the reading on this micrometer?

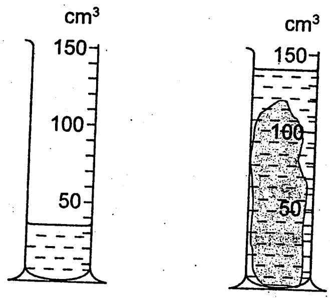


A 5.43 mm **B** 6.63 mm
C 7.30 mm **D** 8.13 mm

[J08/P1/Q1]

11. A lump of metal has a mass of 210 g. It is lowered into a measuring cylinder containing water.

The level of the water rises from 35 cm³ to 140 cm³.



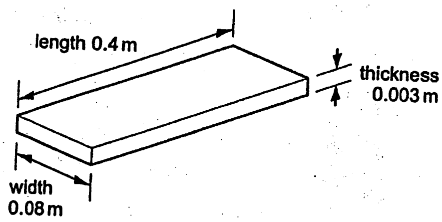
What is the density of the metal?

A 0.67 g/cm³ **B** 1.5 g/cm³
C 2.0 g/cm³ **D** 6.0 g/cm³

[J08/P1/Q6]

12. A manufacturer needs to measure accurately the dimensions of a wooden floor tile.

The approximate dimensions of the tile are shown.



Which instruments measure each of these dimensions accurately?

	length	thickness	width
A	metre rule	micrometer	vernier calipers
B	metre rule	vernier calipers	micrometer
C	micrometer	metre rule	vernier calipers
D	vernier calipers	micrometer	metre rule

[N08/P1/Q1]

MCQ Answers

7. A density $= \frac{\text{mass}}{\text{volume}}$
A balance is needed to find the mass of the stone and a measuring cylinder to measure the volume of the stone.

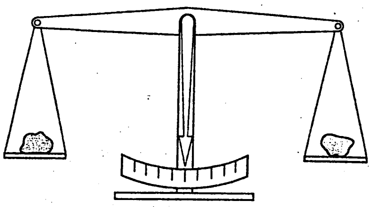
8. C A metre rule cannot measure accurately the length of a curved track. Similarly a micrometer or vernier callipers also cannot measure this length accurately and moreover the length of the track is too long to be measured with them. A measuring tape being flexible can easily measure the length of the curved track accurately.

9. B The gravitational field strength $= \frac{\text{weight}}{\text{mass}} = \frac{16\text{ N}}{10\text{ kg}} = 1.6\text{ N/kg}$

10. B Reading = 6.5 + 0.13 = 6.63 mm.

11. C density $= \frac{\text{mass}}{\text{volume}}$
$= \frac{210\text{ g}}{105\text{ cm}^3} = 2.0\text{ g/cm}^3$

13. The diagram shows two objects on a beam balance in equilibrium.

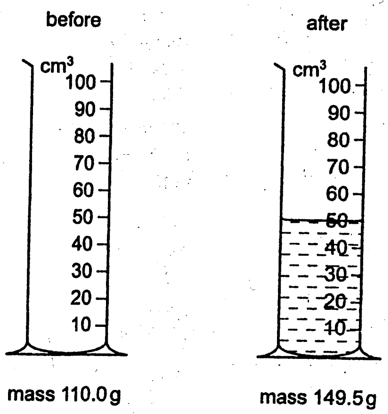


Which need not be the same?

A the masses of the two objects
B the moments about the pivot of the two objects
C the volumes of the two objects
D the weights of the two objects

[N08/P1/Q5]

14. The mass of a measuring cylinder is measured before and after pouring a liquid into it.



What is the density of the liquid?

A 0.79 g/cm^3
B 1.3 g/cm^3
C 1.4 g/cm^3
D 2.2 g/cm^3

[N08/P1/Q6]

15. Which instrument is most easily used to measure the internal diameter of a pipe?

A manometer
B measuring cylinder
C micrometer
D vernier calipers

[J09/P1/Q1]

16. A measuring cylinder contains 118 cm^3 of water. When a small object is fully immersed in the water, the reading goes up to 132 cm^3. The object has a mass of 42 g.
What is the density of the object?

A $\frac{14}{42}\,g/cm^3$

B $\frac{42}{14}\,g/cm^3$

C $\frac{42}{118}\,g/cm^3$

D $\frac{132}{42}\,g/cm^3$

[J09/P1/Q7]

17. Vernier calipers read to one tenth of a millimetre.
Which reading shows this precision?

A 3.3 cm **B** 3.31 cm
C 3.310 cm **D** 3.312 cm

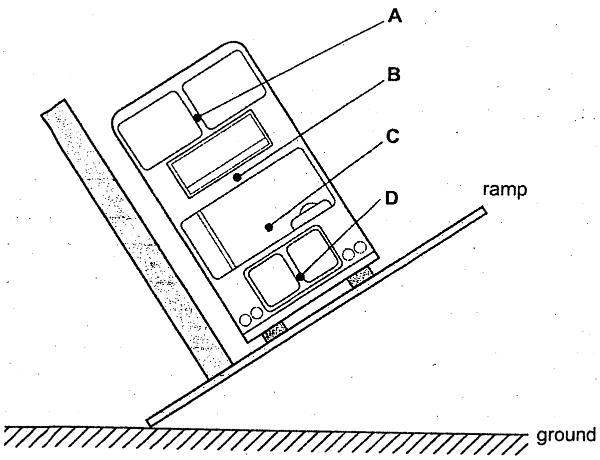
[N09/P1/Q1]

18. A room measures 4.0m × 3.0m × 2.0m. The density of the air in the room is 1.3 kg/m^3.
What is the mass of air in the room?

A 0.054 kg **B** 18 kg
C 24 kg **D** 31 kg

[N09/P1/Q7]

19. The stability of a bus is tested by tilting it on a ramp. The diagram shows a bus that is just about to topple over.
Where is the centre of mass of the bus?



[N09/P1/Q8]

2a

MCQ Answers

12. A The length of the tile, (0.4m = 40cm) can be measured with a metre rule whereas the width (0.08m = 8 cm) can be measured accurately with a vernier calliper and the thickness of the tile (0.003m = 3mm) can be measured accurately with a micrometer screw gauge.

13. C The beam balance shows that the two objects have the same mass, so their weights are also the same and since the beam of the balance is in equilibrium, so the anti-clockwise moment produced by the left object is equal to the clockwise moment produced by the right object but their volumes may not necessarily be the same.

14. A Mass of liquid = mass of cylinder with liquid − mass of empty cylinder = 149.5 − 110.0 = 39.5g

$$\text{density} = \frac{\text{mass of liquid}}{\text{volume of liquid}} = \frac{39.5}{50} = 0.79\ g/cm^3$$

20. Power is measured in watts.

What is the correct symbol for millions of watts?

A mw **B** mW

C Mw **D** MW

[J10/P1/Q2]

21. A passenger is sitting in an aeroplane, which takes off and climbs to 10 000 m.

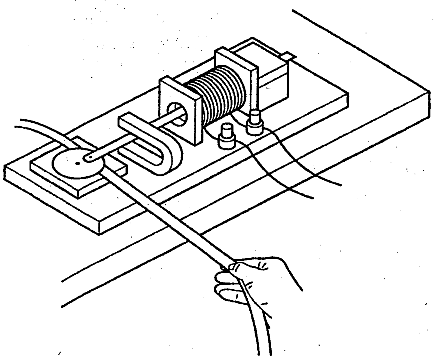
During this time, what happens to the mass and to the weight of the passenger?

	mass	weight
A	decreases	decreases
B	increases	increases
C	unchanged	decreases
D	unchanged	increases

[J10/P1/Q6]

22. A student pulls a piece of tape through a ticker-tape timer. Every 0.02 s, the timer prints a dot on the tape.

First the tape is pulled quickly, then slowly, then quickly again.



Which piece of tape does the student obtain?

A 

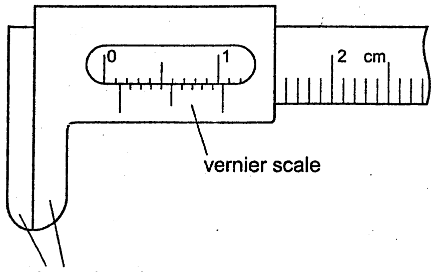
B 

C 

D 

[N10/P1/Q5]

23. Vernier calipers are shown with the jaws closed.



What is the zero error?

A 0.04 cm **B** 0.05 cm

C 0.14 cm **D** 0.15 cm

[N10/P1/Q4]

24. A person of weight 600 N at the bottom of a mountain climbs to the top. The gravitational field strength changes from 10.00 N/kg at the bottom to 9.97 N/kg at the top. His mass is unchanged as he climbs.

What are his mass and his weight at the top of the mountain?

	mass at top of mountain/kg	weight at top of mountain/N
A	60.0	598
B	60.0	600
C	60.1	598
D	60.1	600

[N10/P1/Q9]

Thinking Process

MCQ Answers

15. D A vernier callipers with its internal jaws is ideal for measuring the internal diameter of a pipe easily and with greater accuracy.

16. B

$$\text{Density} = \frac{\text{mass}}{\text{volume}} = \frac{42\text{ g}}{(132-118)\text{cm}^3} = \frac{42}{14}\text{ g/cm}^3$$

17. B Change all the readings into millimetres, i.e. 33 mm, 33.1mm, 33.10 mm and 33.12mm. The first reading is a measurement correct up to 1 mm. The second reading is correct to 0.1 of a mm i.e. correct to 1/10th of a millimetre. The third and fourth readings are correct to 1/100th or 0.01 of a mm.

18. D Area of the room $= 4.0 \times 3.0 \times 2.0 = 24.0\text{ m}^3$

Density of the air $= 1.3\text{ kg/m}^3$

$\therefore$ mass of the air in the room = density × vol.

$= 1.3 \times 24.0$

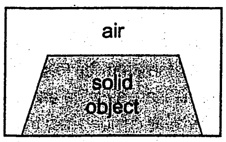
$= 31.2 \approx 31\text{ kg}$

19. C If the vertical line of force of gravity is drawn from the point C, it is seen that this line is about to move out of the base of the bus. On a little more tilting, the vertical line of weight will move out of the base of the bus and bus will topple over.

20. D Fact.

25. A box has an internal volume of 1000 cm^3. When a solid object is placed in the closed box, the volume of air in the box is 520 cm^3.

The density of the object is 8.00 g/cm^3.



What is the mass of the object?

A 60.0 g **B** 3840 g

C 4160 g **D** 8000 g

[N10/P1/Q11]

26. What is the correct unit for the quantity shown?

	quantity	unit
A	electromotive force (e.m.f.)	N
B	latent heat	J
C	pressure	kg/m^3
D	weight	kg

[J11/P1/Q1]

27. A plumber measures, as **accurately** as possible, the length and internal diameter of a straight copper pipe.

The length is approximately 80 cm and the internal diameter is approximately 2 cm.

What is the best combination of instruments for the plumber to use?

	internal diameter	length
A	rule	rule
B	rule	tape
C	vernier calipers	rule
D	vernier calipers	tape

[J11/P1/Q2]

28. A student collects stones and finds their density.

Which apparatus is needed to measure the mass and the volume of the stones?

	mass	volume
A	newton meter	measuring cylinder and water
B	newton meter	ruler and calipers
C	top-pan balance	measuring cylinder and water
D	top-pan balance	ruler and calipers

[J11/P1/Q8]

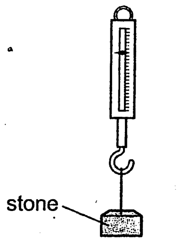
29. A balloon filled with air is gently heated.

What happens to the mass and the density of the air inside the balloon?

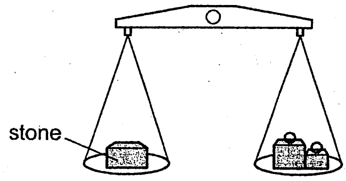
	mass	density
A	decreases	decreases
B	decreases	stays the same
C	stays the same	decreases
D	stays the same	stays the same

[J11/P1/Q15]

30. The weight of a stone is found using a newton meter, and its mass is found using a pan balance.



newton meter



pan balance

The experiment is carried out on the Earth and on the Moon.

For each meter, is its reading the same or different on the Earth and on the Moon?

	reading on newton meter	reading on pan balance
A	different	different
B	different	same
C	same	different
D	same	same

[N11/P1/Q5]

Thinking Process

MCQ Answers

21. C The mass remains constant everywhere in the universe but the weight being dependent on the gravitational field strength decreases considerably due to the decrease in the earth's gravitational field strength at 10 000 m above the earth.

22. B The spacing between the dots is larger when the tape is pulled quickly than the spacing between the dots when the tape is pulled slowly.

23. C Main scale reading = 0.1 cm

Vernier scale reading
$= 4 \times 0.01 = 0.04$ cm

zero error = 0.14 cm

24. A Mass at bottom
$= \frac{W}{g} = \frac{600}{10} = 60$ Kg

As the mass remains the same

So, weight at the top
$= mg = 60 \times 9.97$
≈ 598 N

25. B Total volume of the box = 1000 cm^3

Volume of the air = 520 cm^3

∴ Volume of the object
$= 1000 - 520 = 480 cm^3$

Hence, the mass of the object = density × volume
$= 8.0 \times 480$
$= 3840$ g

26. B The e.m.f. is measured in volts (V), latent heat in Joules (J), pressure in N/m^2 and weight in N.

31. The diameter and the length of a thin wire, approximately 1 m in length, are measured as accurately as possible.

What are the best instruments to use?

	diameter	length
A	micrometer	rule
B	micrometer	vernier calipers
C	rule	tape
D	vernier calipers	rule

[N11/P1/Q6]

32. A quantity is quoted as having a value of 6.2 ms.

In what units is it measured?

A metres
B metres per second
C microseconds
D milliseconds

[N11/P1/Q7]

33. A reel of copper wire is labelled 'length 30 m' and 'diameter 2 mm'. A student calculates the volume of the copper wire.

Which instruments does he use to measure accurately the length and the diameter of the wire?

	length	diameter
A	rule	calipers
B	rule	micrometer
C	tape	calipers
D	tape	micrometer

[J12/P1/Q1]

34. The mass of a paper-clip is 0.50 g and the density of its material is 8.0 g/cm³. The total volume of a number of clips is 20 cm³.

How many paper-clips are there?

A 80 **B** 160
C 240 **D** 320

[J12/P1/Q10]

35. The level of water in a measuring cylinder is 75 cm³. A stone of volume 20 cm³ is lowered into the water.

What is the new reading of the water level?

A 20 cm³ **B** 55 cm³
C 75 cm³ **D** 95 cm³

[N12/P1/Q1]

ThinkinG ProceSS

MCQ Answers

27. C The length of 80cm long wire cannot be measured with a vernier calliper because it is beyond its range and a tape is too long for this measurement. Hence a metre rule is more suitable and convenient to measure it. The vernier calliper has the jaws which enables it to measure accurately the internal diameter of a pipe.

28. C To find the density of a stone, the mass of the stone can be measured using a top-pan balance because a Newton-meter measures weight. As a stone is a body of irregular shape hence its volume can only be measured by using a measuring cylinder and water.

29. C The mass remains constant and as the density $\propto \frac{1}{\text{volume}}$. So the density decreases because the volume of the air in the balloon increases upon heating.

30. B The mass of a body remains constant in all locations whereas the weight of a body depends upon the gravitational pull acting on the body.

31. A The length of 1 m long wire cannot be measured with a vernier callipers because it is beyond its range. The diameter of the wire is very small which can only be measured accurately with a micrometer.

32. D Fact.

33. D The length of a 30m long wire can only be measured accurately with a tape measure, as it is beyond the range of a micrometer, vernier callipers or even a metre rule. Whereas the diameter of a '2mm' thick wire can accurately be measured with a micrometer only.

34. D $\text{Volume of one clip} = \frac{\text{mass of one clip}}{\text{density}}$

$$= \frac{0.50}{8.0} = 0.0625 \text{ cm}^3$$

$$\text{Total number of clips} = \frac{\text{Total volume of all clips}}{\text{Volume of one clip}}$$

$$= \frac{20}{0.0625} = 320$$

35. D The measuring cylinder measures the total volume of the contents in cm³ which are added into it.

Total volume = volume of water + volume of stone
= 75 + 20 = 95 cm³

The mass and the volume of a bar made from metal X are measured.

The masses and volumes of four other bars are measured.

Which bar is made from a metal with a density that is double that of X?

	mass compared with X	volume compared with X
A	double	half
B	half	same
C	same	double
D	same	half

[N12/P1/Q10]

37. Before marking the finishing line on a running track, a groundsman measures out its 100 m length.

Which instrument is the most appropriate for this purpose?

A measuring tape

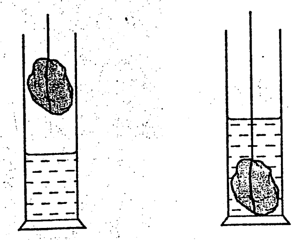
B metre rule

C 30 cm ruler

D micrometer

[J13/P1/Q2]

38. A measuring cylinder contains 20 cm^3 of water. A stone is placed in the water and the water level rises to 38 cm^3.



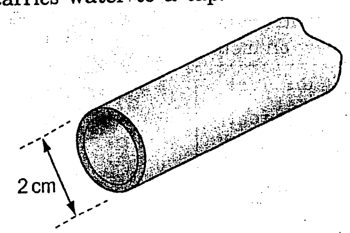
What is the volume of the stone?

A 18 cm^3 **B** 29 cm^3

C 38 cm^3 **D** 58 cm^3

[J13/P1/Q8]

39. A length of copper pipe, of uniform cross-section and several metres long, carries water to a tap.



Measurements are taken to determine accurately the volume of copper in the pipe.

Which instruments are used?

A calipers and micrometer

B micrometer and rule

C rule and tape

D tape and calipers

[N13/P1/Q1]

40. The weight of a cylinder on the Moon is less than its weight on the Earth.

How do the gravitational field strength and the mass of the cylinder on the Moon compare with their values on the Earth?

	gravitational field strength on Moon	mass on Moon
A	the same	less
B	the same	the same
C	less	the same
D	zero	zero

[N13/P1/Q6]

41. A student measures, as **accurately** as possible, the length and internal diameter of a straight glass tube.

The length is approximately 25 cm and the internal diameter is approximately 2 cm.

What is the best combination of instruments for the student to use?

	internal diameter	length
A	ruler	micrometer
B	ruler	ruler
C	vernier calipers	micrometer
D	vernier calipers	ruler

[J14/P1/Q3]

42. Four rocks on different planets have masses and weights as shown.

Which planet has the greatest gravitational field strength?

	mass/kg	weight/N
A	2.0	14
B	2.5	20
C	3.0	21
D	3.5	19

[J14/P1/Q7]

36. D As, density $= \frac{\text{mass}}{\text{volume}}$

So, density $\propto$ mass

and density $\propto \frac{1}{\text{volume}}$

$\therefore$ In order to have the density doubled

(i) the mass should be doubled but this option is not given.

(ii) the volume should be halved which is the option **D**.

37. A The length of a several metres, long track, which may be straight or curved can only be measured accurately using a measuring tape.

38. A Volume of water displaced by the stone = 38 − 20 = 18 cm^3. So, the volume of the stone is = 18 cm^3.

39. D Measure the external and internal diameters of pipe using external and internal jaws of a vernier callipers and hence find external radius (R) and internal radius (r). Also measure the length of the pipe using a tape measure. Then find the volume using the formula:

$V = (\pi R^2 - \pi r^2) \times h$

40. C The mass is a property that always remains constant, regardless of the location. Whereas the weight depends on the gravitational field strength which varies from the Earth to the Moon.

41. D A ruler has a precision of 1 mm. A vernier caliper has a precision of 0.1 mm. A micrometer has a precision of 0.01 mm. Therefore in this case, a vernier caliper and a ruler would be the best combination to measure the internal diameter and length as accurately as possible.

43. A stone has a mass of 390 g and a density of 2.7 g/cm³.

Cooking oil has a density of 0.90 g/cm³.

Which mass of oil has the same volume as the stone?

A 130 g **B** 160 g
C 900 g **D** 1200 g

[J14/P1/Q8]

44. A man uses clay to make a pot. He wants the pot to be as stable as possible when placed on a flat surface.

Which two features of the pot must the man consider?

A the area of the base and the height of the centre of gravity
B the density of the clay and the area of the base
C the density of the clay and the height of the centre of gravity
D the weight and the height of the centre of gravity

[J14/P1/Q10]

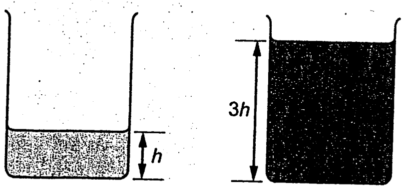
45. A boy stands on some bathroom scales. The reading on the scales is 50 kg.

What is the mass and what is the weight of the boy?

	mass	weight
A	50 kg	50 N
B	50 kg	500 N
C	5.0 N	50 kg
D	50 N	5.0 kg

[N14/P1/Q4]

46. Two identical beakers contain the same mass of liquid. There is a different liquid in each beaker.



Liquid Q has a density ρ.
What is the density of liquid P?

A $\dfrac{\rho}{3}$ **B** ρ
C 3ρ **D** 9ρ

[N14/P1/Q5]

47. What affects the stability of an object?

A only its base area and the location of its centre of mass
B only its weight and its base area
C only the location of its centre of mass
D only its weight

[N14/P1/Q6]

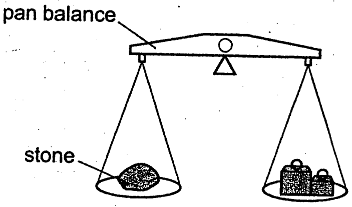
48. The diameter and the length of a thin wire, approximately 50 cm in length, are measured as precisely as possible.

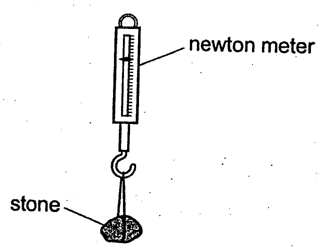
What are the best instruments to use?

	diameter	length
A	micrometer	rule
B	micrometer	vernier calipers
C	rule	tape
D	vernier calipers	rule

[J15/P1/Q2]

49. The mass of a stone is found on Earth using a pan balance. The weight of the stone is found using a newton meter.





Are the readings the same or different on the Moon?

	reading on pan balance	reading on newton meter
A	different	different
B	same	different
C	different	same
D	same	same

[J15/P1/Q8]

MCQ Answers

42. B $W = mg$

$\Rightarrow g = \dfrac{W}{m}$

In option A, $g = \dfrac{14}{2} = 7$

In option B, $g = \dfrac{20}{2.5} = 8$

In option C, $g = \dfrac{21}{3} = 7$

In option D, $g = \dfrac{19}{3.5} = 5.4$

Therefore, B has the greatest gravitational strength.

43. A Volume of stone $= \dfrac{\text{mass of stone}}{\text{density of stone}} = \dfrac{390}{2.7}$

Given that,
vol. of oil = vol. of stone

$\dfrac{m}{0.90} = \dfrac{390}{2.7}$

$m = 130$ g

44. A A low center of gravity and a base with a large area make an object more stable on a flat surface.

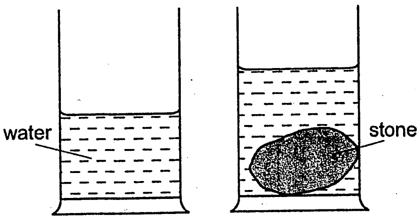
45. B Weight $= mg$
$= 50 \times 10$
$= 500$ N

46. C Mass of liquid Q $= 3\rho h$
Since both beakers contain the same mass of liquids, therefore

density of liquid P $= \dfrac{3\rho h}{h}$
$= 3\rho$

47. A A large base and low center of mass make an object more stable.

50. During an experiment to find the density of a stone, the stone is lowered into a measuring cylinder partly filled with water.



Which statement is correct?

A The difference between the readings gives the density of the stone.

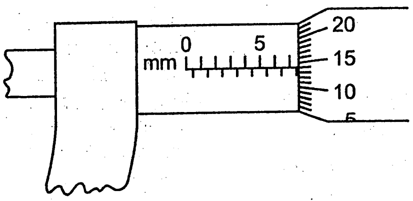
B The difference between the readings gives the volume of the stone.

C The final reading gives the density of the stone.

D The final reading gives the volume of the stone.

[N15/P1/Q2]

51. The diagram shows a micrometer scale.

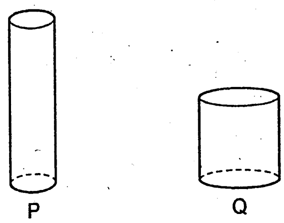


Which reading is shown?

A 5.64 mm **B** 7.14 mm
C 7.16 mm **D** 7.64 mm

[N15/P1/Q3]

52. Two cylinders P and Q are made of copper.



The height of P is twice the height of Q. The diameter of P is half the diameter of Q.

Which statement is correct?

A The density of cylinder P is four times that of cylinder Q.

B The density of cylinder P is twice that of cylinder Q.

C The density of cylinder P is equal to that of cylinder Q.

D The density of cylinder P is half that of cylinder Q.

[N15/P1/Q10]

Thinking Process

MCQ Answers

48. A The length of 50 cm long thin wire can be measured accurately and conveniently with a metre rule as this length is beyond the range of a vernier callipers or a micrometer and a tape is too long for this measurement. The diameter of a thin wire can only be measured accurately with a micrometer.

49. B The pan balance measures the mass which remains constant in all locations. The newton meter measures the weight of the stone which will be different on the earth and on the moon due to the different value of the force of gravity at these two places.

50. B When the stone is immersed in water, it causes the level of the water to rise by an amount equal to its own volume. So, the difference in the two levels or readings is equal to the volume of stone.

51. D Main scale reading = 7.5 mm

Vernier scale reading
= 14 × 0.01 = 0.14 mm

Final reading = 7.5 + 0.14
= 7.64 mm

52. C The density does not depend on the size or shape of an object but rather on the material from which it is made. Since both cylinders are made up of the same material i.e. copper, they both have the same density.

Topic 1 *Mass, Weight, Density And Volume*

THEORY Section

Question 1

A student measures the mass and the volume of four samples of rock A, B, C and D. The results are shown in Fig. 2.1.

	A	B	C	D
mass / g	101	202	448	4508
volume / cm^3	22	44	80	978

Fig. 2.1

(a) **(i)** Describe in detail how a measuring cylinder is used to find the volume of rock A. [2]

(ii) Explain why the volume of rock D cannot be found with an ordinary laboratory measuring cylinder. [1]

(b) Calculate the density of rock A. [2]

(c) Three of the rocks are made from the same material.
State and explain which of the rocks is made from a different material. [2]

[N07/P2/Q2]

Solution

(a) **(i)** Some water is taken in the measuring cylinder and its reading is noted down. Let it be V_1. The rock is tied with cotton and lowered into water in the cylinder. The reading of the new level of water is noted down. Let it be V_2. The volume of the rock is then $= V_2 - V_1$.

(ii) The volume of the rock D is too large to be measured with an ordinary laboratory measuring cylinder. It will not fit in an ordinary laboratory measuring cylinder

(b) density $= \frac{\text{mass}}{\text{volume}} = \frac{101}{22} = 4.6\ \text{g/cm}^3$

(c) The rock C is made from a different material because the density of the material of rock C is different from the density of the material of other rocks.

COMMENT on ANSWER

" **(a)** **(i)** Alternatively:
Fill a eureka can with water to the spout. Place a beaker under its spout. The rock tied with thread is lowered into the eureka can. The water overflows through the spout into the beaker. Measure the volume of this water with a measuring cylinder. The volume of this water is equal to the volume of the rock.

(c) Also:
The mass of the rock is not proportional to its volume. "

Question 2

A space research organisation plans to send astronauts to Mars to examine rocks on its surface.

The organisation will produce a report containing information about conditions on Mars.

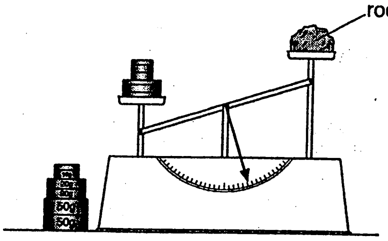
(a) **(i)** The gravitational field strength on the surface of Mars is 3.7 N / kg.
Calculate the weight, on Mars, of a rock of mass 0.50 kg. [2]

(ii) A rock dropped on Mars falls to the surface. State the acceleration of the falling rock.
Assume that there is no air resistance on Mars. [1]

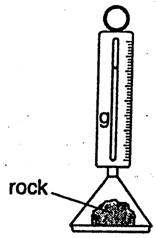
(iii) Calculate the kinetic energy of a 0.50 kg rock as it strikes the surface at a speed of 3.2 m/s. [3]

(b) While still on the surface of Mars, the astronauts will measure the mass of each rock collected.

Fig. 10.1 shows two devices for measuring mass.



A lever arm balance and a set of brass discs. The mass of each disc is accurately determined on Earth and the value is marked on it.



A spring balance. The spring balance is accurately calibrated on Earth and the mass values are marked on the vertical scale.

Fig. 10.1

(i) When the two devices are used on Mars, they will give different readings for the mass of the same rock. Explain why. [3]

(ii) State which device will give the correct reading for the mass. [1]

(c) The astronauts will also determine the density of each rock.

(i) Apart from the mass of the rock, state what other information is needed in order to calculate the density of the rock. [1]

(ii) Describe a method for determining the density of a small, irregularly shaped rock of known mass *m*. [4]

[N09/P2/Q10]

Solution

(a) (i) $W = mg = 0.50 \times 3.7 = 1.85\ N$

(ii) $3.7\ ms^{-2}$

(iii) $K.E. = \frac{1}{2}\ mv^2 = \frac{1}{2} \times 0.50 \times (3.2)^2 = 2.56\ J$

(b) (i) The lever arm balance (device A) compares the mass of a body with the standard masses and it is independent of the gravitational field strength (i.e. the value of g). So, it gives the same value of the mass of a body whether measured on the Earth or on the Mars. Whereas the spring balance (device B) is dependent on the force of gravity and as this device is calibrated on the earth, it will give a different value of the mass of the same body on the Mars where the gravitational field strength is smaller than the earth.

(ii) device A.

(c) (i) Volume of the rock.

(ii) Take some water in a measuring cylinder and note down its volume as V_1. Tie the rock with a thread and lower it into the water gently until it is completely submerged in the water. Note down the new reading of the volume as V_2.

The volume of the rock is then found as:

Volume of rock (V) = $V_2 - V_1$

The density of the rock is then calculated as follows:

$$\text{density}(\rho) = \frac{\text{mass of rock } (m)}{\text{volume of rock (V)}}$$

Question 3

A student wishes to find the density of a stone. He uses a measuring cylinder and a spring balance with a scale marked in newtons. The measuring cylinder, spring balance and stone are shown in Fig. 1.1.

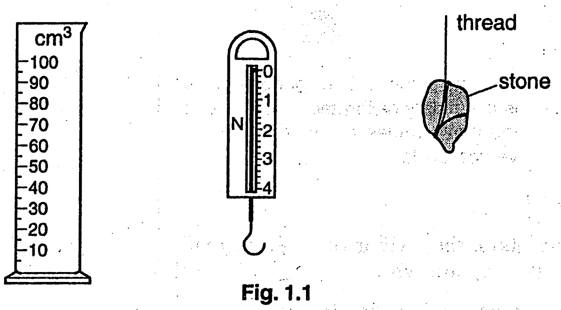


Fig. 1.1

The student knows that the gravitational field strength is 10 N/kg.

(a) Describe how the student uses the spring balance to find the mass of the stone. [2]

(b) Describe how the student uses the measuring cylinder to find the volume of the stone. [2]

(c) The mass of the stone is 150 g and its volume is 70 cm³.
Calculate the density of the stone. [1]

(d) The stone is taken to another place, where the gravitational field strength is less than 10 N/kg. State how this affects the mass and the weight of the stone. [1]

[J11/P2/Q1]

Solution

(a) He uses the spring balance and measures the weight of the stone. He then applies the equation $W = mg$ to find the value of the mass of the stone.

(b) Some water is taken in the measuring cylinder and its volume is noted down as V_1. The stone is then immersed fully in water and the new reading of the volume is noted down as V_2. Then, volume of stone = $V_2 - V_1$.

(c) Density of stone = $\frac{\text{mass}}{\text{volume}} = \frac{150}{70} = 2.14$ g/cm³

(d) mass: unchanged
weight: less

COMMENT on ANSWER

(a) Take $g = 10$ N/kg

(b) *Precautions:*
— Flat surface cylinder not tilted.
— Read the lower meniscus.
— Stone is completely immersed.
— Take reading when water is steady.

(c) As the mass is the quantity of matter in a body, so it is not affected by the gravitational field strength and its value remains constant every where in the universe, but weight depends on the gravitational field strength. So, its value changes from place to place on the surface of earth or in the universe.

Question 4

Fig. 2.1 shows a boy moving a water container in a wheelbarrow.

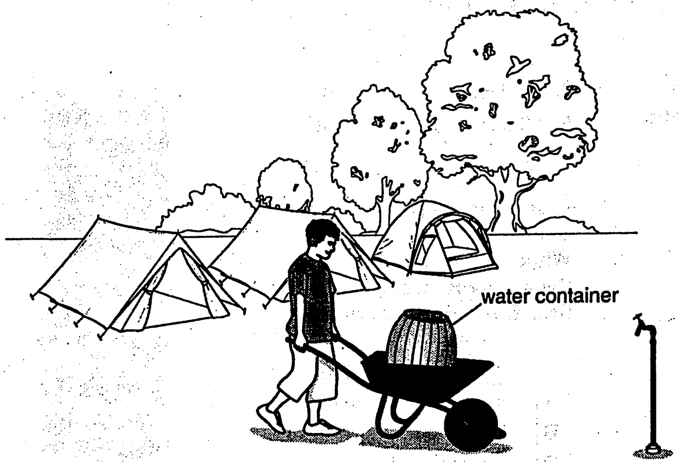


Fig. 2.1

The container has a volume of 0.15 m^3 and is filled with water of density 1000 kg / m^3.

(a) Calculate the mass of water in the container when it is full. [2]

(b) It is harder to stop the wheelbarrow when the container is full than when it is empty. Explain this. [2]

[N13/P2/Q2]

Solution

(a) Mass = density × volume

$= 1000 \times 0.15 = 150\,\text{kg}$

(b) The container has a greater mass when it is full; so it has a greater inertia and hence it provides more resistance to a change in its state of motion.

COMMENT on ANSWER

“(b) *Alternative answer:*

With greater mass, the wheelbarrow will have a greater K.E., so it will require a greater work done to stop it.

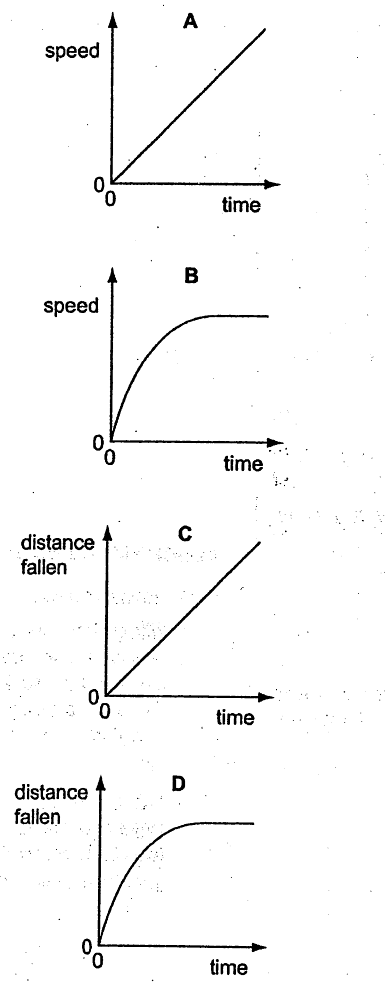
OR

With greater mass, a larger force will be required to decelerate the wheelbarrow.”

Topic 2 Kinematics

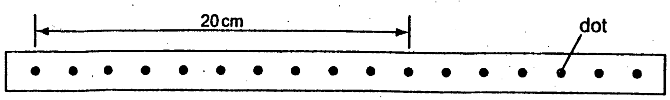
MCQ Section

1. Which graph shows the motion of a heavy, steel ball falling from a height of 2 m?



[J06/P1/Q1]

2. The diagram shows a strip of paper tape that has been pulled under a vibrating arm by an object moving at constant speed. The arm is vibrating regularly, making 50 dots per second.



What was the speed of the object?

A 2.0 cm/s　　**C** 100 cm/s
B 5.0 cm/s　　**D** 200 cm/s

[N06/P1/Q5]

3. A student drops a table-tennis ball in air.
What happens to the velocity and to the acceleration of the ball during the first few seconds after release?

	velocity	acceleration
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

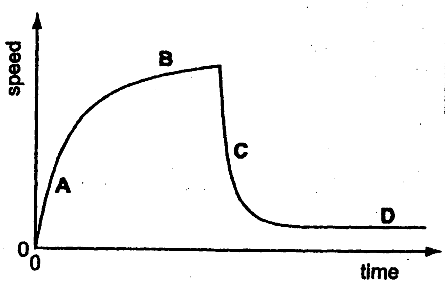
[J07/P1/Q3]

4. A car is brought to rest in 5 s from a speed of 10 m/s.
What is the average deceleration of the car?

A 0.5 m/s²　　**B** 2 m/s²
C 15 m/s²　　**D** 50 m/s²

[J07/P1/Q4]

5. The speed-time graph for a falling skydiver is shown below. The skydiver alters his fall first by spreading his arms and legs and then by using a parachute.
Which part of the graph shows the diver falling with terminal velocity?



[N07/P1/Q3]

MCQ Answers

1. **A** Neglecting air resistance, the steel ball falls with constant acceleration (i.e, the value of g), hence the gradient of the speed-time graph is constant.

2. **C** The time taken to travel the distance of 20 cm is given by $\frac{10}{50}$ = 0.20 s. Since the speed of the object is constant,
$\text{speed} = \frac{\text{distance}}{\text{time}} = \frac{20}{0.20}$
= 100 cm/s.

3. **C** The velocity of the ball increases with time due to the pull of gravity but this increase in velocity i.e. acceleration decreases with time due to the increase in air resistance.

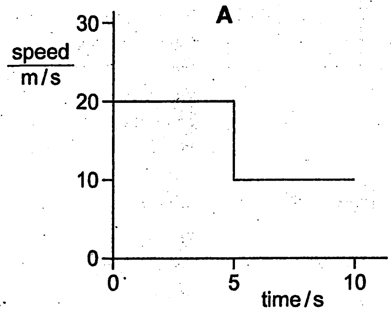
4. **B** $a = \frac{v-u}{t}$
$= \frac{0-10}{5} = -2$
∴ deceleration = 2 m/s²

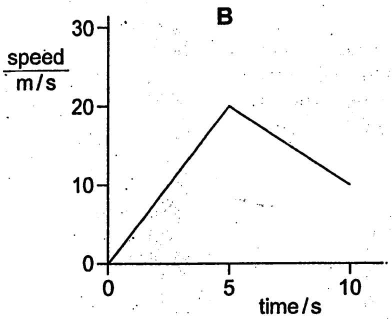
5. **D** The horizontal part of the speed-time graph shows the motion of the diver with steady velocity or the terminal velocity.

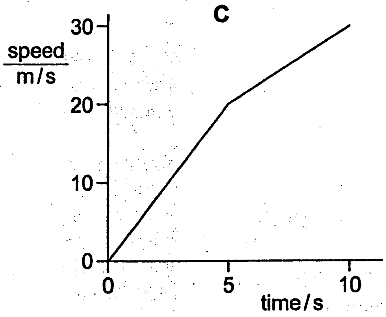
Thinking Process

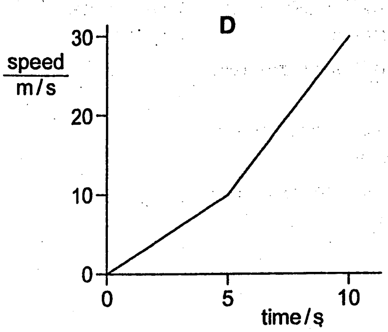
6. A skier is travelling downhill. The acceleration on hard snow is $4\ m/s^2$ and on soft snow is $2\ m/s^2$.

Which graph shows the motion of the skier when moving from hard snow to soft snow?





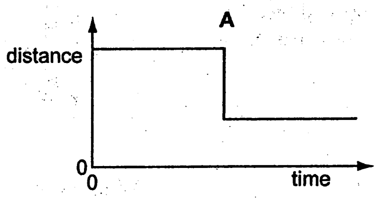


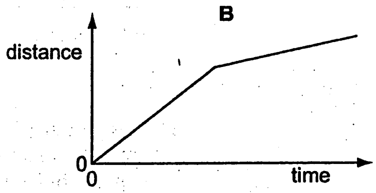


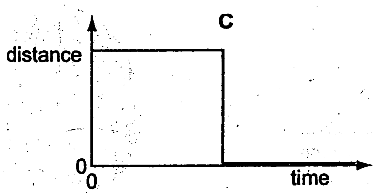
[J08/P1/Q4]

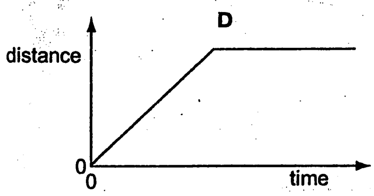
7. A free-fall parachutist falls at a constant speed. He then opens his parachute and continues to fall to Earth at a lower, constant speed.

Which diagram shows how the distance fallen by the parachutist varies with time?



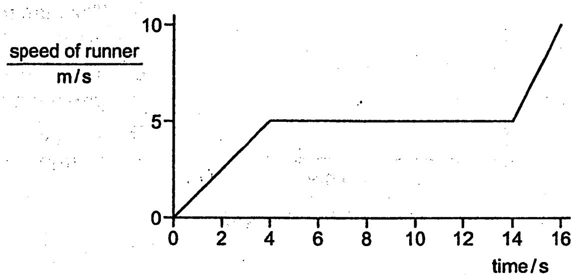






[J09/P1/Q3]

8. The graph shows the speed of a runner during a race.



MCQ Answers

6. **C** Acceleration = gradient (slope) of the speed-time graph. The first part of the graph should be steeper than the second part.

7. **B** The gradient (slope) of a distance-time graph gives the speed of a moving body. In Option B the straight line with a greater slope shows the greater constant speed followed by the straight line with lesser slope showing the lower constant speed.

8. **C** Distance travelled = Area under the graph line = Area of triangle + Area of rectangle + Area of trapezium = $(\frac{1}{2}\times4\times5) + (5\times10) + (\frac{1}{2}\times(10+5)\times2) = 10 + 50 + 15 = 75\ m$

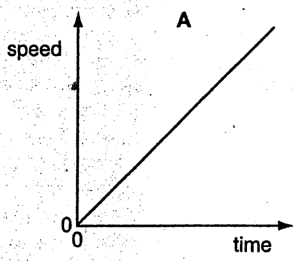
What is the distance travelled by the runner during the race?

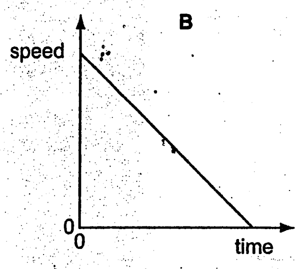
A 50 m **B** 65 m

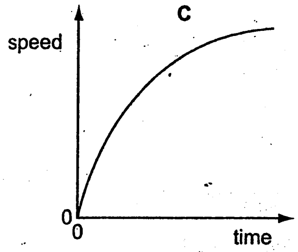
C 75 m **D** 90 m

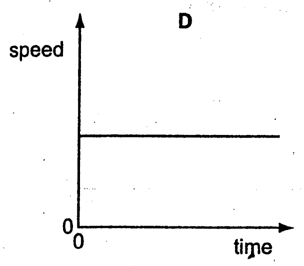
[J09/P1/Q4]

9. Which speed-time graph shows an object moving with non-uniform acceleration?



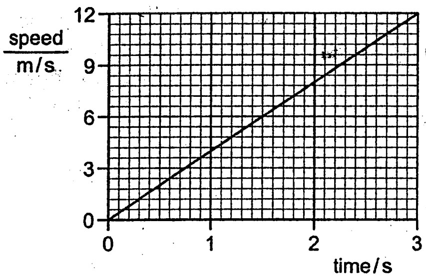






[N09/P1/Q3]

10. The graph shows the speed of a car as it moves from rest.



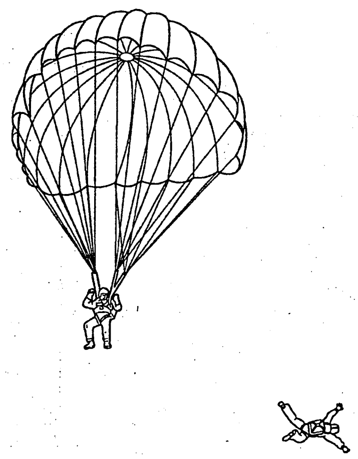
What is the average speed of the car during the first 3 s?

A 4 m/s **B** 6 m/s

C 18 m/s **D** 36 m/s

[N09/P1/Q4]

11. Two men jump out of an aeroplane at the same time. One of the men opens his parachute and the other man remains in free-fall.



Why is the man in free-fall moving faster than the parachutist?

A The man in free-fall experiences greater air resistance.

B The man in free-fall has a greater mass.

C The parachutist experiences greater air resistance.

D The parachutist has not reached terminal velocity.

[J10/P1/Q3]

MCQ Answers

9. C The slope (gradient) of a speed-time graph gives the value of the acceleration. Since the graph C is not a straight line but a curve with changing slope so it shows that the object is moving with a non-uniform acceleration.

10. B Total distance travelled by the car

$= \frac{1}{2} \times 3 \times 12 = 18$ m

Total time taken = 3 s.
Hence,

$$\langle V \rangle = \frac{\text{Total distance}}{\text{Total time}} = \frac{18}{3} = 6 \text{ m/s}$$

Alternatively:

$$\text{Average speed} = \frac{u+v}{2} = \frac{0+12}{2} = 6 \text{ m/s}$$

11. C Initially, both the men accelerate downwards at 10 ms^{-1} due to the pull of gravity. On opening the parachute, the larger surface area of the parachutist and hence the greater air resistance reduces his acceleration to zero while the other man keeps on accelerating due to a much smaller air resistance acting on him.

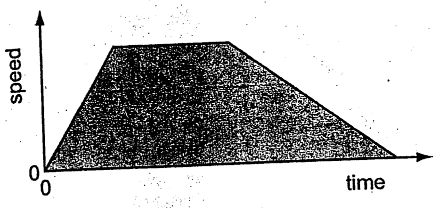
12. A student measures the speed of a trolley. At one instant, the speed of the trolley is 1.0 m/s and two seconds later the speed is 4.0 m/s.

What is the acceleration of the trolley?

A 1.5 m/s² **B** 2.0 m/s²
C 2.5 m/s² **D** 5.0 m/s²

[J10/P1/Q4]

13. The speed-time graph shows the movement of a car.



What does the shaded area of the graph represent?

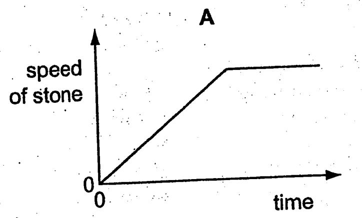
A the average acceleration of the car
B the average speed of the car
C the total distance travelled by the car
D the total travelling time of the car

[J10/P1/Q5]

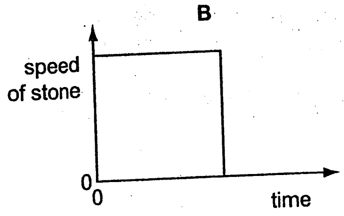
14. A small stone is dropped from the top of a ladder, falls and hits the ground. It does not rebound.

Which speed-time graph is correct?

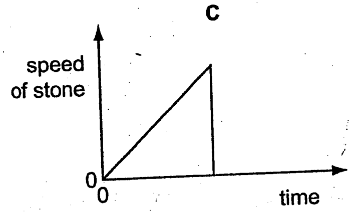
A



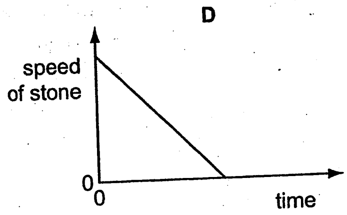
B



C



D



[N10/P1/Q2]

15. Which vehicle has an acceleration of 5 m/s²?

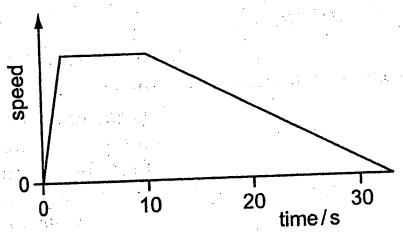
A a bicycle, when its speed changes from rest to 2.5 m/s in 2 s
B a car, when its speed changes from rest to 15 m/s in 5 s
C a lorry, when its speed changes from rest to 20 m/s in 15 s
D a motorbike, when its speed changes from rest to 50 m/s in 10s

[J11/P1/Q4]

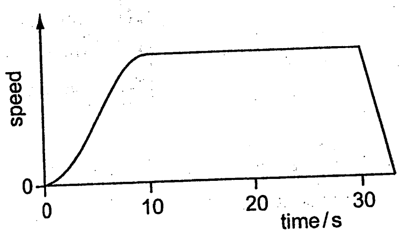
16. A car accelerates from traffic lights for 10 s. It stays at a steady speed for 20 s and then brakes to a stop in 3 s.

Which graph shows the journey?

A



B



Think Process

MCQ Answers

12. A $a = \frac{v - u}{t}$

$= \frac{4.0 - 1.0}{2}$

$= \frac{3}{2} = 1.5\ m/s^2$

13. C Fact

14. C During the free fall, the stone accelerates uniformly and then comes to rest on hitting the ground.

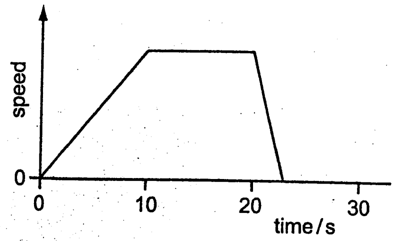
15. D $a = \frac{v - u}{t}$

$= \frac{50 - 0}{10}$

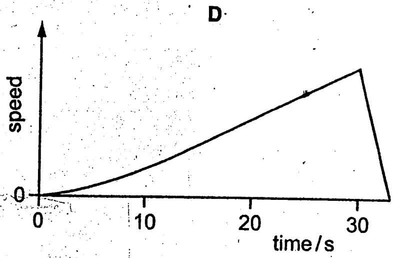
$= 5\ m/s^2$

16. B The slope (gradient) of a speed-time graph represents the acceleration. The graph B shows that the car accelerates during the first 10 seconds. Its speed remains constant from 10 seconds to 30 seconds and then it comes to a stop in the last 3 seconds.

C

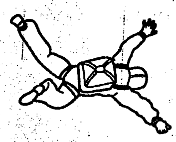


D



[J11/P1/Q5]

17. A skydiver falls from rest through the air and reaches terminal velocity.



What is the acceleration of the skydiver during his fall?

A constant at $0\,m/s^2$

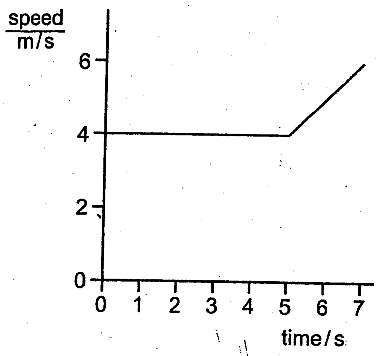
B constant at $10\,m/s^2$

C starting at $0\,m/s^2$ and increasing to $10\,m/s^2$

D starting at $10\,m/s^2$ and decreasing to $0\,m/s^2$

[J11/P1/Q6]

18. The graph shows part of a journey made by a cyclist.



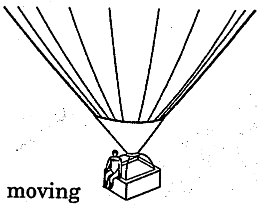
How far did the cyclist travel in 7 s?

A	28 m	**B**	30 m
C	32 m	**D**	42 m

[N11/P1/Q3]

19. The diagrams show a parachutist in four positions after she jumps from a high balloon.

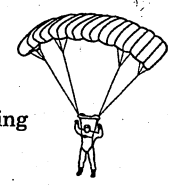
At which position does she have terminal velocity?



A not yet moving

B accelerating

C not accelerating



D not moving

[N11/P1/Q1]

20. A student drops a table-tennis ball in air.

What happens to the velocity and to the acceleration of the ball during the first few seconds after release?

	velocity	acceleration
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

[J12/P1/Q4]

MCQ Answers

17. D At the start of his fall the sky diver is acted upon by the only force of gravity so he accelerates at $10\,m/s^{-2}$ and his speed increases. The air resistance acting on him also increases with the increase in speed and gradually becomes equal to the downward force of gravity. The resultant force then becomes zero and he then falls with the terminal velocity and $0\,m/s^{-2}$ acceleration.

18. B Distance travelled = area under the graph

= area of rectangle + area of trapezium

$= (5 \times 4) + \frac{1}{2} \times 2(4 + 6)$

$= 20 + 10 = 30$ m

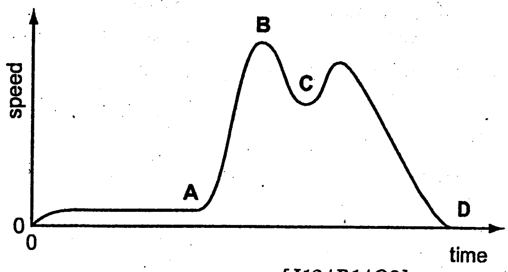
19. C When the parachute is opened, the air resistance gradually becomes equal to the weight of the body. The resultant force is then zero and the body falls with terminal velocity and zero acceleration.

20. C As the ball just starts falling, it accelerates due to the pull of gravity so its velocity increases but this increase in velocity (i.e. acceleration) decreases with time due to increase in air resistance.

Thinking Process

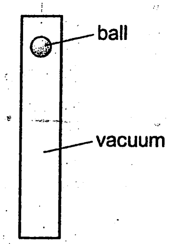
21. A cyclist travels along a hilly road without using the pedals or brakes. Air resistance and friction are negligible. The speed / time graph of the cyclist is shown.

At which point did he reach the bottom of the first hill?



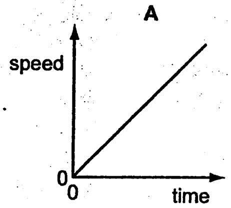
[J12 / P1 / Q3]

22. A table-tennis ball is released from the top of an evacuated tube.

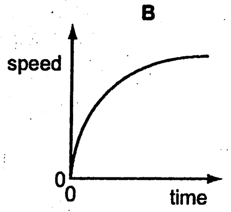


Which graph shows how the speed of the ball changes with time as it falls to the bottom of the tube?

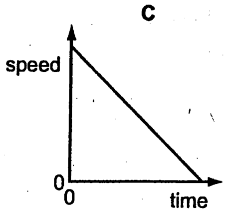
A



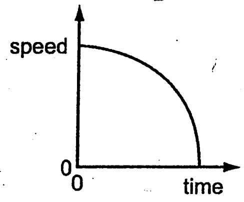
B



C

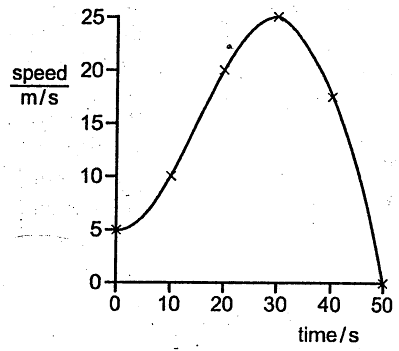


D



[N12 / P1 / Q3]

23. The speed-time graph for a car is shown.



What is the acceleration of the car at 30 s?

A 0

B $\dfrac{25-5}{30}$ m/s^2

C $\dfrac{25}{30}$ m/s^2

D $\dfrac{25}{50}$ m/s^2

[N12 / P1 / Q4]

24. The speed-time graph for a falling skydiver is shown below. As he falls, the skydiver spreads out his arms and legs and then opens his parachute.

Which part of the graph shows the skydiver falling with terminal velocity?

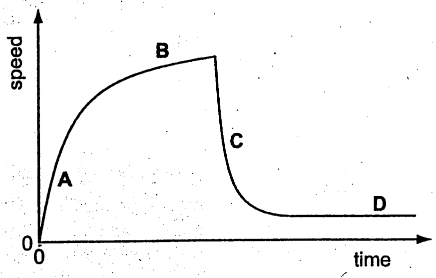
MCQ Answers

21. B A cyclist moving down a hill accelerates and his speed becomes maximum at the bottom. The point **B** represents the maximum speed of the cyclist during his downward motion.

22. A In vacuum, the only force acting on the ball is the constant force of gravity (i.e. weight). So, it falls with a constant acceleration due to gravity (i.e. $g = 10$ m/s^2).

23. A The gradient of a *v-t* graph gives the acceleration of a body. And the gradient (slope) of the graph at 30 second is zero. Hence, the acceleration is zero.

24. D The gradient (slope) of a speed-time graph gives the acceleration. As the horizontal part D gives the zero acceleration. So it represents the skydiver falling with terminal velocity.



[J13/P1/Q3]

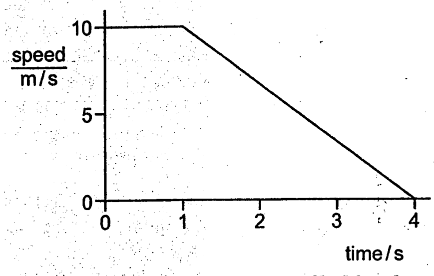
What is the terminal velocity?

A 1.0 m/s　　**B** 1.3 m/s

C 1.6 m/s　　**D** 2.0 m/s

[N13/P1/Q3]

25. The diagram shows the speed-time graph of the motion of a car for four seconds.



What is the distance travelled by the car in the four seconds?

A 15 m　　**B** 25 m

C 30 m　　**D** 40 m

[J13/P1/Q4]

26. An object moves from P to Q in 10 s with uniform acceleration.

velocity at P = 5 m/s

velocity at Q = 12 m/s

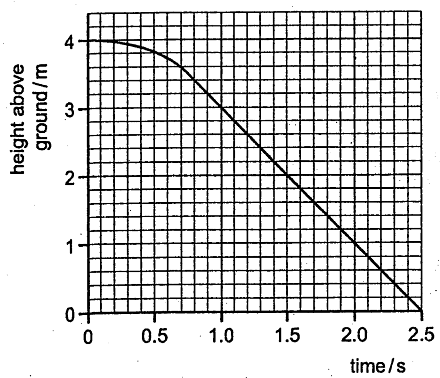
What is the acceleration?

A 0.5 m/s²　　**B** 0.7 m/s²

C 1.2 m/s²　　**D** 1.7 m/s²

[N13/P1/Q2]

27. The graph shows how the height of an object above the ground changes with time.



28. An object falls from rest through the air. Its velocity increases until it reaches terminal velocity.

Which quantity **increases** until its terminal velocity is reached?

A acceleration

B air resistance

C resultant force

D weight

[J14/P1/Q4]

29. A car travels along a road at 50 km/h.

The driver applies the same braking force at the same place on a day when the surface is dry and then on a day when the road is wet.

On the **wet** surface, how many of these distances are greater than on the dry surface?

braking distance
stopping distance
thinking distance

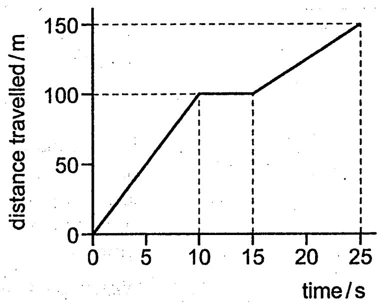
A 0　　**B** 1

C 2　　**D** 3

[N14/P1/Q2]

30. A cyclist takes a ride lasting 25 s.

The diagram shows how her distance travelled from the starting position varies with time.



What is her average speed for the whole ride?

A 6.0 m/s　　**B** 7.5 m/s

C 10.0 m/s　　**D** 11.0 m/s

[J15/P1/Q3]

MCQ Answers

25. B Distance travelled
= area under the graph (trapezium)
$= \frac{1}{2} \times 10 \times (1+4)$
= 25 m

26. B $a = \frac{v-u}{t}$
$= \frac{12-5}{10}$
$= 0.7\ m/s^2$

27. D Using the straight section of the distance-time graph,
the terminal (constant) velocity = gradient of the graph $= \frac{3-0}{2.5-1.0}$
$= \frac{3}{1.5} = 2\ m/s$

28. B Weight remains constant. Air resistance increases, which reduces the resultant force, which in turn reduces the acceleration of the object.

29. C Braking distance and stopping distance are increased by greater speed, icy or wet road conditions. But the thinking distance is independent of the conditions of the road.

30. A Average speed
$= \frac{\text{total distance}}{\text{total time}}$
$= \frac{150}{25} = 6.0\ m/s.$

31. A car begins to move. It speeds up until it reaches a constant speed. It continues to travel at this constant speed for the rest of the journey.

What happens to the acceleration and what happens to the velocity of the car during the journey?

A Both the acceleration and the velocity change.

B Only the acceleration changes.

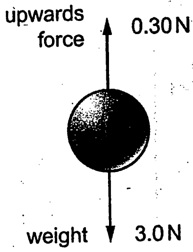
C Only the velocity changes.

D Neither the acceleration nor the velocity changes.

[J15/P1/Q4]

32. A metal ball of mass 0.30 kg and weight 3.0 N is held so that it is below the surface of oil.

It experiences an upwards force of 0.30 N.



When the ball is released, what is its initial acceleration?

A 1.0 m/s^2

B 9.0 m/s^2

C 10 m/s^2

D 11 m/s^2

[J15/P1/Q5]

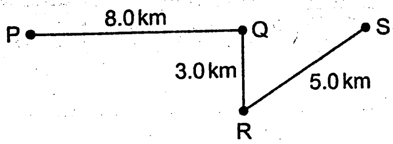
33. A student drops, from rest, a table-tennis ball in air.

What happens to the velocity and to the acceleration of the ball during the first few seconds after release?

	velocity	acceleration
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

[J15/P1/Q6]

34. A lorry takes 15 minutes to travel along the path PQRS.



What is the average speed of the lorry?

A 4.0 km/h

B 22 km/h

C 48 km/h

D 64 km/h

[N15/P1/Q4]

35. An apple of mass 0.15 kg and weight 1.5 N falls from a tree. At one point during its fall, the air resistance on the apple is 0.60 N upwards.

What is the acceleration of the apple at this point?

A 4.0 m/s^2 **B** 6.0 m/s^2

C 10 m/s^2 **D** 14 m/s^2

[N15/P1/Q5]

36. At time t_1, a stone is dropped from a stationary balloon. The stone reaches terminal velocity at time t_2.

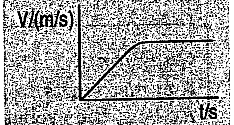
Which row gives the acceleration of the stone at time t_1 and at time t_2 ?

	acceleration at t_1 m/s^2	acceleration at t_2 m/s^2
A	0	0
B	10	0
C	0	10
D	10	10

[N15/P1/Q6]

MCQ Answers

31. A The graph shows the motion of a car.



It shows that the speed increases from zero to maximum value and the acceleration decreases from the maximum value to zero.

32. B Resultant force = mass × acceleration

$3.0 - 0.30 = 0.30 \times a$

$a = \frac{2.7}{0.30}$

$= 9.0\ m/s^2$

33. C The velocity of the ball increases with time due to the pull of gravity but this increase in velocity (i.e. acceleration) decreases with time due to the increase in air resistance, since air resistance ∝ velocity.

34. D Average speed

$= \frac{\text{total distance}}{\text{total time}}$

$= \frac{16\ km}{0.25\ hour} = 64\ km/h$

35. B Resultant force $= ma$

$F - f = ma$

$1.5 - 0.60 = 0.15 \times a$

$a = \frac{0.90}{0.15}$

$a = 6\ ms^{-2}$

36. B At the time of dropping, the only force acting on stone is the force of gravity (no air resistance), so the acceleration due to gravity is 10 m/s^2 and when the stone has attained the terminal velocity, the acceleration becomes zero.

Topic 2 *Kinematics*

THEORY Section

Question 1

A cyclist starts from rest. He accelerates and then travels at a constant speed. At 12 s, the cyclist applies the brakes and slows down. Photographs are taken of the cyclist at 4 s intervals. Fig. 2.1 shows the results.

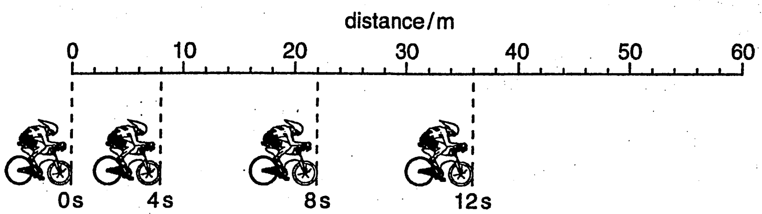


Fig. 2.1

(a) On Fig. 2.1, draw a possible position of the front wheel of the cycle at 16 s. **[1]**

(b) On Fig. 2.2, plot a distance-time graph of the cyclist for the first 16 s. **[4]**

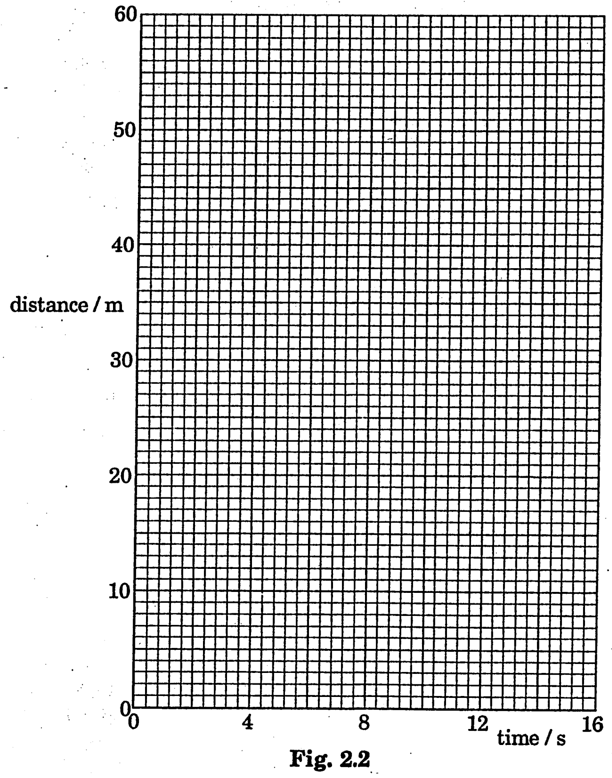


Fig. 2.2

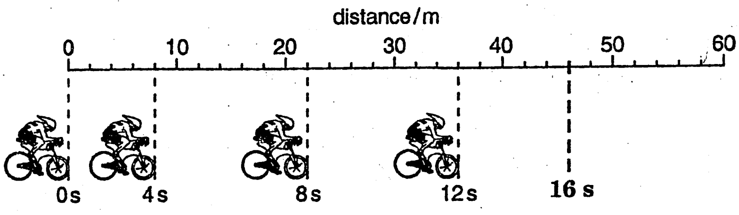
(c) Calculate the average speed of the cyclist during the first 12 s.

average speed = ... **[2]**

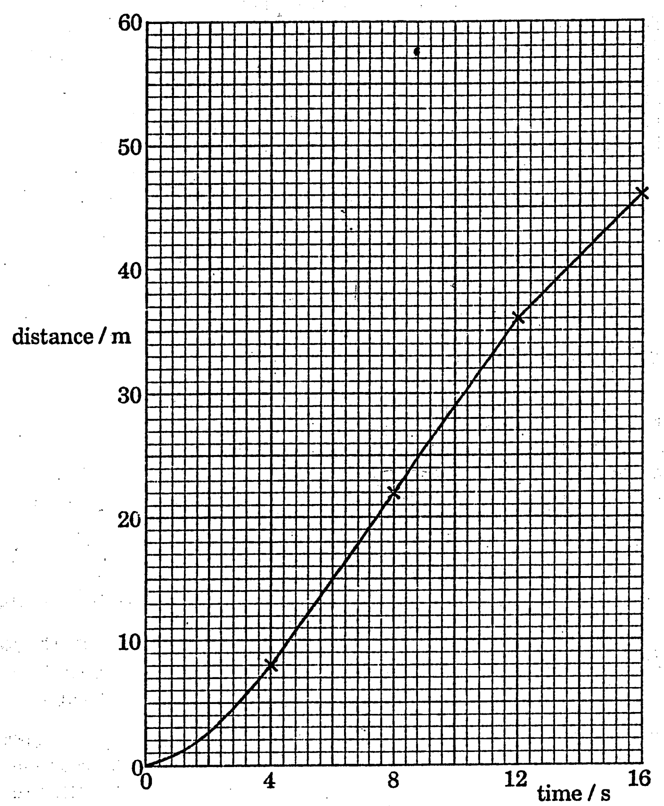
[J06/P2/Q2]

Solution

(a)



(b)



(c) Average speed = $\frac{\text{total distance}}{\text{total time}} = \frac{36}{12} = 3$ m/s

COMMENT on ANSWER

" (a) As the brakes have been applied and the cycle has slowed down, the distance travelled during the last 4 sec will be less than the distance travelled during the previous 4 sec. So the position of the front wheel of the cycle could be anywhere before 50 m mark.

(b) As the speed of the cyclist increases from zero to maximum gradually during the first 4 seconds, so the graph between 0 to 4 sec would be a curve with increasing gradient. The cyclist then moves with a constant speed from 4 to 12 seconds, so its graph would be a straight line with constant gradient.

The cyclist then applies brakes and slows down between 12 and 16 seconds, so its graph would be a straight line with a smaller gradient.

Note that the gradient of a distance-time graph is equal to the speed. "

Question 2

Fig. 1.1 represents the motion of a car along a straight road. As the car approaches a small town, it slows down. The car travels at a constant speed from the start of the town to the end of the town. After passing through the town, the car speeds up.

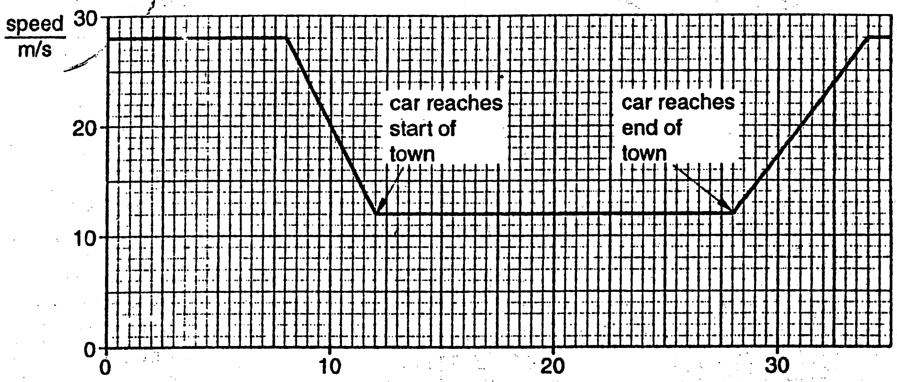


Fig. 1.1

(a) Calculate the distance travelled by the car through the town. [2]

(b) The car accelerates after passing through the town. Calculate the acceleration. [2]

(c) A second car is stationary on the road at the point where the town starts. It accelerates uniformly for 30 s and reaches a speed of 10 m/s. Determine whether this car reaches the end of the town in the 30 s. You may plot a speed-time graph of the second car on Fig. 1.1 if you wish. [2]

[N06/P2/Q1]

Solution

(a) Distance travelled = (12)(28 – 12) = 192 m

(b) acceleration = $\dfrac{v-u}{t} = \dfrac{28-12}{6}$ = 2.7 m/s^2

(c) Distanced travelled = $\dfrac{1}{2}$(10)(30) = 150 m

The second car does not reach the end of the town at the end of 30 s.

COMMENT on ANSWER

" **(a)** Distance travelled = area under the speed-time graph.

(b) Since the speed-time graph is a straight line, the acceleration is constant.

(c) The area under the speed-time graph is triangular. Since the distance travelled is less than than the distance calculated in (a), the second car does not reach the end of town in 30s. "

Question 3

Two athletes, A and B, run a 100 m race. At time $t = 0$, a gun is fired to start the race.

Fig. 1.1 shows the distance-time graph for the two athletes.

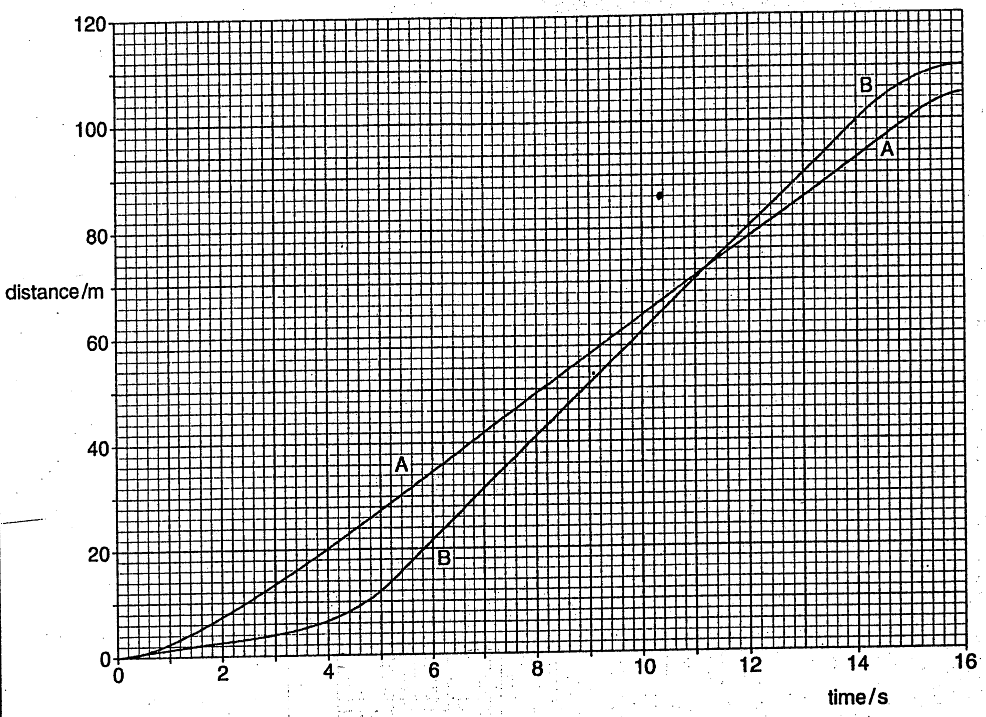


Fig. 1.1

(a) Describe the motion of athlete A during the first 8 s of the race. [2]

(b) State the distance between the two athletes as the winner passes the 100 m mark. [1]

(c) Calculate the speed of athlete A between $t = 4$ s and $t = 15$ s. [2]

[J07/P2/Q1]

Solution

(a) The athlete 'A' accelerates and his speed increases from zero to 4 seconds. He then moves with a constant speed from 4 to 8 seconds

(b) When the winner (athlete B) passes the 100 m mark, the other athlete (A) has covered a distance of 93 m. So,

the distance between the two athletes = 100 – 93 = 7 m

(c) Speed = gradient of the distance-time graph $= \dfrac{100-20}{15-4} = 7.27 \approx 7.3$ m/s

COMMENT on ANSWER

" (a) The gradient of a distance–time graph is equal to the speed. As the slope of the graph line 'A' is increasing between zero and 4 seconds, so it shows that the speed of the athlete 'A' is increasing and he is accelerating. The slope of the graph 'A' is constant from 4 to 8 seconds, which shows that the speed, of the athlete 'A' is constant between 4 and 8 seconds. "

Question 4

Fig. 9.1 shows the horizontal forces acting on a moving car.

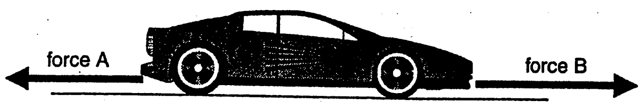


Fig. 9.1

(a) Compare the sizes and directions of the two forces when the car is

(i) moving along a straight road at constant speed, **[1]**

(ii) accelerating. **[1]**

(b) Suggest the direction of the resultant force on the car when the car turns a corner at constant speed. **[1]**

(c) Fig. 9.2 shows the speed-time graph for the first 24 s of the motion of the car along a straight road.

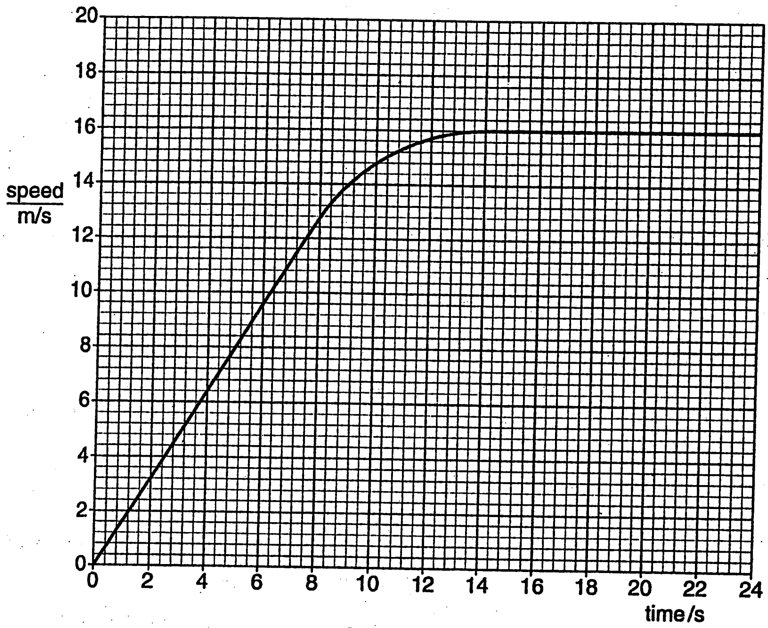


Fig. 9.2

(i) During the motion there is a period of uniform acceleration. State both the start and finish times of this period. **[1]**

(ii) State the main energy changes that occur in the 24 s. **[3]**

(iii) Calculate the acceleration of the car during the first 5 s. State clearly the equation that you use. **[3]**

(iv) Determine the distance travelled in the first 5 s. **[3]**

(d) The car is stopped by applying the brakes. Various factors can affect the distance travelled by the car during the time that the brakes are applied. Apart from the force applied by the brakes, state **two** of these factors. **[2]**

[J07/P2/Q9]

Solution

(a) (i) Since the car is moving at constant speed, so
the engine's forward force B = the backward frictional force A

(ii) As the car is accelerating, therefore the forward driving force B is greater than the backward frictional force A.

(b) The car moves along a curved (circular) path as it turns a corner so the direction of the resultant force acting on it is towards the centre of the curved path.

(c) (i) 0 and 8 second.

(ii) The chemical energy in the fuel is converted to heat energy due to the burning of the fuel which in turn changes into K.E. in the engine and finally changes into heat and internal energy due to the friction and the air resistance.

(iii) acceleration = gradient $= \dfrac{8-0}{5-0} = 1.6\ \text{m/s}^2$

(iv) distance travelled = area under the graph

$$= \frac{1}{2} \times b \times h = \frac{1}{2} \times 5 \times 8 = 20\ \text{m}$$

(d) The two factors are:
1. the speed of the car
2. the friction between the tyres and the road.

Question 5

A parachutist jumps from an aircraft. Some time later, the parachute opens.

Fig. 1.1 is a graph of the vertical speed of the parachutist plotted against time *t*.

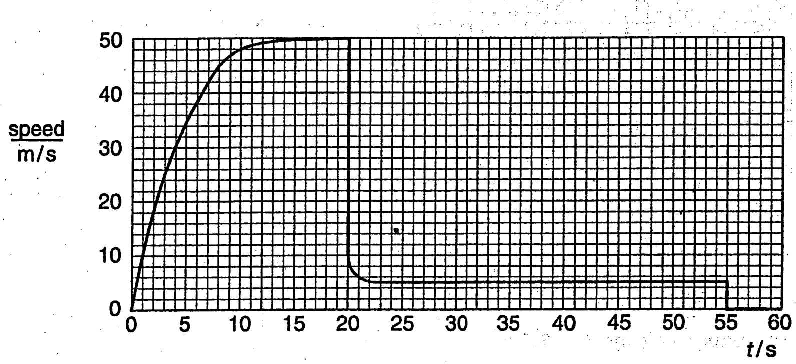


Fig. 1.1

(a) State what happens at $t = 20$ s and $t = 55$ s. [1]

(b) Describe the motion of the parachutist between $t = 0$ and $t = 20$ s. [2]

(c) Explain, in terms of the forces acting, why the speed of the parachutist is constant between $t = 25$ s and $t = 55$ s. [2]

(d) Calculate the distance travelled by the parachutist between $t = 25$ s and $t = 55$ s. [2]

[N07/P2/Q1]

Solution

(a) at 20 s: The parachute opens

at 55 s: The parachutist lands on the ground.

(b) The speed of the parachutist increases at the decreasing rate and becomes constant. His acceleration decreases from a maximum positive value to zero.

(c) The speed of the parachutist during this time interval is constant because the resultant force acting on him is zero as the upward air resistance is equal to the force of gravity acting on him.

(d) Distance travelled = Area under the graph

$$= 5 \times (55 - 25)$$
$$= 5 \times 30 = 150 \text{ m}$$

COMMENT on ANSWER

"(a) Alternatively:
at 20 s: speed drops from 50 m/s to 5 m/s.
at 55 s: speed becomes zero or the parachutist stops moving.

(b) Alternatively:
The parachutist accelerates between 0 and 15 seconds and then acceleration decreases to 0 between 15 s and 20 s.

(c) Alternatively:
Equal and opposite forces of weight of the parachutist and air resistance acting on him balance each other. The resultant force becomes zero. The acceleration too then becomes zero and the speed becomes constant."

Question 6

A piece of paper falls from 4.0 m above the ground.
Fig. 1.1 shows how the height h above the ground varies with the time t.

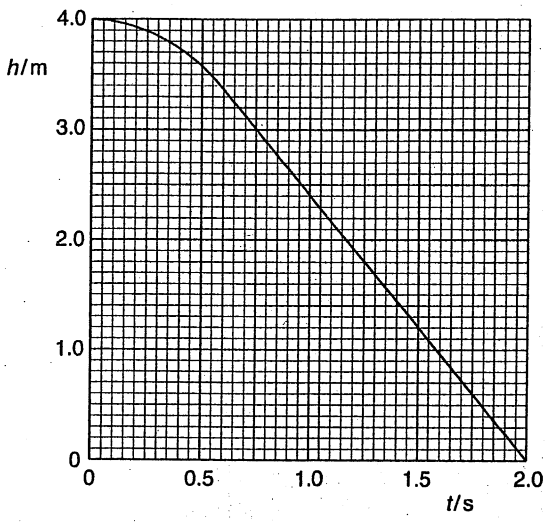


Fig. 1.1

(a) State what happens to the speed of the paper as it falls. [2]

(b) Calculate the speed of the paper at time t = 1.5 s.

speed = ... [2]

(c) As the paper falls, energy changes from one form to another.
State the main energy change between t = 1.0 s and t = 2.0 s. [2]

[J09/P2/Q1]

Solution

(a) As the paper falls, it accelerates and its speed increases till 0.5 seconds. After this it falls with a constant speed from 0.5 second to 2.0 second.

(b) Speed $= \dfrac{\text{distance fallen}}{\text{time taken}} = \dfrac{4.0 - 1.2}{1.5} = 1.87\ \text{ms}^{-1}$

(c) As the paper falls, its P.E. decreases but since its K.E. remains constant so the decrease in P.E. becomes the heat energy and the internal energy.

COMMENT on ANSWER

" **(a)** The gradient (slope) of a distance (height) - time graph is equal to speed. Since, the slope of the graph increases at the beginning so it shows that the speed increases till 0.5 second. After 0.5 s the slope becomes constant so, the speed becomes constant.

(c) During the fall of the paper, its height from the ground decreases so, its P.E. decreases. The K.E. of the paper remains constant because the speed of the paper is constant during this period. "

Question 7

Fig. 1.1 shows a cricket ball as it comes into contact with a cricket bat.

Fig. 1.1

The cricket ball has a mass of 0.16 kg and it hits the bat with a speed of 25 m/s. After being in contact with the bat for 0.0013 s, the ball rebounds with a speed of 22 m/s in the direction exactly opposite to its original direction.

(a) State the difference between *speed* and *velocity*. [1]

(b) Calculate

(i) the change in velocity of the cricket ball, [1]

(ii) the average acceleration of the ball whilst it is in contact with the bat, [2]

(iii) the average force exerted on the ball by the bat. [2]

[N10/P2/Q1]

Solution

(a) Speed has only a magnitude but no direction whereas velocity has a magnitude as well as a direction.

(b) (i) Change in velocity $= v - u$

$$= (-22) - (+25) = -47\ \text{ms}^{-1}$$

(ii) Acceleration, $a = \dfrac{v-u}{t}$

$$= \frac{-47}{0.0013} = -36153.8 \approx -3.6 \times 10^{4}\ \text{ms}^{-2}$$

(iii) Force, $F = ma$

$$= 0.16 \times 36154 = 5784.6 \approx 5785\ \text{N}$$

COMMENT on ANSWER

" **(b) (i)** When dealing with velocity of a body tis direction of motion must be considered. If the initial velocity (u) of the ball while moving towards the bat is taken as 'positive', then the final velocity (v) of the ball when it moves away from the bat after rebounding must be taken as 'negative'.

Hence, $u = +25$ m/s

$v = -22$ m/s. "

Question 8

Fig. 9.1 shows a sky-diver falling vertically.

Fig. 9.1

The sky-diver starts from rest at time $t = 0$.
His acceleration is non-uniform until he reaches a steady speed of 50 m/s at $t = 10$ s.
He opens his parachute at $t = 20$ s and decelerates until $t = 25$ s.
From $t = 25$ s he falls at a steady speed of 5 m/s.

(a) **(i)** On Fig. 9.2, draw the speed-time graph for the sky-diver. [4]

(ii) State how your graph shows that the acceleration is non-uniform between $t = 0$ and $t = 10$ s. [1]

(b) Explain, in detail, why **after** the sky-diver opens his parachute, he decelerates and eventually reaches a steady speed. [4]

(c) For the time interval between $t = 10$ s and $t = 20$ s, calculate the distance that the sky-diver falls. [1]

(d) The mass of the sky-diver is 60 kg.
For the time interval between $t = 20$ s and $t = 25$ s,

(i) calculate the average deceleration of the sky-diver, [2]

(ii) calculate the average resultant force acting on the sky-diver, [2]

(iii) state how your graph in Fig. 9.2 may be used to obtain the distance that the sky-diver falls. [1]

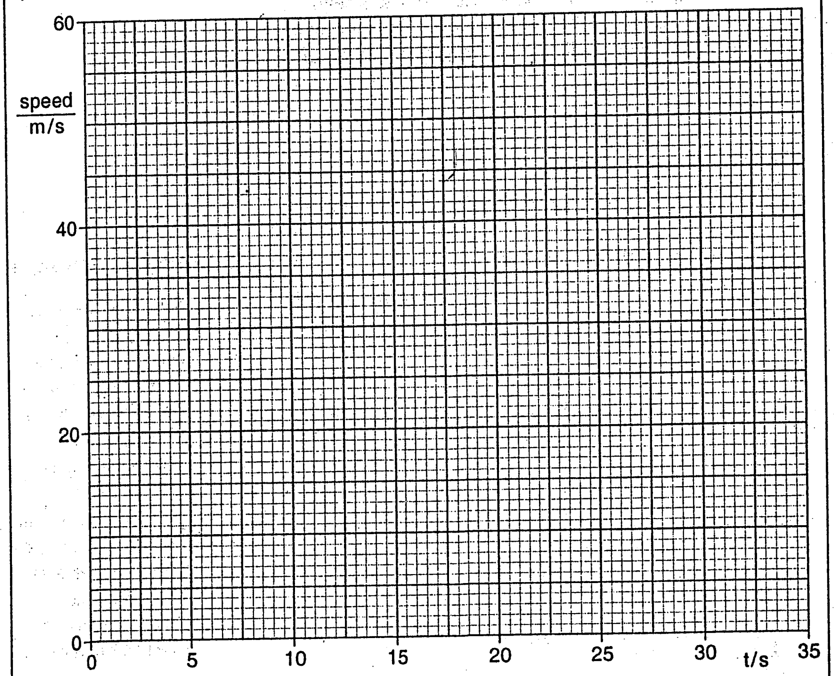
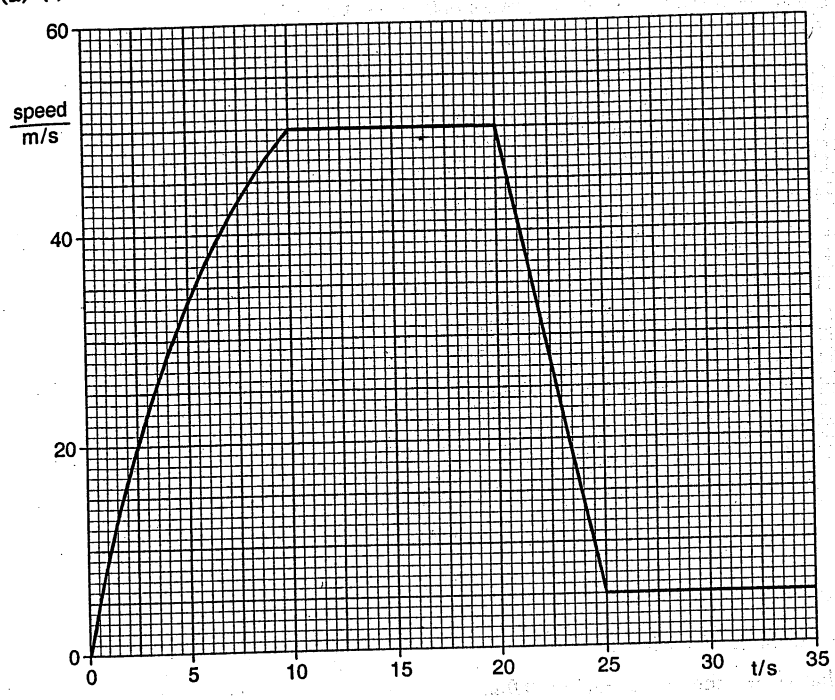


Fig. 9.2

[J11/P2/Q9]

Solution

(a) (i)



(ii) The gradient of the graph between $t = 0$ and $t = 10$ seconds is not constant.

(b) As the parachute opens, the upward air resistance increases and becomes greater than the downward force of gravity acting on the sky-diver. As a result, he decelerates and his speed decreases. The decrease in the speed reduces the air resistance. Consequently, the upward air resistance becomes equal to the downward force of gravity. The resultant force then becomes zero and the sky-diver falls with a steady speed.

(c) distance = area under the v-t graph

$= 50 \times 10 = 500$ m

(d) (i) Average deceleration = gradient of the graph

$$= \frac{50-5}{25-20} = 9.0 \text{ ms}^{-2}$$

(ii) Resultant force, $F = ma$

$= 60 \times 9 = 540$ N

(iii) The area under the v-t graph is equal to the distance fallen by the sky-diver.

COMMENT on ANSWER

"(c) *Alternatively:*

$d = v \times t$

$= 50 \times 10 = 500$ m

(d) (i) *Alternatively:*

$$a = \frac{v-u}{t}$$

$$= \frac{5-50}{25-20}$$

$$= -\frac{45}{5} = -9\text{ms}^{-2}$$"

Question 9

Fig. 9.1 is the speed-time graph for a racing car of total mass 650 kg as it sets off from rest at the start of a race.

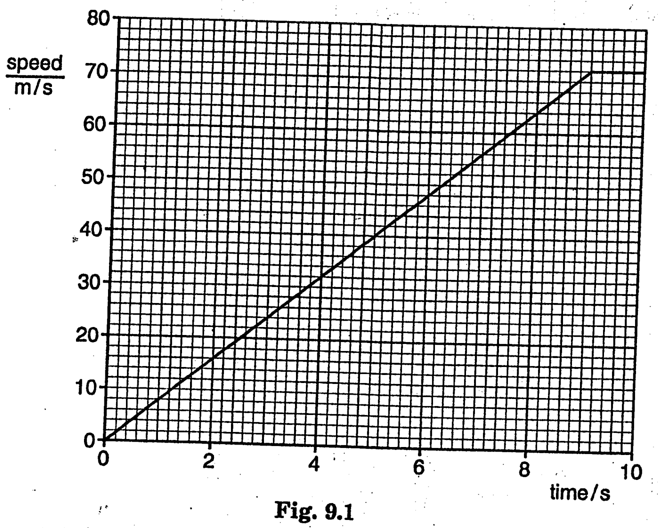


Fig. 9.1

The car travels in a straight line until time $t = 9.0$ s.

(a) State the speed of the car at time $t = 9.0$ s. [1]

(b) Calculate, for the car between times $t = 0$ and $t = 9.0$ s,

(i) the distance travelled, [2]

(ii) the acceleration of the car, [2]

(iii) the resultant force acting on the car. [2]

(c) The acceleration of the car is constant between $t = 0$ and $t = 9.0$ s. Suggest and explain why the driving force on the car must increase to keep the acceleration constant. [3]

(d) After $t = 9.0$ s, the car starts to turn a corner and follows a circular path at constant speed.

(i) Explain why the car is accelerating even though its speed is constant. [2]

(ii) State the direction of this acceleration. [1]

(iii) State and explain what causes the car to accelerate as it turns the corner. [2]

[N11/P2/Q9]

Solution

(a) speed = 72 m/s

(b) (i) Distance travelled = Area under the graph

$$= \frac{1}{2} \times \text{base} \times \text{height}$$

$$= \frac{1}{2} \times 9 \times 72$$

$$= 324 \text{ m}$$

(ii) Acceleration = slope of the speed-time graph

$$= \frac{72-0}{9-0} = 8.0 \text{ m/s}^2$$

(iii) Force, $F = ma$

$$F = 650 \times 8.0$$
$$= 5.2 \times 10^3 \text{ N}$$

(c) As the speed of the car increases, the air resistance also increases which decreases the resultant force. To maintain a constant acceleration, the driving force must be increased so that the resultant force remains contant.

(d) (i) The car has acceleration as its velocity changes due to change in its direction.

(ii) Towards the centre of circular path.

(iii) Friction between tyres and road provides the resultant force acting towards the centre of the circular path.

COMMENT on ANSWER

" (b) (ii) *Alternatively*:

acceleration

$$= \frac{\text{change in velocity}}{\text{time}} = \frac{v-u}{t} = \frac{72-0}{9} = 8.0 \text{ m/s}^2$$

(d) (i) Velocity is a vector quantity, it can be changed either by changing its magnitude (speed) or by changing its direction. "

Question 10

A ball rolls down a slope, as shown in Fig. 1.1.

The metre rule shows the position of the ball at times $t = 0$, 1.0 s, 2.0 s and 3.0 s.

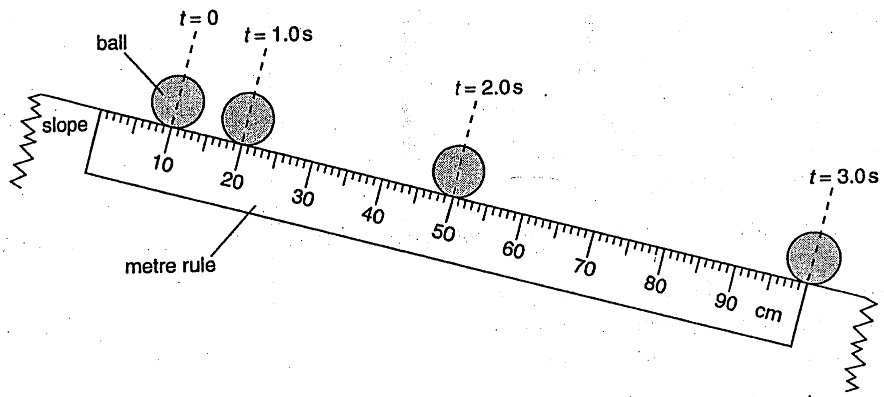


Fig. 1.1

(a) Explain how Fig. 1.1 shows that the ball is accelerating. [1]

(b) Calculate the average speed of the ball between t = 1.0 s and 3.0 s. [2]

(c) Two of the forces that act on the ball are air resistance and weight.
State what, if anything, happens to these forces as the ball accelerates. [2]

(d) Explain why, if the slope is long enough, the ball eventually reaches a constant speed. [1]

[J13/P2/Q1]

Theory 2 ☞ page 13

Solution

(a) A greater distance is covered by the ball in each second. Which means that the velocity of the ball is increasing every second.

(b) Average speed $= \dfrac{\text{total distance}}{\text{total time}}$

$= \dfrac{80}{2.0}$

$= 40$ cm/s or 0.40 m/s

(c) **air resistance:** It increases due to the increase in the speed of the ball.
weight: It remains constant.

(d) The backward and forward forces become equal. The resultant force becomes zero, so the speed becomes constant.

COMMENT on ANSWER

"(a) *Alternative Answer:* The ball travels further in each second.

(d) As the ball accelerates, its speed increases. As a result the air resistance acting on the ball also increases and becomes equal to the forward force.
The resultant force then becomes zero and the ball then reaches a constant speed."

Question 11

A children's ride consists of a steel cable that runs between two posts of different heights, as shown in Fig. 9.1.

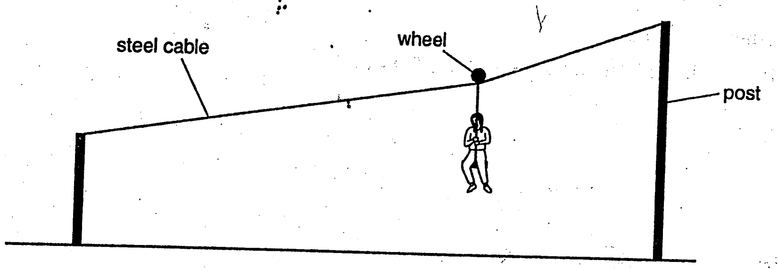
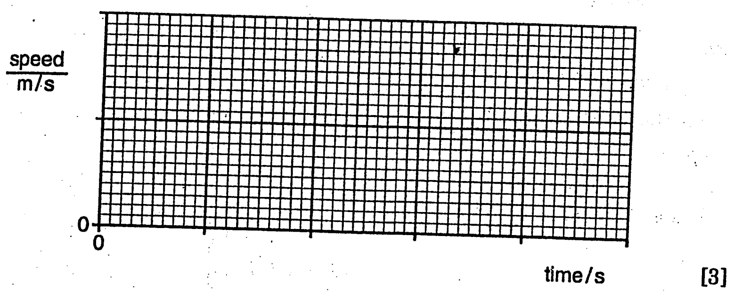


Fig. 9.1

A girl starts and finishes the ride at rest. Her horizontal motion can be taken as

- an initial uniform acceleration for 3.0 s, followed by
- a constant speed of 2.4 m/s for a further 5.0 s and
- a final uniform deceleration that lasts for 1.0 s.

(a) On Fig. 9.2, draw a speed-time graph of the horizontal motion.



[3]

(b) Explain what is meant by *uniform acceleration*. [2]

(c) The final deceleration is larger in size than the initial acceleration. Explain how the data shows this. [1]

(d) Calculate the horizontal distance travelled by the girl in the first 8.0 s. [3]

(e) (i) The girl has a mass of 30 kg and falls a vertical distance of 1.6 m during the ride.
The gravitational field strength g is 10 N/kg.
Calculate the decrease in gravitational potential energy of the girl. [2]

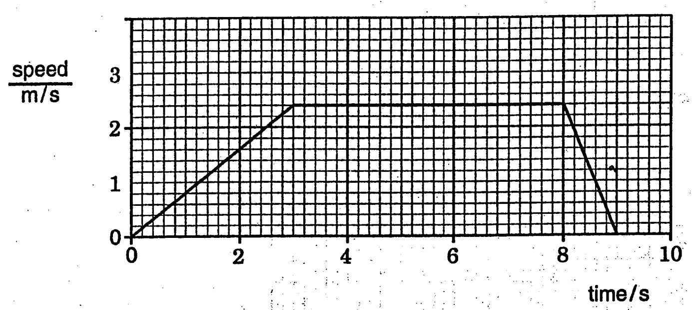
(ii) The gain in kinetic energy of the girl is less than the decrease in her potential energy.
Suggest one reason for this. [1]

(f) A group of pupils make measurements to show that the girl's speed is constant during the middle section of the ride.
Suggest what measurements are made and how they show that the speed is constant. [3]

[J14/P2/Q9]

Solution

(a)



(b) Uniform acceleration refers to a constant increase in velocity per unit time.

(c) Accelerating upto 2.4 m/s took three seconds whereas decelerating from 2.4 m/s to 0 m/s took just one second.

(d) Distance travelled = aea of trapezium

$$= \frac{1}{2} \times 2.4 \times (5+8) = 15.6 \text{ m.}$$

(e) (i) Decrease in potential energy $= mgh$

$$= 30 \times 10 \times 1.6 = 480 \text{ J}$$

(ii) Some energy may have been lost as thermal energy due to work done against air resistance.

(f) The middle section of the ride is marked, on the ground, at equal distances of 1 meter each. Using a stopwatch, time is recorded as the girl passes each of these marks. A distance-time graph is then plotted. A constant slope of the distance-time graph would indicate that the speed of the girl is constant during the middle section of the ride.

Question 12

A bungee jumper falls from a bridge above a river, as shown in Fig. 11.1.

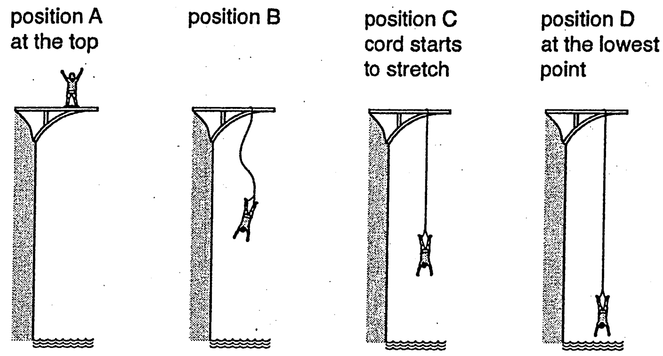


Fig. 11.1 (not to scale)

The man starts from position A in Fig. 11.1. The elastic cord starts to stretch at position C and he stops for the first time at position D. He continues to rise and fall.

Fig. 11.2 shows how the velocity of the man varies with time *t*.

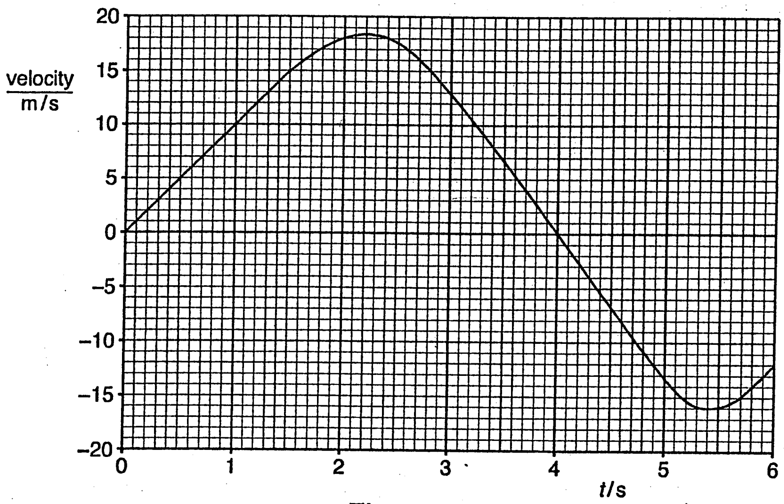


Fig. 11.2

(a) **(i)** State what is meant by *velocity*. [2]

(ii) State the difference between a positive velocity and a negative velocity. [1]

(iii) In the first 1.4 s the acceleration is uniform.

1. Using values from Fig. 11.2, determine the acceleration of the man in the first 1.4 s. [3]
2. Comment on your value of acceleration. [1]

(iv) 1. State the value of *t* when the man is at position D. [1]

2. Explain, in terms of the forces acting, why the man is accelerating upwards at D. [3]

(b) Fig. 11.3 shows the values for the gravitational potential energy of the man, the kinetic energy of the man and the elastic potential energy in the cord at A, C and D.
You may ignore the effect of air resistance in this question.

	gravitational potential energy / J	kinetic energy / J	elastic potential energy / J
position A	20 000	0	0
position C	15 000		0
position D	0	0	

Fig. 11.3

(i) Complete Fig. 11.3 to show the kinetic energy of the man at C and the elastic potential energy in the cord at D. [2]

(ii) The man has a mass of 50 kg.
The gravitational field strength g is 10 N / kg.
Using values from Fig. 11.3, calculate the vertical distance between A and C. [2]

[J15 / P2 / Q11]

Solution

(a) (i) The rate of change of displacement is called velocity.

(ii) The only difference between a positive velocity and a negative velocity is of their opposite direction.

(iii) 1. Acceleration, $a = \dfrac{v-u}{t}$

$$= \frac{14-0}{1.4-0} = 10 \text{ m/s}^2$$

2. This value is the same as the acceleration due to gravity.

(iv) 1. $t = 4.0$ s.

2. At position D, a downward force of gravity (weight) and an upward elastic force in the cord (tension) act on the man. But as this upward tension in the cord is greater than the downward force of gravity on the man, the resultant force is in the upward direction, so he accelerates upwards.

(b) (i)

	gravitational potential energy / J	kinetic energy / J	elastic potential energy / J
position A	20 000	0	0
position C	15 000	**5 000**	0
position D	0	0	**20 000**

(ii) P.E. $= mgh$

$5000 = 50 \times 10 \times h$

$h = 10$ m

COMMENT on ANSWER

“ (a) (i) The velocity is also defined as:
— distance travelled per second in a given direction,
— displacement / time
— change in displacement per unit time,

(iii) *Alternatively:*
Acceleration in first 1.4 second = gradient of graph in first 1.4 seconds.

$$a = \frac{14-0}{1.4-0} = 10 \text{ m/s}^2$$ ”

Topic 3 Force, Vector And Scalar Quantities

MCQ Section

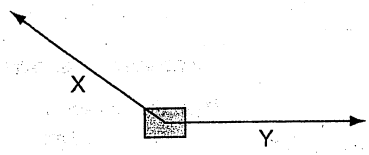
1. A force of 20 N pushes an object of mass 5.0 kg along a rough horizontal surface where the frictional force is 5.0 N.

What is the acceleration of the object?

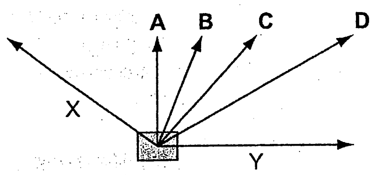
A 1.0 m/s² **B** 2.0 m/s²
C 3.0 m/s² **D** 4.0 m/s²

[J06/P1/Q2]

2. Forces X and Y act on a block in the directions shown on the scale diagram.



In which direction is the resultant force acting?



[J06/P1/Q4]

3. A metal wire, initially 1.000 m long, extends by 4 mm when a load of 2 N is added to it.

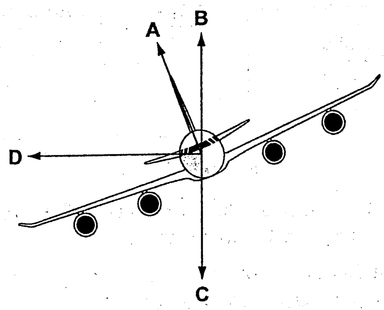
What will the length of the wire be if a further 3 N is added, assuming it does not extend beyond its limit of proportionality?

A 1.060 m **B** 1.080 m
C 1.010 m **D** 1.012 m

[J06/P1/Q10]

4. The diagram shows an aeroplane turning in a horizontal circle at constant speed.

In which direction is there a resultant force?



[J10/P1/Q8] & [J06/P1/Q5]

5. A student studies some equations.

power = work/time
force = mass × acceleration
velocity = displacement/time

How many different vector quantities are contained in the equations?

A 1 **C** 3
B 2 **D** 4

[N06/P1/Q2]

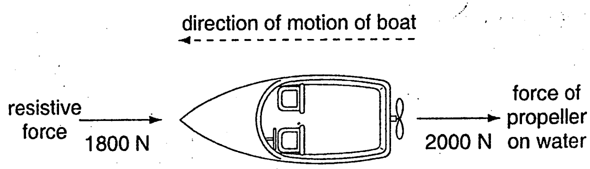
6. When a block of wood of mass 2 kg is pushed along the horizontal flat surface of a bench, the friction force is 4 N.

When the block is pushed along the bench with a force of 10 N, it moves with a constant

A speed of 3 m/s.
B speed of 5 m/s.
C acceleration of 3 m/s².
D acceleration of 5 m/s².

[N06/P1/Q4]

7. The propeller on a boat pushes water backwards with a force of 2000 N. The boat moves through the water against a total resistive force of 1800 N.



MCQ Answers

1. **C** According to the Newton's law $a = \frac{F}{m} = \frac{20 - 5}{5} = 3\ m/s^2$
Note that both forward pushing force and frictional force are vectors and are acting in opposite directions.

2. **B** Using the vectors X and Y as two sides, a parallelogram is completed. Its diagonal along B gives the magnitude and direction of the resultant force.

3. **C** Original length of wire = 1.000 m
Extension with a force of 2 N = 4 mm
Extension with a force of 3 N = 6 mm
Total extension = 4 + 6 = 10 mm or $\frac{10}{1000}$ = 0.010 m
Hence, the total length of the wire = 1.000 + 0.010 = 1.010 m

4. **D** The direction of the resultant force that acts on the aeroplane to make it move round the horizontal circle is towards the centre of the circle.

5. **D** A vector quantity has both magnitude and direction. The four vector quantities found in the equations are: force, acceleration, velocity and displacement.

According to Newton's third law, what is the forward force on the propeller due to the water?

A 3800 N **B** 2000 N
C 1800 N **D** 200 N

[J07/P1/Q5]

8. Which of the following correctly lists one scalar and one vector quantity?

	scalar quantity	vector quantity
A	displacement	work
B	energy	force
C	force	acceleration
D	velocity	mass

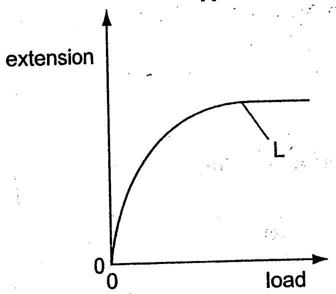
[J07/P1/Q2]

9. A steel spring is stretched by a load. The load is increased.

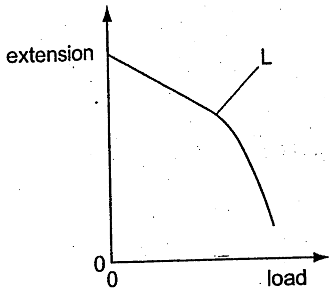
At first the extension is proportional to the load. The spring reaches its limit of proportionality at L.

Which is the correct graph of the extension against load for the spring?

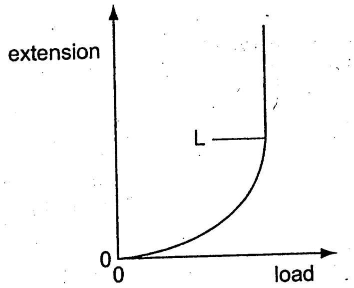
A



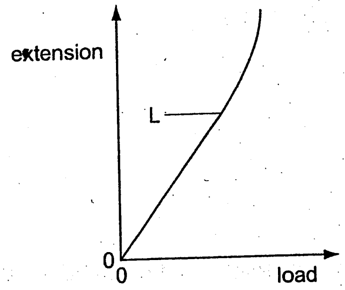
B



C



D



[J07/P1/Q8]

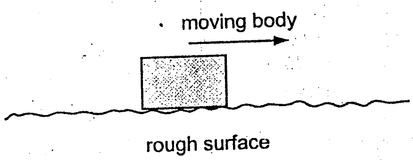
10. Forces of 30 N and 50 N act on the same body, but in different directions.

Which value could **not** be the resultant force on the body?

A 10 N **B** 30 N
C 50 N **D** 70 N

[N07/P1/Q2]

11. When a body moves across a rough surface, a frictional force is produced.



Which statement about this force is **always** true?

A It acts in the direction of the motion.

B It is equal in value to the force producing the motion.

C It makes the body recoil in the opposite direction after stopping it.

D It opposes the motion across the surface.

[N07/P1/Q4]

MCQ Answers

6. C When the blocking is moving, the frictional force of 4 N is at its maximum value. When a new pushing force of 10 N is applied, the new resultant force is (10 – 4) = 6 N. Using Newton's 2nd Law,

acceleration = $\frac{F}{m} = \frac{6}{2}$
= 3 m/s².

7. B The action of the propeller on water is equal to the reaction of the water on the propeller.

8. B 'Energy' is a scalar quantity as it has only the magnitude but no direction. Force is a vector quantity as it has a magnitude as well as a direction.

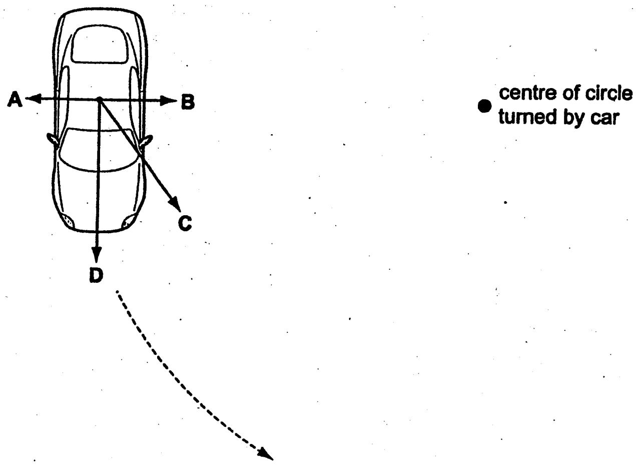
9. D At first, the load-extension graph is a straight line passing through the origin till the limit of proportionality (L) is reached and beyond this limit, the graph bends in the direction of the extension.

10. A The resultant force can have any value between the maximum and minimum possible values. The maximum resultant force = 30 + 50 = 80 N and the minimum resultant force = 50 – 30 = 20 N. So, the option **A** is not the possible value of the resultant force since it is less than the minimum possible value.

11. D It is a fact that a frictional force always opposes the motion of a body.

12. A car moves in a circle at a constant speed.

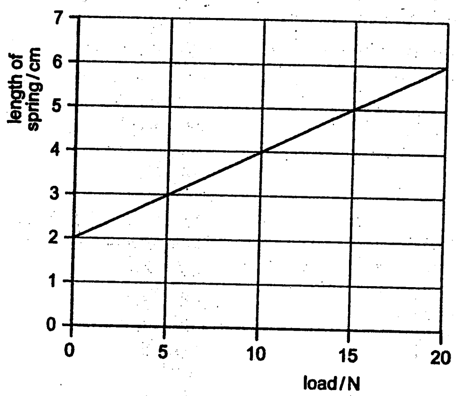
What is the direction of the resultant force acting on the car?



[N07/P1/Q5]

13. A spring balance is calibrated to give readings in newtons.

The graph shows how the length of the spring varies with the load.



A load causes the spring of the balance to extend by 3 cm.

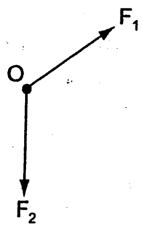
What is the balance reading?

A 3 N **B** 5 N

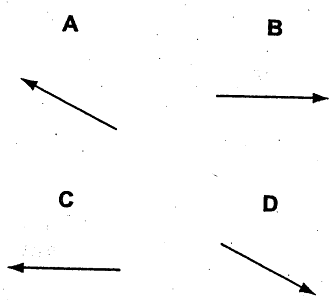
C 10 N **D** 15 N

[N07/P1/Q8]

14. Two forces F_1 and F_2 act on an object O in the directions shown.



What is the direction of the resultant force?



[J08/P1/Q2]

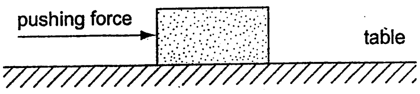
MCQ Answers

12. B The car is moving in a circle so the direction of the resultant force acting on the car is towards the centre of the circular path.

13. D The original length of the spring is 2cm. After producing the extension of 3cm the total length of the spring = 2+3 = 5cm. So, the load required to obtain a total length of 5 cm can be found from the graph.

14. D Applying the parallelogram law, the resultant force can be seen to be along the diagonal shown in option D.

15. A wooden block is pushed across a table at constant speed.



Which statement is correct?

A The frictional force increases as the block moves at constant speed.

B The frictional force is equal and opposite to the pushing force.

C The frictional force is greater than the pushing force.

D The frictional force is less than the pushing force.

[J08/P1/Q3]

16. What keeps an electron moving in a circle around the nucleus of an atom?

A a gravitational force away from the nucleus

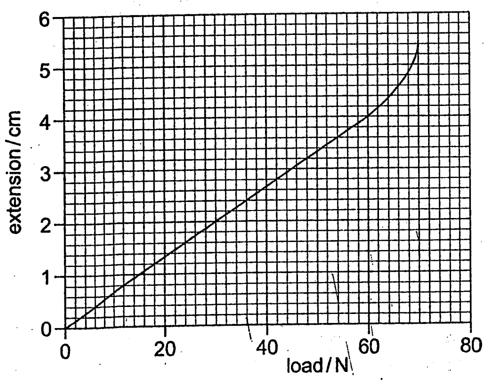
B a gravitational force towards the nucleus

C an electrostatic force away from the nucleus

D an electrostatic force towards the nucleus

[J08/P1/Q5]

17. An extension-load graph for a wire is shown.



What is the load at the limit of proportionality for the wire?

A 4 N **B** 15 N

C 60 N **D** 70 N

[J08/P1/Q7]

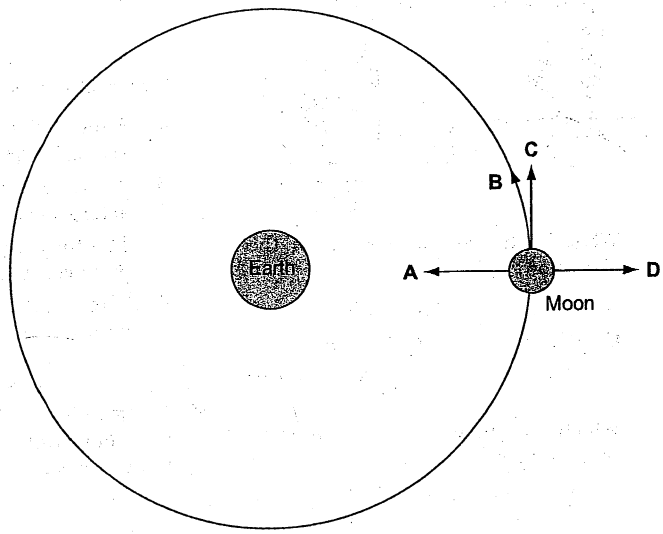
18. How is the motion of a body affected by balanced and unbalanced forces acting on it?

	balanced forces	unbalanced forces
A	velocity changes	velocity changes
B	velocity changes	velocity constant
C	velocity constant	velocity changes
D	velocity constant	velocity constant

[N08/P1/Q3]

19. The diagram represents the Moon in its orbit around the Earth.

Which arrow represents the direction of the resultant force acting on the Moon at the instant shown?



[N08/P1/Q4]

MCQ Answers

15. B At constant speed, the resultant force acting on a body is always equal to zero.

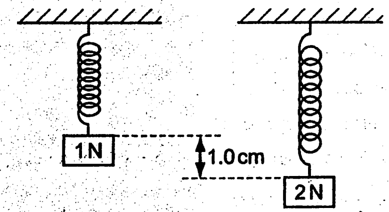
16. D The electrostatic force of attraction between a positively charged nucleus and a negatively charged electron provides the centripetal force towards the nucleus for the motion of the electron around the nucleus in an atom.

17. C The limit of proportionality is the point which separates the linear and the non-linear sections of the extension-load graph. The diagram shows that this point is reached with the 60 N load.

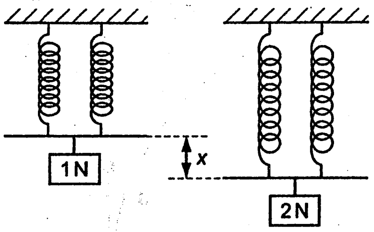
18. C Fact.

19. A The direction of the resultant force (centripetal force) acting on a body moving in a circle is towards the centre of the circle.

20. A single spring is loaded with a 1 N weight. The load is then increased to 2 N and the extension increases by 1.0 cm, as shown.



Two springs that are identical to the first one are put side by side. They are connected at both ends, and a 1 N weight is hung on them. The load is then increased to 2 N.



What is the new increase x in the extension?

A 0.5 cm **B** 1.0 cm
C 2.0 cm **D** 3.0 cm

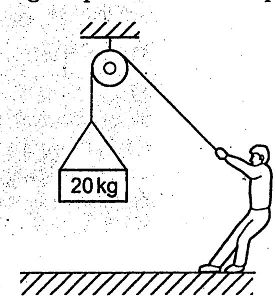
[N08/P1/Q9]

21. Which statement about scalars and vectors is correct?

A A scalar has direction but no size.
B A scalar has size but no direction.
C A vector has direction but no size.
D A vector has size but no direction.

[J09/P1/Q2]

22. A person just supports a mass of 20 kg suspended from a rope.

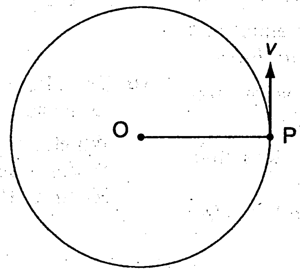


What is the resultant force acting on the mass?

A 0 N **B** 10 N
C 20 N **D** 200 N

[J09/P1/Q5]

23. A particle P is moving in a horizontal circle about O. P moves at constant speed v.

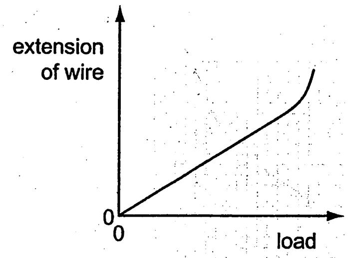


Which statement is true?

A A force of constant magnitude is acting in the same direction as v.
B A force of constant magnitude is acting towards O.
C The force on P varies in size as it moves around the circle.
D There is no resultant force acting on P.

[J09/P1/Q6]

24. The graph shows the extension of a piece of copper wire as the load on it is increased.



What does the graph show?

A At a certain load the wire becomes easier to extend.
B At a certain load the wire becomes harder to extend.
C The load and extension are directly proportional for any load.
D The load and extension are inversely proportional for any load.

[J09/P1/Q9]

MCQ Answers

20. A Comparing the extensions produced in the same spring with a load of 1 N and then with 2N, in diagram 1, it can be seen that a force of 1 N produces an extension of 1cm in the spring. Using this as a scale i.e. 1 N = 1cm and applying on the parallel combinations of two springs, it can be found that overall extension produced in the left system of parallel springs is 0.5cm and 1.0cm in the system on the right. So, x = extension in the parallel system on the right − extension in the parallel system on the left = 1.0 − 0.5 = 0.5 cm.

21. B A scalar quantity has a magnitude (size) only but no direction.

22. A By Newton's 2nd law, Resultant force (F) = ma. Since the mass is at rest, so its acceleration is zero.
Resultant force = 20 × 0 = 0 N

23. B For an object going round a circular path, a force of constant magnitude acts on it towards the centre of the circular path.

24. A After the elastic limit of a wire is exceeded, it becomes easier to extend the wire further.

25. Which list contains only scalar quantities?

A acceleration, displacement, mass
B acceleration, distance, speed
C displacement, mass, velocity
D distance, mass, speed

[N09/P1/Q2]

26. A tractor pulls a trailer at a constant speed.

The tractor exerts a forward force of 1600 N on the trailer.

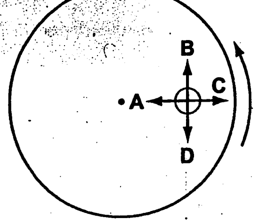
What is the force exerted by the trailer on the tractor?

A 0 N
B 1600 N backwards
C 1600 N forwards
D 3200 N forwards

[N09/P1/Q5]

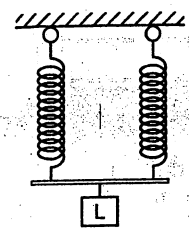
27. A turntable rotates at constant speed. A coin is placed on the turntable at P. The friction force between the coin and the turntable keeps the coin in the same position on the turntable.

In which direction does the friction force act?

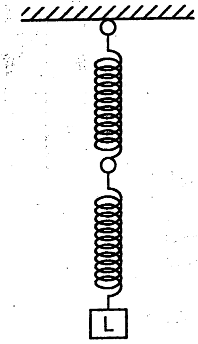


[N09/P1/Q6]

28. A load L is suspended from two springs that are in parallel. The extension of each spring is x.



The springs are then arranged to hang vertically, one below the other.



In this new arrangement, what is the total extension of the two springs?

A $\frac{1}{2}x$ **B** x
C $2x$ **D** $4x$

[N09/P1/Q9]

29. The following statements are about motion.

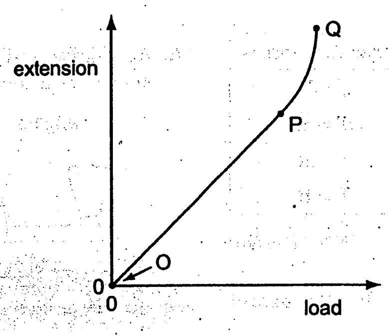
1 A plane flies due East for 600 km.
2 A runner's average speed in a race around a track is 5 m/s.
3 A snail crawls at 3 mm/s in a straight line towards a lettuce.
4 A tourist travels 500 km on a journey.

Which statements describe vector quantities?

A 1 and 2 **B** 1 and 3
C 2 and 3 **D** 2 and 4

[J10/P1/Q1]

30. Which part of the graph shows the limit of proportionality for an elastic solid?



A O **B** OP
C P **D** PQ

[J10/P1/Q10]

MCQ Answers

[redacted]

31. Which list contains only scalar quantities?

A acceleration, displacement, velocity
B distance, force, speed
C force, length, time
D length, mass, speed

[N10/P1/Q1]

32. A car travels along a road. The driver stops the car by pushing his foot down on the brake pedal.

What does **not** change if he pushes harder on the brake pedal?

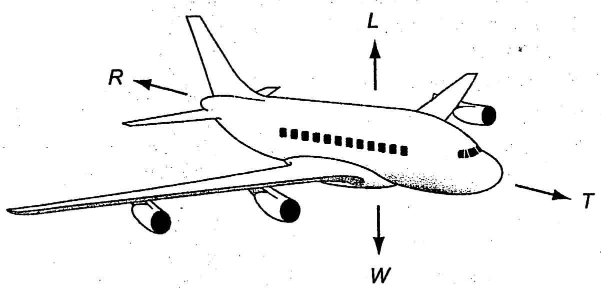
A the braking distance
B the braking force
C the stopping distance
D the thinking distance

[N10/P1/Q3]

33. An aircraft, flying at a constant height, is gaining speed.

The four forces acting are

L lift due to the wings
R air resistance
T the thrust due to the engines
W the weight



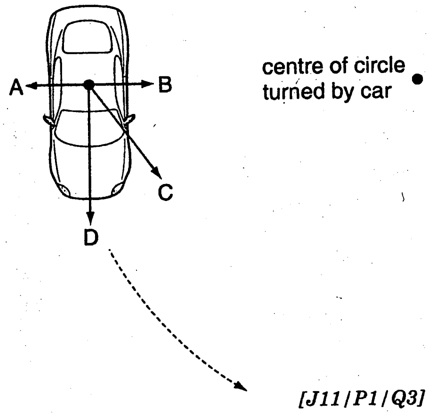
Which row is correct?

	vertical forces	horizontal forces
A	L = W	T = R
B	L > W	T > R
C	L = W	T > R
D	L > W	T = R

[N10/P1/Q6]

34. A car moves in a circle at constant speed.

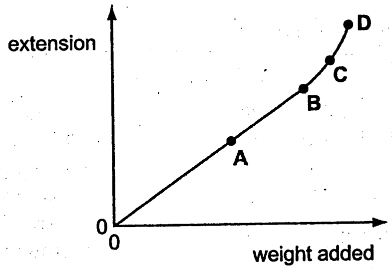
What is the direction of the resultant force acting on the car?



[J11/P1/Q3]

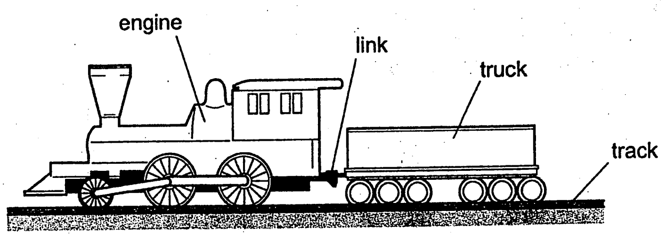
35. The extension of a spring is measured as weights are added. The graph shows the results.

Which point is the spring's limit of proportionality?



[N11/P1/Q11]

36. An engine pulls a truck at constant speed on a level track.



The link between the truck and the engine breaks. The driving force on the engine remains constant.

MCQ Answers

31. D All the three quantities, length, mass and speed have magnitude but no direction.

32. D If the brake is pushed harder, the braking distance, the braking force and the stopping distance will all be affected except the thinking distance.

33. C As the aircraft is flying at a constant height, so its upward force (*L*) is equal to the downward force (*W*) and since it is also gaining speed, hence its forward force (*T*) is greater than the backward force (*R*).

34. B The car is moving in a circle so the direction of the resultant force acting on the car is towards the centre of its circular paths.

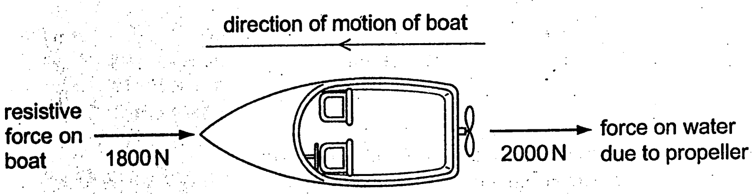
35. B The limit of proportionality is a point on the load-extension graph uptill which the graph is a straight line passing through the origin.

What effect does this have on the truck and on the engine?

	truck	engine
A	slows down	speed stays constant
B	slows down	speeds up
C	stops immediately	speed stays constant
D	stops immediately	speeds up

[N11/P1/Q4]

37. The propeller on a boat pushes water backwards with a force of 2000 N. The boat moves through the water against a total resistive force of 1800 N.



According to Newton's third law, what is the forward force on the propeller due to the water?

A 200 N **B** 1800 N
C 2000 N **D** 3800 N

[N11/P1/Q2]

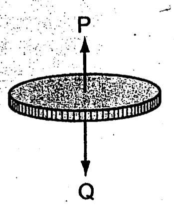
38. Which row correctly shows examples of a vector quantity and a scalar quantity?

	vector	scalar
A	area	force
B	mass	density
C	velocity	acceleration
D	weight	volume

[J12/P1/Q2]

39. A coin falls through the air from rest, and eventually reaches a constant speed.

Two forces P and Q act on the coin.



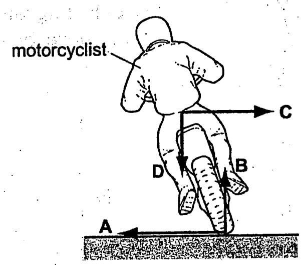
What happens to the force P and to the resultant force acting on the coin before it reaches constant speed?

	force P	resultant force
A	decreases	increases
B	decreases	decreases
C	increases	decreases
D	increases	increases

[J12/P1/Q5]

40. The diagram shows a motorcyclist leaning over in order to move around a corner.

Which force causes him to move around the corner?



[J12/P1/Q6]

41. A metal wire, of initial length 1000 mm, extends by 4mm when a load of 2N is added to it.

What is the length of the wire when a further 3 N is added, assuming that the wire does not extend beyond the limit of proportionality?

A 1006 mm
B 1008 mm
C 1010 mm
D 1012 mm

[J12/P1/Q9]

MCQ Answers

36. B Since the driving force on the engine is constant, therefore by Newton's second law of motion $a \propto \frac{1}{m}$. As the engine is not pulling the truck, its value of m decreases, and hence, its acceleration increases and the engine speeds up. The truck slows down due to friction.

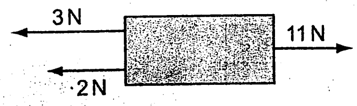
37. C The backward action of the propeller on water is equal to the forward reaction of the water on the propeller.

38. D "Weight" is a vector quantity because it is a force with which a body is pulled towards the Earth and 'volume' is a scalar quantity.

39. C A freely falling coin in air accelerates due to the constant force of gravity (force Q). The upward air resistance (force P) increases with the increase in speed. As a result the difference between these two forces (i.e. resultant force) decreases and becomes zero. The coin then falls with a constant speed.

40. A The motorcyclist is seen moving anticlockwise along a circular path while turning around a corner. The direction of the force (i.e. centripetal force) acting on him during this motion is towards A i.e. towards the centre of the circular path.

42. The diagram shows three forces acting on a block.

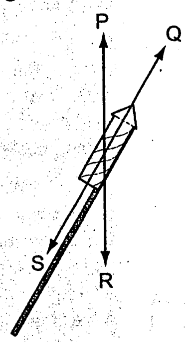


Which additional force will produce a resultant force of 3 N to the left?

A 3 N to the left
B 6 N to the right
C 9 N to the left
D 13 N to the right

[N12/P1/Q2]

43. The diagram shows a firework rocket.



As the rocket flies through the air, three forces act on it. These forces are weight, thrust and air resistance.

What are the three forces?

	thrust	air resistance	weight
A	P	R	S
B	P	S	R
C	Q	R	S
D	Q	S	R

[N12/P1/Q5]

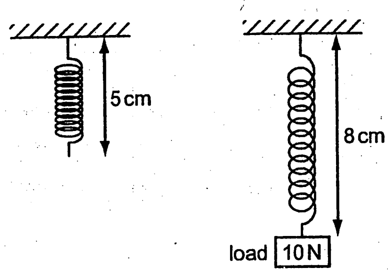
44. An object has a mass of 15 kg. It is pushed horizontally by a force of 40 N. The frictional force is 10 N.

What is the acceleration of the object?

A 0.50 m/s^2
B 1.5 m/s^2
C 2.0 m/s^2
D 2.7 m/s^2

[N12/P1/Q6]

45. The diagram shows how the length of a spring changes when a load of 10 N is hung on it.

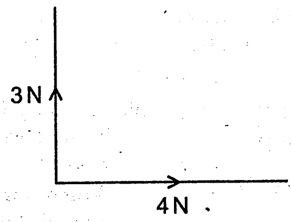


The 10 N load is replaced by a 20 N load. What is the new length of the spring?

A 6 cm **B** 11 cm
C 14 cm **D** 16 cm

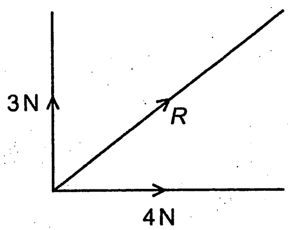
[N12/P1/Q9]

46. Forces of 3 N and 4 N act as shown in the diagram.

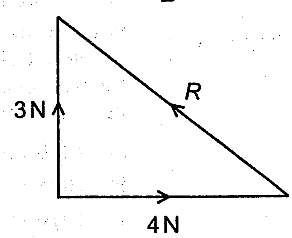


Which diagram shows the resultant *R* of these two forces?

A



B



41. C As the spring's constant for this spring is:
$K = \frac{F}{e} = \frac{2}{4} = 0.5$
So, $F = Ke$
$5 = 0.5 \times e$
$\therefore e = 10$ mm
Final length of wire = original length + extension = 1000 + 10 = 1010 mm

42. C (Original force on left + additional force required on left) − (original force on right) = 3
$(5 + x) - 11 = 3$
$\therefore x = 9$ N to the left.

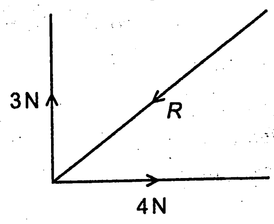
43. D Thrust (Q): forward force along the direction of motion.
Air resistance (S): opposing force in the opposite direction of motion.
Weight (R): a force acting vertically downwards.

44. C $F - f = ma$
$40 - 10 = 15 \times a$
$a = 2\ m/s^2$
where,
F = forward force
f = force of friction.

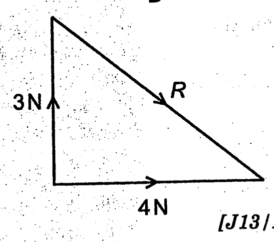
45. B Original length = 5 cm
extension with 10 N = 3 cm
extension with 20 N = 6 cm
$\therefore$ New length of spring = 5 + 6 = 11 cm

46. A Since the two forces are acting perpendicularly to each other, their resultant force is found by applying the parallelogram law, which is along the diagonal *R*.

C



D



[J13/P1/Q1]

47. A car of mass 1500 kg travels along a horizontal road.

It accelerates steadily from 10 m/s to 25 m/s in 5.0 s.

What is the force needed to produce this acceleration?

A 300 N **B** 500 N
C 4500 N **D** 7500 N

[J13/P1/Q5]

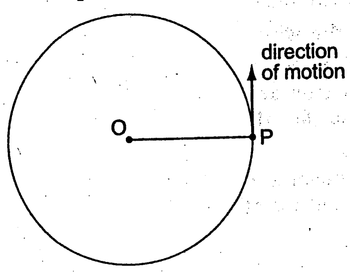
48. Balanced forces are acting on a moving body.

What happens to the direction of movement and to the speed of the body?

	direction of movement	speed
A	changes	changes
B	changes	does not change
C	does not change	changes
D	does not change	does not change

[J13/P1/Q6]

49. A particle P is moving in a horizontal circle about O. P moves at constant speed.



Which statement is true?

A A force of constant size acts on P in the direction of motion.

B A force of constant size acts on P towards O.

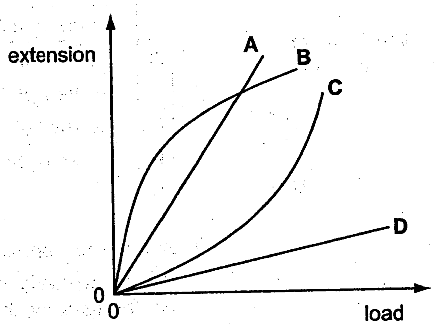
C The force on P varies in size as it moves around the circle.

D There is no resultant force acting on P.

[J13/P1/Q7]

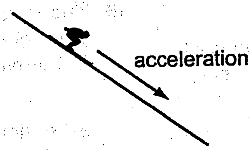
50. The graph shows extension-load curves for four fibres.

Which fibre is the hardest to stretch over the range of loads shown?



[J13/P1/Q10]

51. A skier of mass 80 kg accelerates down a slope at 2 m/s².



The gravitational field strength *g* is 10 N/kg.

What is the weight of the skier and the resultant force on the skier?

	weight / N	resultant force / N
A	8	168
B	80	240
C	800	160
D	800	640

[N13/P1/Q4]

52. The diagram shows an aeroplane turning in a horizontal circle at constant speed.

In which direction is there a resultant force?

MCQ Answers

47. C $F = ma$

$= m \times \left(\frac{v-u}{t}\right)$

$= 1500 \times \left(\frac{25-10}{5}\right)$

$= 4500$ N

48. D By Newton's second law a body experiences a change in its motion if a resultant force acts on it. As in the case of balanced forces, there is no resultant force, so the body does not experience any change in its speed or direction of movement.

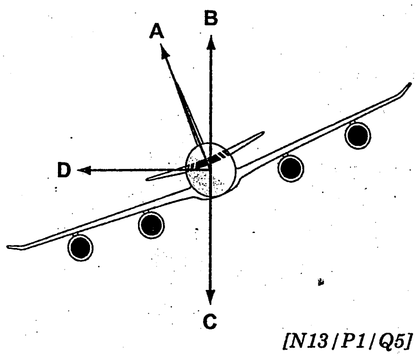
49. B It is a fact that a resultant force of constant size acts on a body moving in a circle towards the centre of the circle. It is known as the centripetal force.

50. D The graph shows that the spring **D** has a larger value for its force constant (i.e. force per unit extension) as compared to the others. So, it is stiffer than the others and hardest to stretch amongst all.

51. C Weight of the skier $= mg = 80 \times 10$
$= 800$N

Resultant force $= ma$
$= 80 \times 2$
$= 160$N

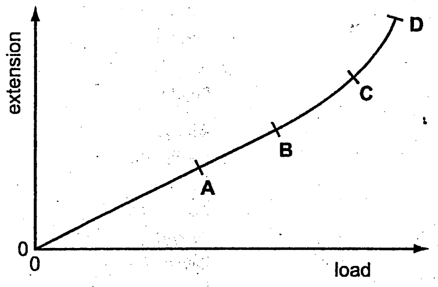
52. D The resultant force acting on the aeroplane is towards the centre of its circular path which is towards **D**.



[N13/P1/Q5]

53. An extension-load graph is plotted to show the result of increasing the load on a spring.

Which point marks the limit of proportionality for this spring?



[N13/P1/Q9]

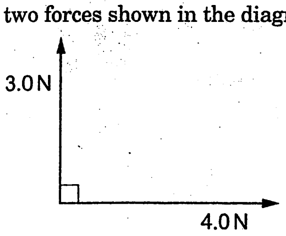
54. Each row contains a vector and a scalar.

In which row is the size of the vector equal to the size of the scalar?

	vector	scalar
A	displacement of a car	speed of the car
B	velocity of a car	distance travelled by the car
C	velocity of a car	speed of the car
D	weight of a car	mass of the car

[J14/P1/Q1]

55. What is the size of the resultant of the two forces shown in the diagram?

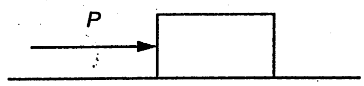


A 1.0 N **B** 3.5 N
C 5.0 N **D** 7.0 N

[J14/P1/Q2]

56. The diagram shows a block of stone on a rough horizontal surface.

Force *P* acts on the block as shown.



The block is at rest. A frictional force *F* acts on the block.

Which row shows the direction and size of *F*?

	direction of *F*	size of *F*
A	to the left	more than *P*
B	to the right	more than *P*
C	to the left	same as *P*
D	to the right	same as *P*

[J14/P1/Q5]

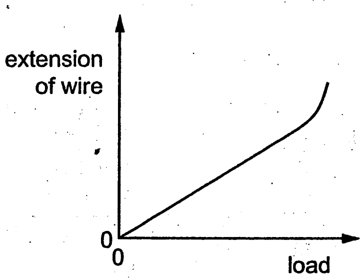
57. A force is applied to a body.

Which property of the body **cannot** be changed by the force?

A its mass **B** its shape
C its size **D** its velocity

[J14/P1/Q11]

58. The graph shows the extension of a piece of copper wire as the load on it is increased.



What does the graph show?

A At a certain load the wire becomes easier to extend.

B At a certain load the wire becomes harder to extend.

C The load and extension are directly proportional for all loads.

D The load and extension are inversely proportional for all loads.

[J14/P1/Q12]

Thinking Process

MCQ Answers

53. B The limit of proportionality is the point which separates the linear and non-linear sections of the extension-load graph.

54. C Velocity is a vector quantity that has both magnitude and direction, the magnitude being equal to the speed of the car in this case.

55. C Resultant force
$= \sqrt{3^2 + 4^2}$
$= \sqrt{25} = 5$ N

56. C If the block is at rest, F should be of the same magnitude as of P, but in the opposite direction.

57. A Fact.

58. A As can be seen from the graph, after the point on which the gradient changes, less load needs to be applied to extend the wire, thus making it easier to extend.

59. When a heavy coin falls a short distance towards the ground it does **not** reach terminal velocity.

Why is this?

A The coin has not hit the ground.
B The weight of the coin equals the air resistance.
C The weight of the coin increases as air resistance increases.
D The weight of the coin is always more than air resistance.

[N14/P1/Q1]

60. In a model of an atom, electrons move in circular orbits around a nucleus.

Which statement about the electrons is correct?

A The electrostatic force on the electrons is away from the nucleus.
B The acceleration of the electrons is towards the central nucleus.
C The speed of the electrons varies continuously.
D The velocity of the electrons remains constant.

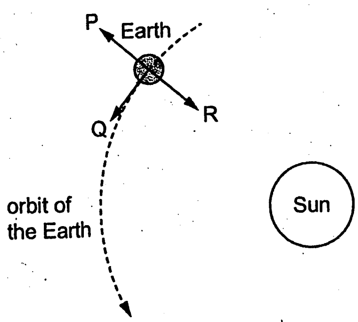
[N14/P1/Q3]

61. Which quantity is a scalar?

A acceleration
B force
C temperature
D velocity

[J15/P1/Q1]

62. The Earth travels in a circular orbit around the Sun at constant speed.



Which arrows show the direction of the acceleration of the Earth and the direction of the velocity of the Earth?

	direction of acceleration	direction of velocity
A	P	Q
B	Q	P
C	Q	R
D	R	Q

[J15/P1/Q7]

63. Which is a scalar quantity?

A mass **B** force
C velocity **D** weight

[N15/P1/Q1]

64. Four of the gravitational forces that act between bodies in the Solar System are described below.

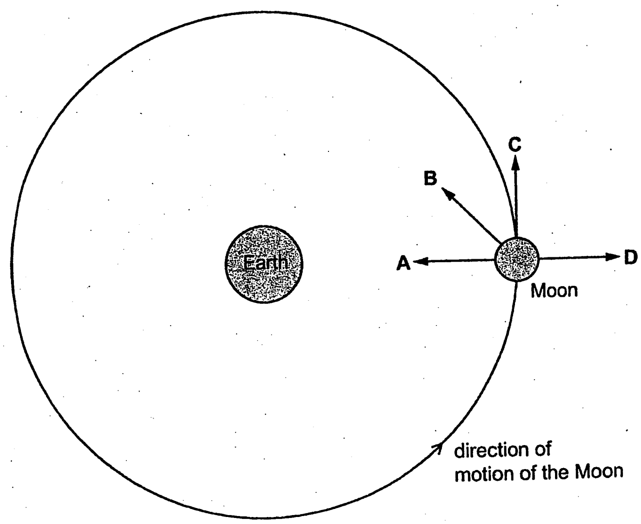
P the force on the Moon due to the Earth
Q the force on the Earth due to the Sun
R the force on the Earth due to the Moon
S the force on the Moon due to the Sun

Which two forces are a Newton's third law pair (action and reaction)?

A P and Q **B** P and R
C Q and S **D** R and S

[N15/P1/Q7]

65. The diagram represents the Moon in its orbit around the Earth.
Which arrow represents the direction of the resultant force acting on the Moon at the instant shown?



[N15/P1/Q8]

MCQ Answers

59. D To achieve terminal velocity, the weight of the falling object must equal the force due to air resistance.

60. B Fact

61. C A scalar quantity has magnitude but no direction whereas a vector quantity has both magnitude and direction. As, temperature has only the magnitude but no direction so it is a scalar quantity.

62. D The direction of the resultant force (i.e. centripetal force) and hence, the direction of the acceleration is towards the centre of the circular orbit of the earth, (i.e. R). Whereas the direction of the velocity of earth is along the direction of motion of the earth i.e. Q which is always at right angle to the resultant force acting on the object moving in a circle.

66. A student produces some revision notes on gravity, mass and weight. Which statement is **not** correct?

A A gravitational field is a region in which a mass experiences a gravitational force.

B Gravitational field strength has the unit of N / kg.

C Mass is a measure of the amount of matter.

D Mass is equal to weight multiplied by gravitational field strength.

[N15 / P1 / Q9]

MCQ Answers

63. A Mass is a scalar quantity as it has magnitude but no direction. Force, velocity and weight are vectors as they have magnitude as well as direction.

64. B Newton's 3rd law applies to the interaction between two bodies, one exerting the action and the other exerting the reaction. In options A, C and D, there are three different bodies exerting forces on each other, on which the Newton's 3rd law is not applicable.

65. A The earth's gravitational force acts as centripetal force on the moon to move it in a circular orbit and its direction is towards the centre of the circular orbit.

66. D It is a fact that

$m \neq W \times g$

but rather $m = \frac{W}{g}$

where g is the gravit-ational field strength.

Topic 3 Force, Vector And Scalar Quantities

THEORY Section

Question 1

Fig. 2.1 shows apparatus that demonstrates how a coin and a piece of paper fall from rest under gravity.

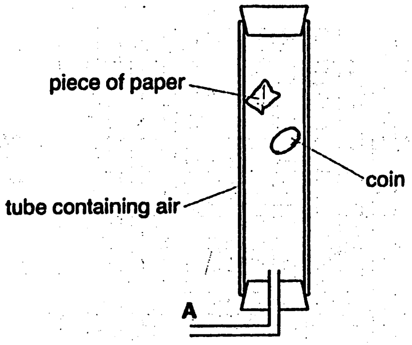


Fig. 2.1

(a) State the initial value of the acceleration of the coin as it falls from rest. [1]

(b) The coin and paper are at the positions shown in Fig. 2.1. Explain, in terms of the forces acting, why

(i) the paper falls with constant speed, [1]

(ii) the coin still accelerates. [1]

(c) A vacuum pump is connected to A and the air in the tube is removed. The coin and paper fall differently in a vacuum from the way they fall in air. State two of these differences. [2]

[N06/P2/Q2]

Solution

(a) 10 m/s^2

(b) (i) The weight of the paper is equal to the air resistance.

(ii) The weight of the coin is greater than the air resistance.

(c) 1. In the vacuum, both paper and coin reach the bottom of tube at the same time.

2. In the vacuum, both paper and coin are at the same vertical height at all times.

COMMENT on ANSWER

" (a) When the coin starts from rest, there is no air resistance and so its acceleration is the same as the acceleration due to free fall.

(b) (i) Due to large surface area of the paper and lower weight of the paper, the paper reaches terminal velocity quickly.

(ii) The air resistance acting on the coin takes a longer time to balance the weight of the coin. Hence the coin reaches terminal velocity at a later time.

(c) In the absence of air resistance, both the paper and coin falls with the same acceleration (= 10 m/s^2) and so their motion are identical. "

Question 2

When a car driver sees an emergency ahead, he applies the brakes. During his reaction time the car travels at a steady speed and covers a distance known as the thinking distance. The braking distance is the distance travelled by the car after the brakes are applied.

(a) State the energy change that occurs as the car brakes. [2]

(b) Fig. 9.1 shows the speed-time graph of a car.
The driver sees the emergency at time $t = 0$.
The total mass of the car is 800 kg.

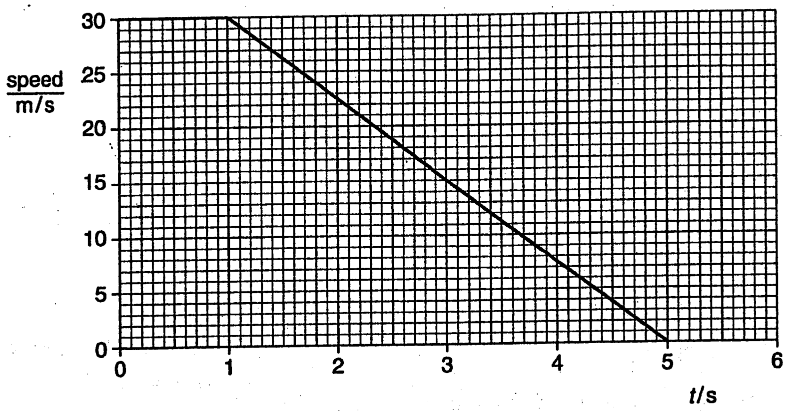


Fig. 9.1

Determine

(i) the thinking distance, [1]

(ii) the braking distance, [2]

(iii) the deceleration of the car during braking, [2]

(iv) the force provided by the brakes. [2]

(c) Using ideas about friction and deceleration, state and explain how the braking distance is affected by

(i) using new tyres rather than badly worn tyres, [2]

(ii) the car skidding on a wet road, [2]

(iii) the car carrying a heavy load of passengers. [2]

[J08/P2/Q9]

Solution

(a) The K.E. of the car changes into heat and sound.

(b) (i) Thinking distance = area under graph
$= (30)(1) = 30$ m

(ii) Braking distance = area under graph

$$= \frac{1}{2} \times b \times h$$

$$= \frac{1}{2} \times 4 \times 30 = 60 \text{ m}$$

(iii) Deceleration = gradient of the graph line

$$= \frac{30}{4} = 7.5 \text{ m/s}^2$$

COMMENT on ANSWER

" (b) (i) *Alternatively,*
Thinking distance
$= u \times t = 30 \times 1$
$= 30$ m

(ii) *Alternatively,*
Braking distance(s)
$= \frac{v^2 - u^2}{2a}$
$= \frac{0-(30)^2}{2(-7.5)} = 60$ m

Note that the value of deceleration is found from the given graph.

(c) (iii) As $a = \frac{F}{m}$

Since the braking force is constant, So,

deceleration $\propto \frac{1}{\text{mass}}$.

Thus, the greater the mass, the lesser would be the deceleration.

Also, breaking distance

$s = \frac{v^2 - u^2}{2a}$

$= \frac{u^2}{2a}$ $(v = 0)$

$\therefore$ $s \propto \frac{1}{a}$

Thus, the lesser the deceleration, the more would be the braking distance. "

(iv) F = ma
$= 800 \times 7.5 = 6000$ N

(c) (i) There is more friction between the new tyres and the road. So, on applying the brakes, the car decelerates faster and stops after covering less braking distance.

(ii) A car decelerates slower due to less friction between the car and the wet road and stops after covering more braking distance.

(iii) A car carrying heavy load of passengers decelerates slower on applying the brakes and covers more braking distance before coming to rest.

Question 3

A microphone has a weight *W* of 6.0 N. It is suspended by wire X from the ceiling in a radio studio.
Fig. 1.1 shows the microphone held in the correct position by a horizontal wire Y.

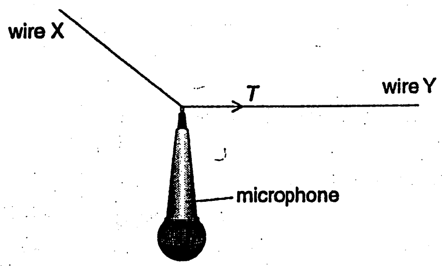


Fig. 1.1

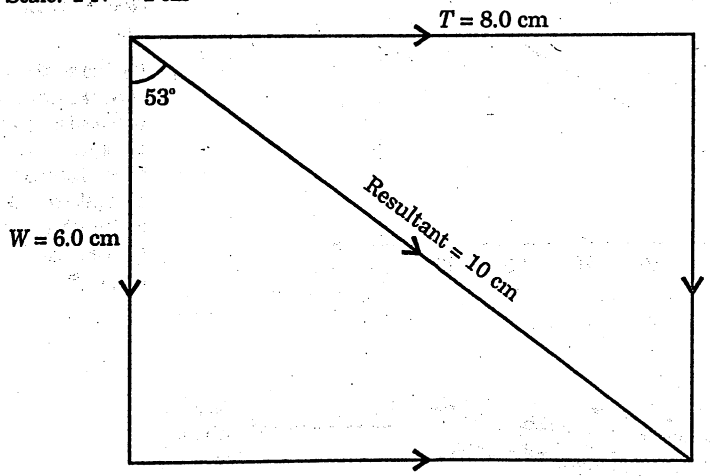
(a) The tension *T* in wire Y is 8.0 N. Use a vector diagram to determine the magnitude and the direction of the resultant of *W* and *T*. [4]

(b) The microphone is at rest. State the tension in wire X. [1]

[N08/P2/Q1]

Solution

(a) Scale: 1 N = 1 cm



Magnitude = 10.0 N, Direction = 53° to the vertical force.

(b) tension in X = 10.0 N.

COMMENT on ANSWER

"(a) The resultant of the two forces acting on the microphone can also be found by the Triangle method, the two forces are represented by the two sides of a triangle and the hypotenuse of the triangle will then represent the value of the resultant of the two forces. As the angle between the two forces is 90°, so the value of the resultant force can be verified by applying the Pythagorus theorem,

Resultant force
$= \sqrt{(8)^2 + (6)^2}$
$= \sqrt{100} = 10$N.

Also, the direction of the resultant can be related to the tension *T* as follows:
143° to the tension in the wire *T*

(b) As the microphone is at rest inspite of the resultant force acting on it, it means that the value of the tension in the wire X is equal to the value of the resultant force and they are opposite in direction to each other. Hence, they cancel the effect of each other and the microphone remains in equilibrium."

Question 4

A passenger aeroplane accelerates from rest along a runway. It accelerates at a uniform rate for 35 s. At this point it reaches a speed of 84 m/s and then takes off.

(a) (i) Calculate the acceleration of the aeroplane along the runway. [2]

(ii) Sketch a speed-time graph for the aeroplane as it travels along the runway. [3]

(b) Two **horizontal** forces act on the aeroplane as it accelerates along the runway.

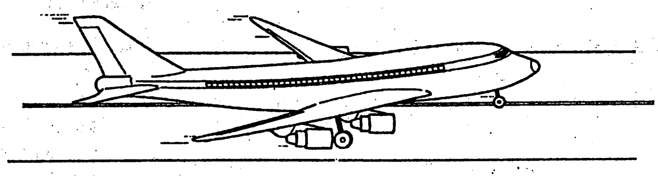


Fig. 4.1

(i) On Fig. 4.1, draw arrows to show the directions and the relative magnitudes of these forces. [1]

(ii) State what causes the smaller of these two forces. [1]

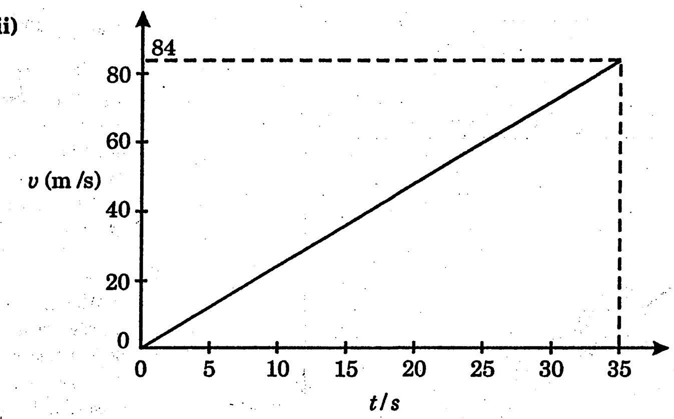
[N08/P2/Q4]

Solution

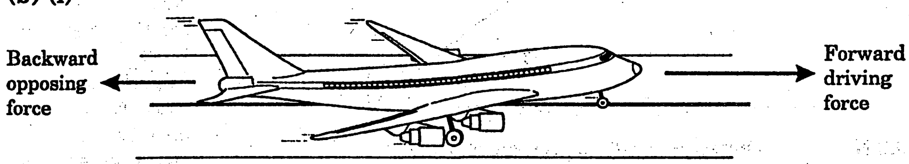
(a) (i) $a = \dfrac{v-u}{t}$

$= \dfrac{84-0}{35} = 2.4 \text{ m/s}^2$

(ii)



(b) (i)



(ii) Friction.

COMMENT on ANSWER

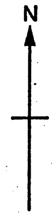
“ (b) (i) As the aeroplane is accelerating, so the magnitude of the 'forward driving force' is greater than the 'backward opposing force' acting on it. A longer arrow should, therefore be used to show the forward force and a shorter arrow is used for the backward force.

(ii) The smaller of these two forces is the backward force which is caused by the friction that includes the air resistance and the friction between the tyres and the ground. ”

Question 5

A journey consists of two displacements: the first is 500 m in a northerly direction and the second is 200 m in an easterly direction.

(a) In the space below draw, to scale, a vector diagram of these displacements. State the scale of your diagram.
On your diagram, show the two displacements and the resultant displacement. Determine the size (magnitude) and direction of the resultant displacement.



scale = ...

size = ...

direction = ...

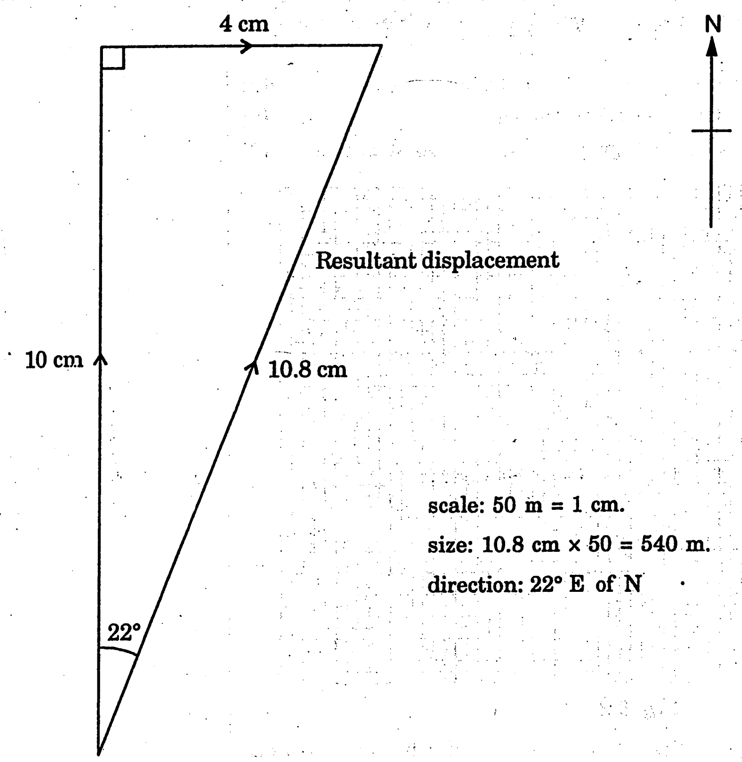
[3]

(b) Another journey covers a distance of 700 m. Describe how it is possible that this journey has no resultant displacement. [1]

[J10/P2/Q1]

Solution

(a)



scale: 50 m = 1 cm.

size: 10.8 cm × 50 = 540 m.

direction: 22° E of N

(b) The resultant displacement of this body is zero if it moves 350m away from its original position and then returns back to its original position.

COMMENT on ANSWER

❝ (b) The total distance covered by the body includes 350 m when moving away from the initial position and then 350 m when it returns back to its original position. Hence total distance = 350 + 350 = 700 m
The resultant displacement is zero because the body comes back to its original position. ❞

Question 6

Fig. 9.1 shows a car braking on a road and coming to rest.

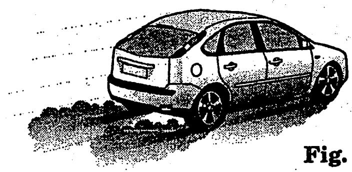


Fig. 9.1

(a) Explain what is meant by

(i) the *thinking distance,* [1]

(ii) the *braking distance.* [1]

(b) An engineer conducts a test on the car and finds that the braking distance is greater when the car is fully loaded than when it is unloaded.

(i) Apart from the road conditions, state what must be kept the same in the test. [1]

(ii) Explain why the car has a greater braking distance when fully loaded. [1]

(c) State and explain how one road condition affects the braking distance of the car. Use ideas about friction in your answer. [2]

(d) Explain how wider tyres affect the pressure of the car on the surface of the road. [1]

(e) The car has a total mass of 900 kg and is travelling at 20 m/s. At time $t = 0$, the driver sees an accident ahead. He applies the brakes at $t = 0.60$s to stop the car. After the brakes are applied, the car comes to rest in a further 4.0 s.

(i) Calculate the deceleration of the car as it brakes. [2]

(ii) Calculate the braking force acting on the car. [2]

(iii) On Fig. 9.2, draw a speed-time graph for the car as it brakes. [3]

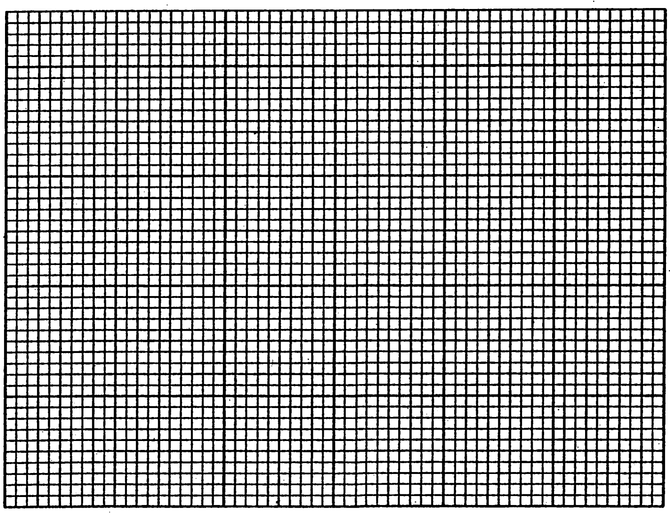


Fig. 9.2

(iv) State how your graph in (iii) can be used to find the total distance travelled by the car. [1]

[J10/P2/Q9]

Solution

(a) (i) It is the distance travelled by the car during the driver's reaction time.

(ii) It is the distance travelled by the car after applying the brakes.

(b) (i) The speed of the cars must be kept the same.

(ii) As $a \propto \frac{1}{m}$, so with a greater mass, the car will decelerate slowly.

(c) On a wet road, there is less friction between the tyres and the road so the car decelerartes slowly and a greater braking distance is covered.

(d) The wider tyres increase the area and decrease the pressure.

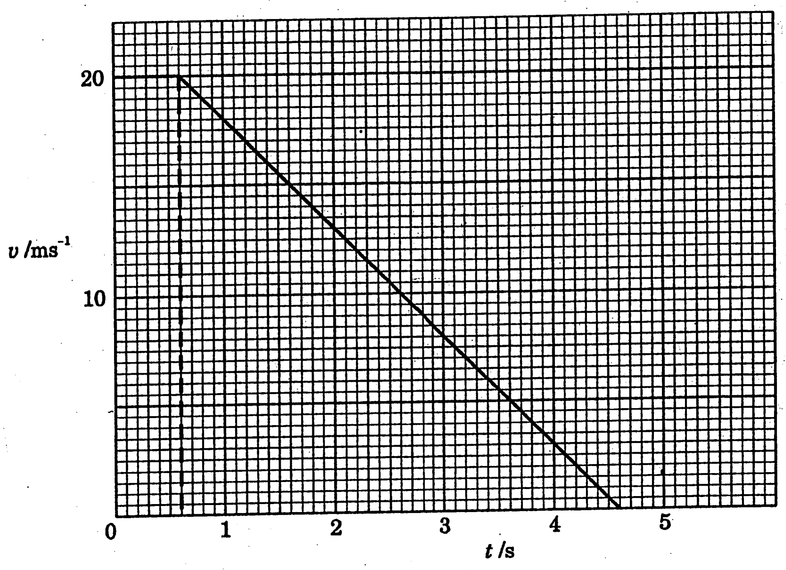
(e) (i) $a = \frac{v-u}{t} = \frac{0-20}{4} = -5 \text{ ms}^{-2}$

$\therefore$ deceleration = 5 ms^{-2}

(ii) $F = ma$

$= 900 \times 5 = 4500$ N

(iii)



(iv) Total distance travelled = Area of the trapezium.

COMMENT on ANSWER

"(b) (i) The other possible answers are:

— Same tyres or same conditions of tyres.

— Same braking force.

(ii) *Alternativelty:*

With the greater mass, the car will have a greater inertia and would need a greater braking force. In the absence of the greater braking force, the car will decelerate slowly and this will increase the braking distance."

Question 7

A bus breaks down on a road with a 10° upward slope. The passengers get out and push the bus to the top of the slope at a constant speed. Fig. 10.1 shows the passengers exerting a force on the bus parallel to the line of the slope.

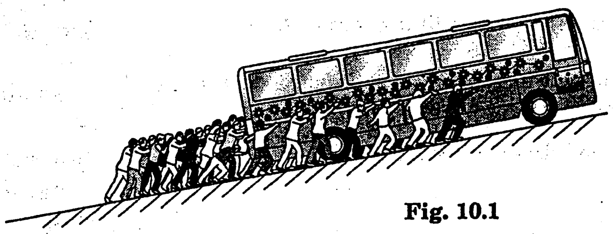


Fig. 10.1

(a) The total mass of the bus is 3200 kg.

(i) Calculate the weight of the bus. [1]

(ii) On Fig. 10.1, draw **two** arrows to show the direction of the weight of the bus and the direction of the force exerted on the bus by the passengers. [1]

(iii) The total force exerted by the passengers on the bus is 17 000 N along the line of the slope. Use a graphical method to determine the size and direction of the resultant of this force and the weight of the bus. State the scale used. [4]

(iv) The bus travels at a constant speed. State the size of the resultant of all the forces acting on the bus. [1]

(b) As the passengers push the bus up the slope, work is done against two forces. State the names of these two forces and, for each force, state the form of energy produced as work is done. [4]

(c) When the bus reaches the top of the slope, it stops and the passengers get back in.

(i) On the axes of Fig. 10.2, sketch the distance-time graph for the bus from a time when the passengers are pushing the bus at constant speed until they get back into the stationary bus.

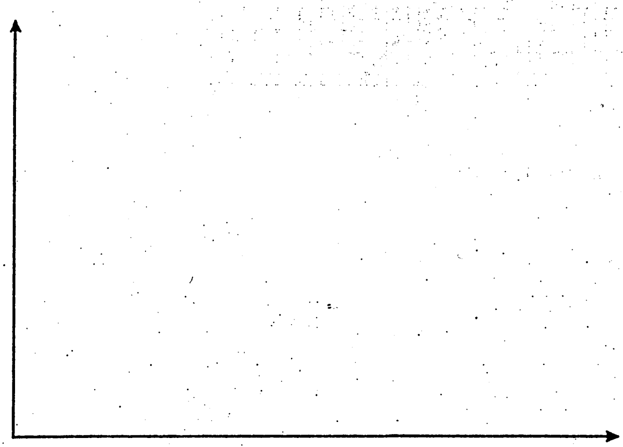


Fig. 10.2

[3]

(ii) State how the speed of a moving object may be obtained from an accurately drawn distance-time graph. [1]

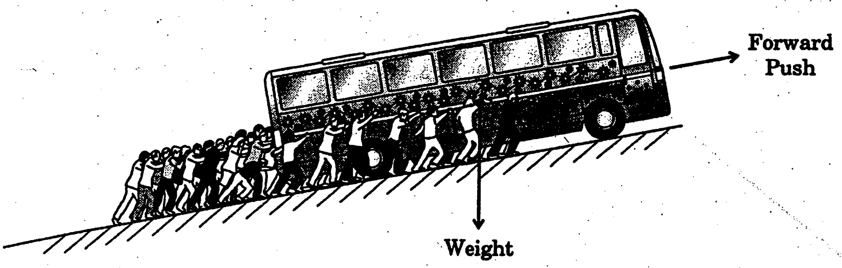
[N10/P2/Q10]

Solution

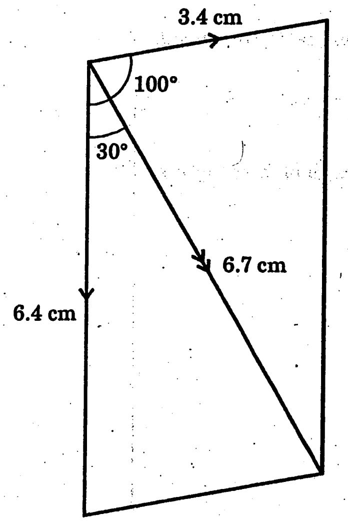
(a) (i) Weight, $W = mg$

$= 3200 \times 10 = 32000$ N

(ii)



(iii)



Key:
5000 N = 1 cm
32000 N = 6.4 cm
17000 N = 3.4 cm

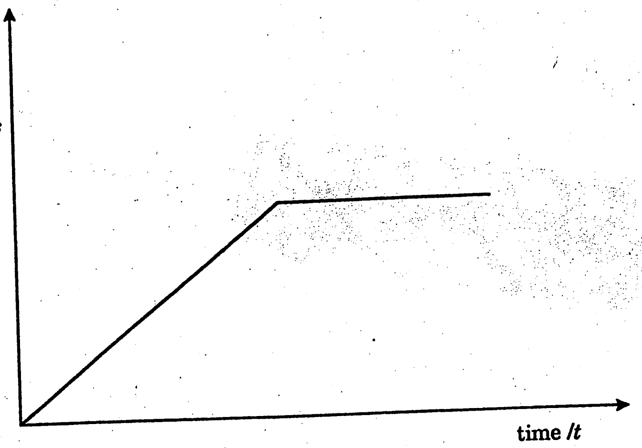
scale: 1 cm = 5000 N
size of resultant: 33500 N
direction of resultant: 30° to the vertical force.

(iv) The value of the resultant force is zero.

(b) force 1: Weight.
form of energy: Potential energy.

force 2: Friction.
form of energy: Heat energy.

(c) (i)



(ii) The gradient of the distance-time graph gives the value of the speed.

Question 8

Fig. 1.1 shows apparatus used to obtain the readings for a graph of force against extension for a spring.

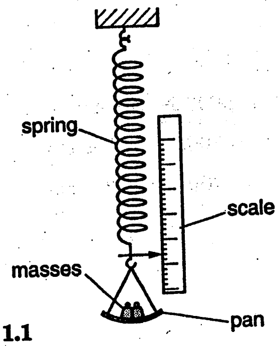


Fig. 1.1

The masses added to the pan produce a force that stretches the spring.

(a) (i) State what is meant by the *mass* of a body. **[1]**

(ii) Describe how the scale is used to find the extension of the spring. [1]

(b) Fig. 1.2 shows the force-extension graphs for two different springs.

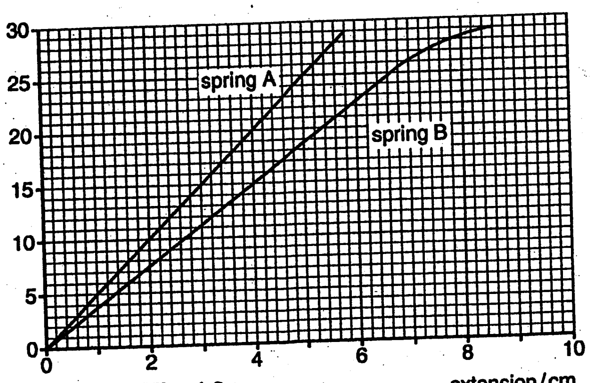


Fig. 1.2

(i) A student states that spring B is easier to stretch than spring A. Use values from Fig. 1.2 to explain what the student means. [1]

(ii) When a force of 25 N is applied, spring B reaches its limit of proportionality but spring A does not. Explain how Fig. 1.2 shows this. [1]

(iii) The same force is applied to each spring. Using Fig. 1.2, determine the force that produces an extension of spring B that is 1.0 cm greater than the extension of spring A. [1]

[J12/P2/Q1]

Solution

(a) (i) The amount of matter contained in a body is called the mass of the body.

(ii) The extension is found by subtracting the pointer's reading on the scale without a mass from the reading with a mass in the pan.

(b) (i) The graph shows that a force of 15 N produces an extension of 3 cm in spring A, while the same force of 15 N produces a greeter extension of 4 cm in spring B. This shows that the spring B is easier to stretch than the spring A.

(ii) The graph line for spring A remains straight but the graph line for spring B bends beyond the force of 25 N showing that the spring B has reached its limit of proportionality.

(iii) Force = 15 N

COMMENT on ANSWER

"(b) (i) *Alternative Answer:* In spring A, an extension of 4 cm requires a force of 20N, whereas in spring B, the same extension of 4 cm is produced by a smaller force of 15N. This shows that the spring B is easier to stretch than spring A.

(b) (ii) The graph line of spring A has a constant gradient which shows that it has not yet reached the limit of proportionality, but the gradient of graph B is not constant showing that it has reached the limit of proportionality."

Question 9

(a) State what is meant by *friction*. [2]

(b) Fig. 2.1 shows two horizontal forces that act on a car. Force B is caused by air resistance and friction.

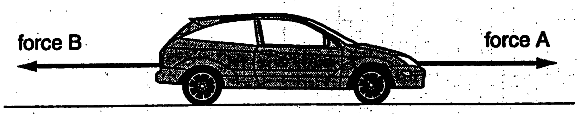


Fig. 2.1

The car is travelling along a straight level road.

(i) The forward force A and the backward force B are equal. Describe the motion of the car. [1]

(ii) The mass of the car is 800 kg. Force A increases to 5000 N. This causes the car to accelerate initially at 1.5 m/s^2. Calculate the size of force B. [3]

(iii) Force A remains constant at 5000 N. Explain why the acceleration decreases as the car travels along the level road. [2]

(c) A car of mass 800 kg climbs a hill and rises a vertical distance of 200 m. Calculate the gain in potential energy of the car. (The gravitational field strength g is 10 N/kg. [2]

[J12/P2/Q2]

Solution

(a) It is the force which opposes the relative sliding motion of two surfaces in contact with one another.

(b) (i) As the forces are balanced, the car moves at constant speed.

(ii) Forward force – frictional force = ma

$$F - f = ma$$
$$5000 - f = 800 \times 1.5$$
$$f = 3800$$

$\therefore$ force B = 3800 N

(iii) As the speed of the car increases, its air resistance also increases. This decreases the resultant force and hence the acceleration decreases.

(c) Gain in P.E. = mgh

$$= 800 \times 10 \times 200$$
$$= 1600000 \text{ J}$$

$\therefore$ Gain in potential energy = 1.6×10^6 J

COMMENT on ANSWER

“ (b) (iii) When the forward driving force A is increased to 5000 N, the car accelerates and its speed increases. As a result, the air resistance also increases, which decreases the resultant force acting on the car. Hence, the acceleration decreases. ”

Question 10

A pupil hangs a load of 45 N from a length of copper wire. The wire extends by 2.5 mm and does not exceed the limit of proportionality.

(a) (i) The gravitational field strength is 10 N / kg. Calculate the mass of the 45 N load. [1]

(ii) Use the grid in Fig. 2.1 to plot the extension-load graph for this wire for a load between 0 and 45 N.

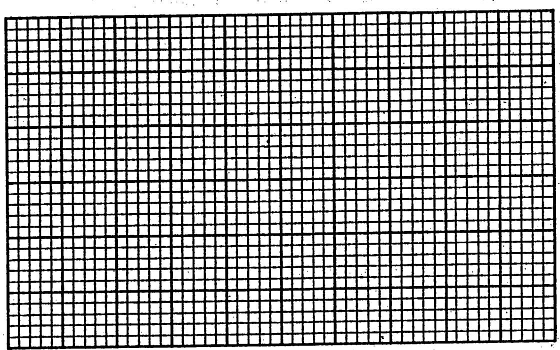


Fig. 2.1 [3]

(b) Use the graph plotted in Fig. 2.1 to determine the load needed to produce an extension of 1.3 mm. [1]

[N12/P2/Q2]

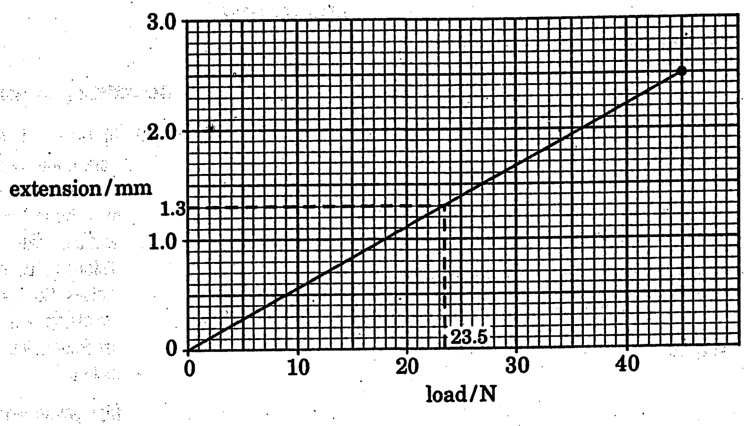
Solution

(a) (i) $W = mg$

$45 = m \times 10$

$m = 4.5\ \text{kg}$

(ii)



(b) load = 23.5 N

COMMENT on ANSWER

“(a) (ii) — Label the axes of the graph with quantity as well as the unit.
— Choose a linear scale on both axes of the graph.”

Question 11

Fig. 3.1 shows a man using a chest expander to increase the strength of his arms.

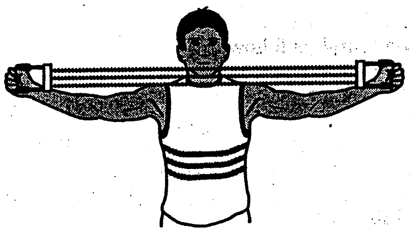


Fig. 3.1

The chest expander may be considered to be a single spring.

Fig. 3.2 shows the force needed to produce different extensions of the spring.

force / N	extension / cm
0	0
60	10
120	20
180	30

Fig. 3.2

(a) The man increases the force on the spring from 0 to 180 N. The spring extends by 30 cm and the average force exerted during this process is 90 N.

(i) Calculate the work done on the spring. [2]

(ii) Twenty extensions are made in 1.0 minute. Calculate the power used to extend the spring. [2]

(b) The force at the limit of proportionality of the spring is 800 N.

(i) Calculate the extension of the spring when the force is 800 N. [2]

(ii) The force on the spring is increased from 800 N to 860 N.
Suggest what happens to the extension. [1]

[J13/P2/Q3]

Solution

(a) (i) Work, $W = F \times d$

$= 90 \times 0.3 = 27\ J$

(ii) Power, $P = \dfrac{\text{total work done}}{\text{total time}}$

$= \dfrac{\text{work done in one extension} \times 20 \text{ extensions}}{60 \text{ seconds}}$

$= \dfrac{27 \times 20}{60} = 9.0\ W$

(b) (i) Using Hooke's law

$F \propto e$

or $F = ke$

Where k is the spring's constant. The value of k is found using the values from the table.

$k = \dfrac{180}{30} = 6\ N/cm$

Hence, extension produced by 800 N can be found as follows:

$F = ke$

$800 = 6 \times e$

$e = \dfrac{800}{6} = 133\ cm$

(ii) The total extension becomes more than 143 cm.

COMMENT on ANSWER

" (a) (i) In order to find the work done by a force, the value of the force must be in Newtons and the value of the distance must be in metres. So, convert the distance in centimetres into metres.

(ii) Convert time in minutes into seconds.

(b) (ii) As previously noted that an increase of 60 N in the force produces an increase of 10 cm in the extension. So, the increase from 800 N to 860 N should produce an extension of = 133+10 = 143 cm. However, since the spring has been stretched beyond its limit of proportionality (i.e. 800 N), the spring becomes permanently stretched and the extention exceeds 143 cm. "

Question 12

A set of traffic lights hangs from the end of a metal cable. A horizontal chain pulls the traffic lights to the right so that they are above the middle of the road. Fig. 1.1 shows the metal cable inclined to the vertical.

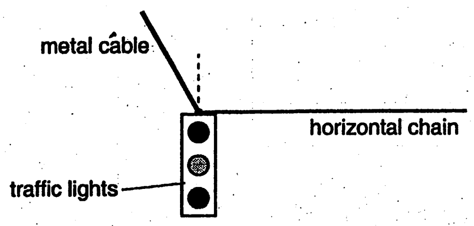


Fig. 1.1

The weight of the traffic lights is 240 N.

(a) Two of the forces on the traffic lights are the tension in the horizontal chain and the weight of the traffic lights.

On Fig. 1.1, mark

(i) an arrow that represents the tension in the horizontal chain, [1]

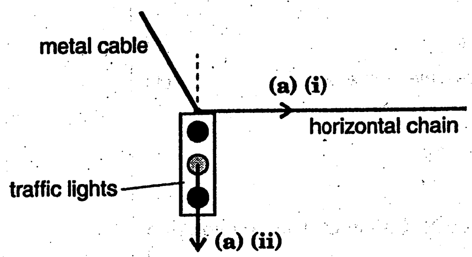
(ii) an arrow that represents the weight of the traffic lights. [1]

(b) The tension in the horizontal chain is 140 N. Use a scale diagram to determine the size of the resultant of the weight and the tension in the chain. State the scale used for the diagram. [3]

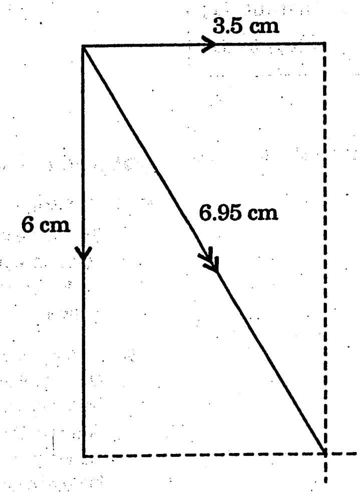
[N13/P2/Q1]

Solution

(a) (i) & (ii)



(b)



scale = 40 N : 1 cm

resultant force = 6.95 x 40 = 278 N

COMMENT on ANSWER

“(a) (ii) The arrow to represent the weight of the traffic light must be drawn from the centre of the lights vertically downwards.

(b) The scale stated must have the units of cm : N or cm/N or N : cm or N/cm.

The resultant force can be found by either the triangle method or the parallelogram method and the value of the resultant force must lie between 272 N and 282 N.”

Question 13

Fig. 1.1 shows a lorry accelerating in a straight line along a horizontal road.

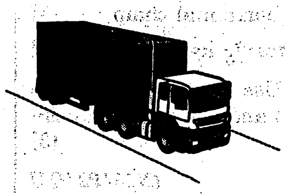


Fig. 1.1

(a) The driving force on the lorry in the forward direction is *D* and the total backward force on the lorry is *B*.

(i) State and explain whether *D* or *B* is the larger force. [1]

(ii) Suggest one possible cause of the backward force *B*. [1]

(b) The weight of the lorry is 300 000 N.

The gravitational field strength *g* is 10 N / kg.

(i) Calculate the mass of the lorry. [1]

(ii) The resultant force on the lorry is 15 000 N. Calculate the acceleration of the lorry. [2]

(c) Later, the lorry turns a corner at constant speed.

Explain why the lorry accelerates even though the speed is constant. [1]

[J14/P2/Q1]

Solution

(a) (i) Since the lorry is accelerating, there is a net resultant force in the forward direction. Therefore *D* is greater than *B*.

(ii) Air resistance.

(b) (i) $W = mg$

$$\Rightarrow \quad m = \frac{W}{g} = \frac{300000}{10} = 30000$$

$\therefore$ **mass of lorry = 30000 kg**

(ii) $F = ma$

$$\Rightarrow \quad a = \frac{15000}{30000} = 0.5$$

$\therefore$ **acceleration of lorry = 0.5 m/s^2**

(c) The direction, and hence the velocity of the lorry changes, causing the lorry to accelerate.

COMMENT on ANSWER

" (a) (ii) Friction between the tyres and the road could have been another possible answer.

(c) Velocity is a vector quantity. It involves both magnitude and direction. On the corner, even though the speed remains constant, the direction of the lorry changes, causing a change in the lorry's velocity. "

Question 14

A student suspends a spring from a clamp stand. He measures the unstretched length of the spring with no load attached. He then attaches different loads to the lower end of the spring and measures the new lengths of the spring.

Fig. 1.1 shows how the total length of the spring depends on the load attached.

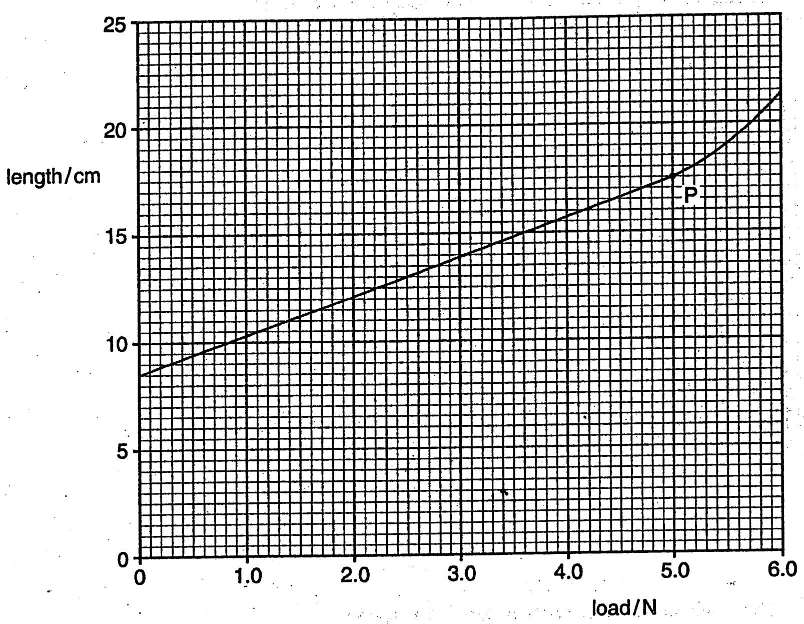


Fig. 1.1

(a) At point P on Fig. 1.1, the line stops being straight and begins to curve.
State the name of point P. [1]

(b) **(i)** Using Fig. 1.1, determine the unstretched length of the spring. [1]

(ii) Calculate the extension of the spring for a load of 4.0 N. [1]

(c) The student attaches a small block of wood to an identical spring. The extension of the spring is 2.7 cm. The gravitational field strength g is 10 N/kg.
Calculate the mass of the block of wood. [2]

[N14/P2/Q1]

Solution

(a) Limit of proportionality.

(b) **(i)** unstretched length = 8.5 cm

(ii) From graph, at a load of 4.0 N, the length of the spring ≈ 15.7 cm

$\therefore$ extension = 15.7 − 8.5 = 7.2 cm

(c) Extension of the spring = 2.7 cm

$\therefore$ total length of the spring = 2.7 + 8.5 = 11.2 cm.

from graph, length of 11.2 cm corresponds to a load of 1.5 N.

using $W = mg$,

$1.5 = m(10) \Rightarrow m = 0.15 \text{ kg} = 150 \text{ g}$.

COMMENT on ANSWER

“(b) (i) The unstretched length of the spring is the y-intercept of the graph.”

Question 15

(a) Explain what is meant by *uniform acceleration*. [2]

(b) Acceleration is a vector quantity.
State how a vector quantity differs from a scalar quantity. [1]

(c) A rock from space is travelling in a straight line at high speed when it enters the Earth's atmosphere. Fig. 9.1 is the speed-time graph for the rock from time $t = 0$ to time $t = 50$ s.

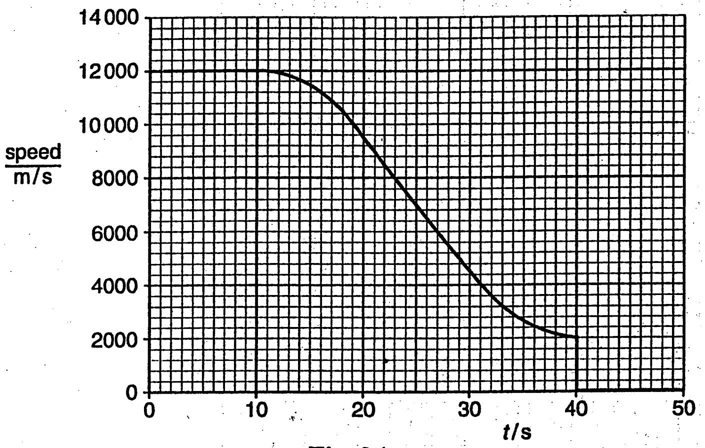


Fig. 9.1

(i) On Fig. 9.1, mark
- a letter X, where the rock is moving with a constant speed,
- a letter Y, where the rock has a uniform deceleration,
- a letter Z, where the rock has a non-uniform deceleration.

[3]

(ii) At time $t = 25$ s, the mass of the rock is 8.4 kg. For the time $t = 25$ s, determine

1. the size of the acceleration of the rock, [3]
2. the size of the resultant force on the rock. [2]

(iii) Fig. 9.2 shows the rock at $t = 25$ s.

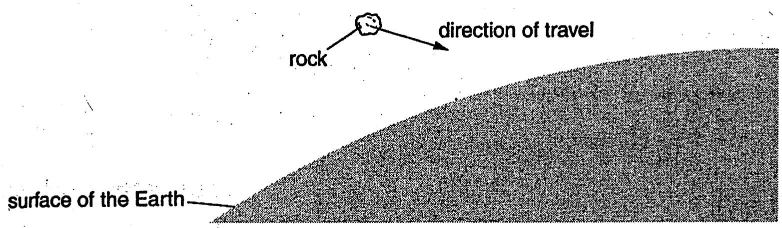


Fig. 9.2 (not to scale)

1. On Fig. 9.2, draw and label two arrows to show the directions of the gravitational force F and the air resistance R acting on the rock. [2]
2. Suggest why the size of the air resistance changes as the rock travels through the Earth's atmosphere. [1]

(iv) Suggest what happens to the rock at $t = 40$ s. [1]

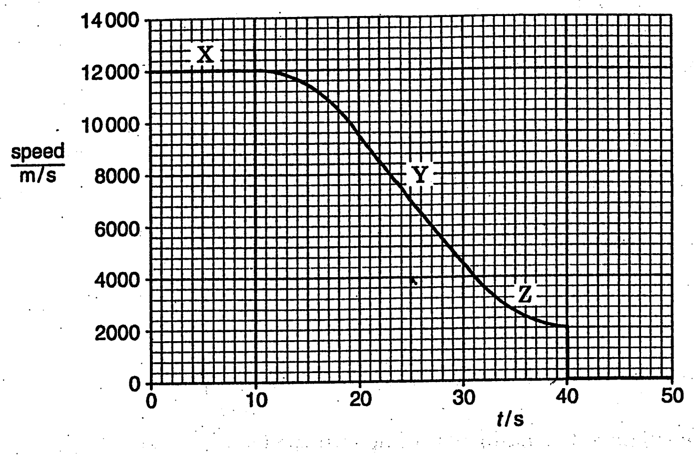
[N14/P2/Q9]

Solution

(a) Uniform acceleration refers to a constant increase in velocity per unit time.

(b) Scalar quantities have only magnitude but vector quantities have magnitude and direction.

(c) (i)



(ii) 1. Taking two points (23, 8000) and (27, 6000) on the graph,

acceleration = gradient of speed-time graph

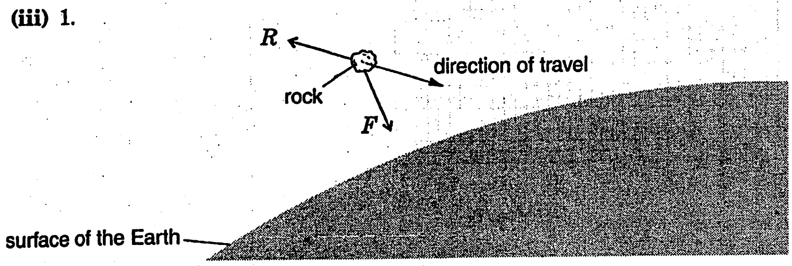
$$= \frac{8000-6000}{23-27} = \frac{2000}{-4} = -500 \text{ m/s}^2$$

$\therefore$ size of acceleration = 500 m/s^2

2. Resultant force = ma

$$= 8.4 \times 500 = 4200 \text{ N.}$$

(iii) 1.



2. As the speed of the rock changes, the size of the air resistance also changes.

(iv) It hits the surface of the earth and stops.

COMMENT on ANSWER

❝ (c) (i) At a constant speed, the gradient of the velocity-time graph should be zero. Under uniform deceleration the velocity-time graph should be linear with a negative constant gradient.
Under non-uniform deceleration, the velocity-time graph should have a non-linear negative gradient.

(iii) 1. The direction of the air resistance R should be opposite to the direction of travel of the rock.
The direction of gravitational force F should be normal to the surface of the Earth.

2. The size of the air resistance could also change due to a change in the density or pressure of the air as the rock makes its way from space to the surface of the Earth. ❞

Question 16

The apparatus shown in Fig. 1.1 is used to measure the extension of a spring.

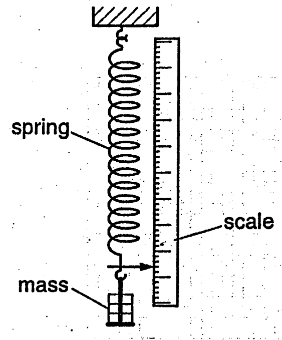


Fig. 1.1

(a) Explain how the mass causes a force on the spring. **[1]**

(b) The force on the spring is a vector quantity. State what is meant by a *vector* quantity. **[1]**

(c) Fig. 1.2 shows a graph of the length of the spring plotted against the force on the spring, for forces between 0 and 10 N.

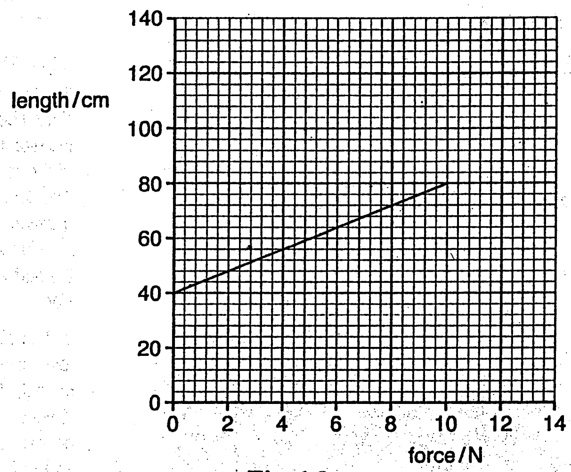


Fig. 1.2

(i) 1. State a formula that relates the unstretched length l_0 of the spring, the stretched length l of the spring and the extension e of the spring. **[1]**

2. A mass produces a force of 9.0 N on the spring. Determine the extension of the spring caused by this mass. **[1]**

(ii) The limit of proportionality of the spring is reached when the force is 10 N.

The spring is easier to stretch after the limit of proportionality.

On Fig. 1.2, continue the line to suggest how the length changes when the force is greater than 10 N. **[1]**

[J15/P2/Q1]

Solution

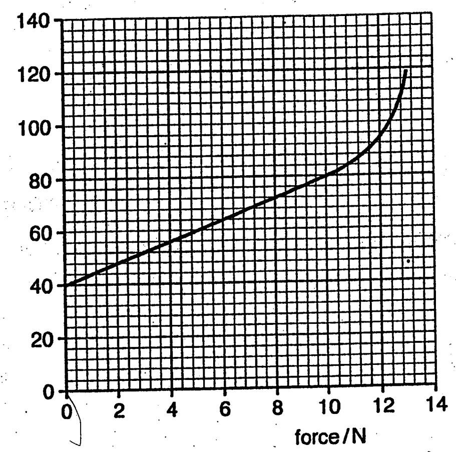
(a) The downward pull of gravity on the mass causes a force on the spring.

(b) A physical quantity that has both magnitude as well as direction is called a vector quantity.

(c) (i) 1. $e = l - l_0$

2. $e = l - l_0$
$= 76 - 40 = 36\,\text{cm}$

(ii)



COMMENT on ANSWER

“(c) (i) 1. *Alternatively,*
$l = l_0 + e$ or $l_0 = l - e$

2. From the graph:
When $F = 9.0$ N, $l = 76$ cm
By subtracting the original length of the spring, the value of extension,
$e = 76 - 40 = 36$ cm.

(ii) The graph line does not remain straight after the limit of proportionality.”

Question 17

(a) The surface of a running track is made of rubber. A heavy trolley is pulled on to the track and it exerts a large force on the rubber track.
State two effects that this force has on the rubber. [2]

(b) A spring is suspended from a support with a small pan attached to its lower end. Masses are added to the pan until the spring is extended well beyond the limit of proportionality.
Fig. 2.1 shows this apparatus.

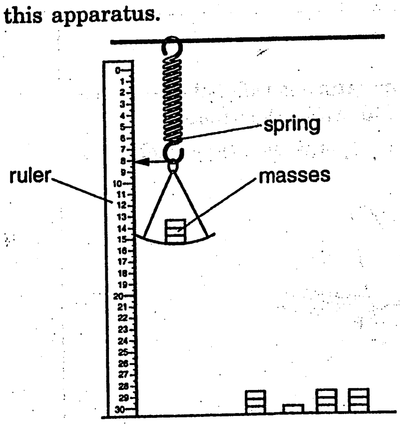


Fig. 2.1

A ruler is used when determining the extension of the spring.

(i) On Fig. 2.2, sketch the extension-load graph for the spring and label the limit of proportionality P. [2]

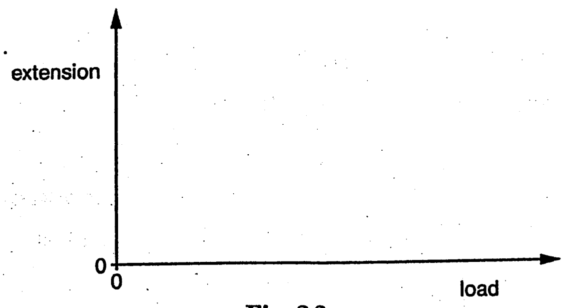


Fig. 2.2

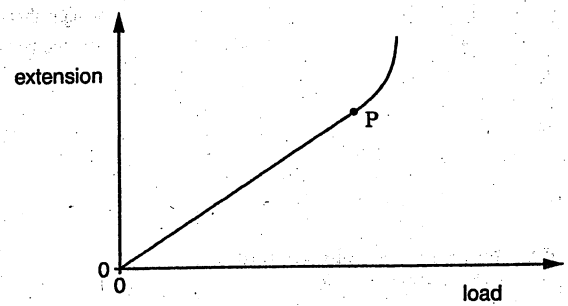
(ii) The masses are then removed and the extension of the spring decreases.
Suggest what is observed when all the masses are removed. [1]

[N15/P2/Q2]

Solution

(a) 1. Heat energy is produced due to the friction between the two surfaces.
2. The surface of the track is deformed due to the heavy weight of the trolley.

(b) (i)



(ii) The spring becomes longer than its original length due to the permanent extension produced in it.

COMMENT on ANSWER

" (a) *Alternative answers:*
- the surface of the track is distorted.
- the surface of the track is stretched or squeezed.
- the surface of the track is compressed.
- It produces change in the shape of the track.
- It produces change in size / volume / density / depth / height "

Question 18

Aeroplanes fly at high altitudes where the temperature is well below 0 °C. Ice that forms on an aeroplane can fall to earth and strike the ground.

Fig. 9.1 shows a block of ice falling from an aeroplane as it approaches an airport.

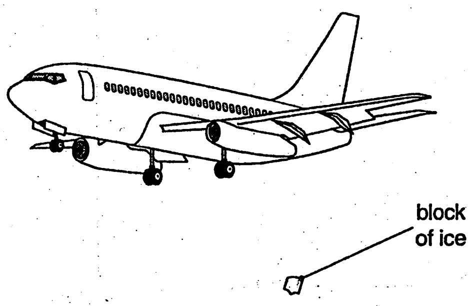


Fig. 9.1 (not to scale)

The mass of the falling block of ice is 1.2 kg and the gravitational field strength g is 10 N/kg.

(a) Calculate the weight of the block of ice. [1]

(b) Fig. 9.2 is the speed-time graph for the block of ice as it falls to the ground.

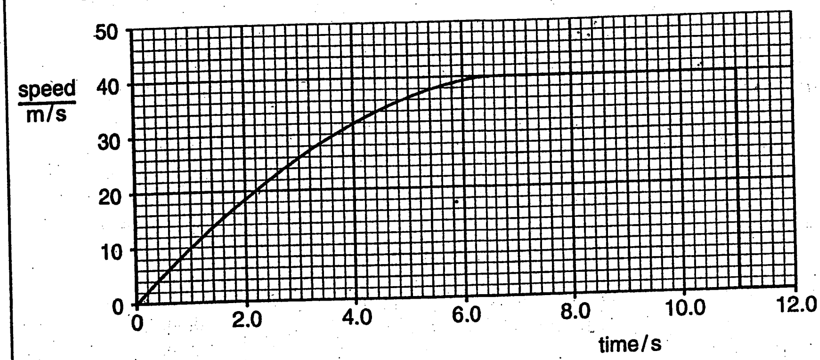


Fig. 9.2

At first, the acceleration of the block of ice is equal to the acceleration of free-fall. The acceleration of the block then decreases to zero as the block reaches terminal velocity.

(i) As the block of ice falls, the force F of air resistance acting on the block changes.

1. State the value of F at time = 0. [1]
2. State the value of F at time = 10.0 s. [1]
3. Explain why F changes. [1]

(ii) State the energy change that takes place when the block is falling at terminal velocity. [1]

(iii) Using information from Fig. 9.2, determine the maximum kinetic energy of the block when it is falling to the ground with terminal velocity. [3]

[N15/P2/Q9(a,b)]

Solution

(a) Weight = mg

$= 1.2 \times 10$

$= 12$ N

(b) (i) 1. $F = 0$

2. $F = 12$ N

3. As the block of ice accelerates, its speed increases. As a result the force F of air resistance also increases.

(ii) The gravitational potential energy of the block of ice changes to the thermal energy.

(iii) Kinetic energy $= \frac{1}{2}mv^2$

$= \frac{1}{2} \times 1.2 \times (40)^2$

$= 960$ J

COMMENT on ANSWER

" (b) (i) 2. The value of F at $t = 10.0$ seconds is equal to the weight because when a body is falling with terminal velocity, then the upward force of air resistance is equal to the downward force of gravity.

3. For a body moving in air, air resistance $\propto$ speed

(ii) Alternatively, The gravitational potential energy changes into kinetic energy of air. "

Topic 4 Work, Energy And Power

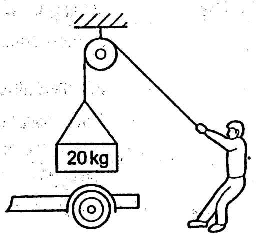
MCQ Section

1. In a hydroelectric power station, water from a reservoir falls down a long pipe before entering the turbines. The turbines then turn the generator.
What is the **overall** energy conversion?
A electrical energy into kinetic energy
B electrical energy into potential energy
C kinetic energy into chemical energy
D potential energy into electrical energy
[J06/P1/Q11]

2. Which statement about fission or fusion is correct?
A During fission, hydrogen converts into helium and releases energy.
B During fission, uranium converts into daughter products and releases energy.
C During fusion, helium converts into hydrogen and releases energy.
D During fusion, uranium converts into daughter products and releases energy.
[J06/P1/Q12]

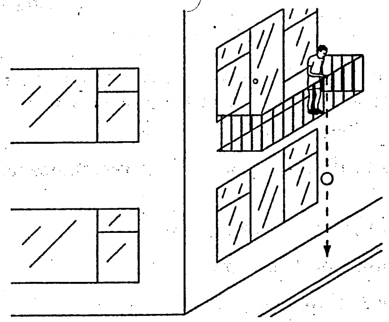
3. The input power to a motor is 300 W. In 20 s it lifts a load of 400 N through a height of 6.0 m.
What is the efficiency of the motor?
A 12% **B** 25%
C 40% **D** 75%
[J06/P1/Q13]

4. A person just supports a mass of 20 kg suspended from a rope.



What is the resultant force acting on the mass?
A 0 N **B** 10 N
C 20 N **D** 200 N
[N06/P1/Q3]

5. A young child holds a ball over the edge of a balcony. The ball possesses gravitational potential energy. The ball is released, falls on to a concrete path below, and bounces back up.



Which sequence represents, in the correct order, the transformations of the gravitational potential energy after the ball is released?
A → elastic potential energy → kinetic energy → chemical potential energy
B → elastic potential energy → kinetic energy → elastic potential energy
C → kinetic energy → elastic potential energy → kinetic energy
D → kinetic energy → gravitational potential energy → elastic potential energy
[N06/P1/Q8]

6. A person exerts a horizontal force of 600 N on a box that also experiences a friction force of 200 N.
If it takes 4.0 seconds to move the box 3.0 m, what is the average useful power?
A 150 W **C** 450 W
B 300 W **D** 600 W
[N06/P1/Q9]

MCQ Answers

1. **D** The P.E. of water stored in the reservoir is converted into K.E. as it rushes down which is then converted into the electrical energy by the generator.

2. **B** It is a fact that during fission, a uranium nucleus splits into daughter nuclei and releases energy. In a fusion process, two hydrogen nuclei fuse together to form a helium nucleus and energy is released.

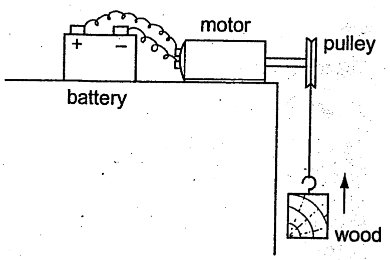
3. **C**
Input power = 300 W
Output power
$= \frac{\text{Work done by motor}}{\text{time}}$
$= \frac{F \times s}{t} = \frac{400 \times 6}{20} = 120\text{W}$
Hence, efficiency
$= \frac{\text{Output power}}{\text{Input power}} \times 100$
$= \frac{120}{300} \times 100 = 40\%$

4. **A** Since the mass is supported, the mass is at rest and its acceleration is 0. Using Newton's 2nd Law, F = ma = m(0) = 0 N.

5. **C** As the ball is released, gravitational potential energy is converted to kinetic energy. When the ball comes in contact with the ground, its kinetic energy is converted to elastic potential energy. As the ball rebounds and begins to leave the ground, its elastic potential energy is converted to kinetic energy.

MCQ Answers

7. The diagram shows a battery-operated motor lifting a block of wood at constant speed.



What is the overall energy change taking place?

A chemical → gravitational potential

B gravitational potential → electrical

C gravitational potential → kinetic

D kinetic → gravitational potential

[J07/P1/Q9]

8. Four students exercise in a gym. Which student does the most work?

	exercise time / s	power developed / W
A	50	250
B	100	150
C	200	200
D	250	30

[J07/P1/Q10]

9. Which formula gives the efficiency of an energy conversion?

A efficiency = total energy input − useful energy output

B efficiency = useful energy output × total energy input

C $\text{efficiency} = \dfrac{\text{useful energy output}}{\text{total energy input}}$

D $\text{efficiency} = \dfrac{\text{total energy input}}{\text{useful energy output}}$

[J07/P1/Q11]

10. A 2 kg mass is moving at constant speed.

The kinetic energy of the mass is 400 J.

What is the speed of the mass?

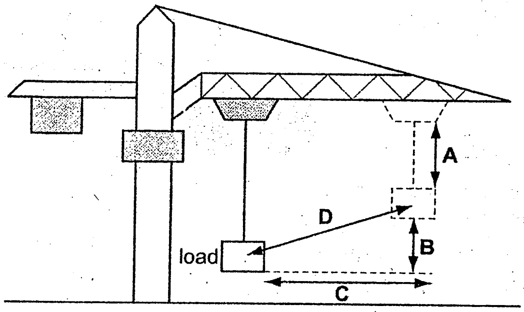
A 0.4 m/s **B** 20 m/s

C 200 m/s **D** 400 m/s

[N07/P1/Q9]

11. A crane moves its load diagonally, as shown.

By what distance is the weight of the load multiplied in order to calculate the increase in gravitational potential energy of the load?



[N07/P1/Q10]

12. The efficiency of an electrical generator is 65%.

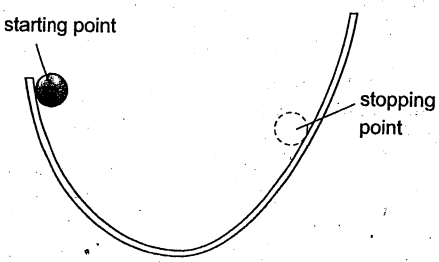
Which useful output can be expected if the energy input to the generator is 12 kJ?

A 4.2 kJ **B** 7.8 kJ

C 19 kJ **D** 780 kJ

[N07/P1/Q11]

13. A ball is held at rest on one side of a curved track.



The ball is released. It rolls down one side of the track and part of the way up the other side. It then stops, be-fore rolling back down again. The height of the stopping point is less than that of the starting point.

What is the sequence of energy changes between starting and stopping for the first time?

A potential energy → kinetic energy → potential energy + heat

B potential energy → kinetic energy → heat → potential energy

C potential energy → heat → kinetic energy → potential energy

D potential energy → kinetic energy + heat → potential energy + heat

[J08/P1/Q9]

6. **B** To determine useful power, we have to disregard the work done in overcoming friction. Hence, useful power

$= \dfrac{\text{work done}}{\text{time}}$

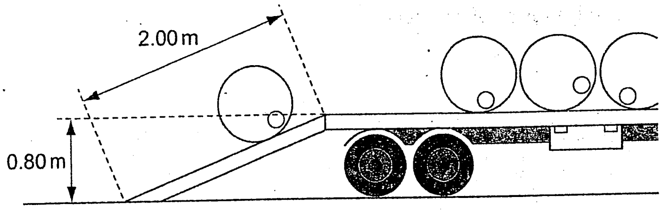
$= \dfrac{\text{force} \times \text{distance}}{\text{time}}$

$= \dfrac{(600 - 200) \times 3.0}{4.0}$

$= 300\ \text{W}$

7. **A** The chemical energy stored in the battery finally changes into the gravitational potential energy of the wooden block.

14. A workman rolls a barrel of weight 2000 N up a plank of length 2.00 m and on to a lorry. The back of the lorry is 0.80 m above the horizontal sur-face of the road.

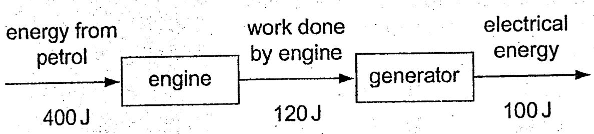


What is the work done on the barrel against gravity?

A 1000 J **B** 1600 J
C 2500 J **D** 4000 J

[J08/P1/Q10]

15. Energy from petrol is used to operate an engine. The engine drives a generator, which produces electrical energy.

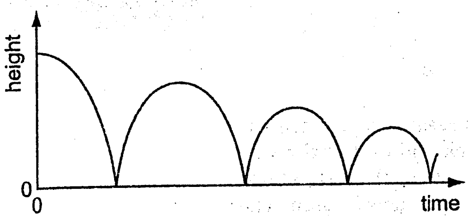


What is the overall efficiency of the process?

A 25 % **B** 30 %
C 55 % **D** 83 %

[J08/P1/Q11]

16. The graph shows how the height above the ground of a bouncing ball changes with time.



Which statement explains why the height of each peak decreases with time?

A Kinetic energy is converted to potential energy at each bounce.
B Kinetic energy is converted to thermal energy at each bounce.
C The ball gains energy on impact with the floor.
D The ball is wearing out.

[N08/P1/Q10]

MCQ Answers

8. C As workdone = power × time
Therefore, workdone by
Student **A** : 250 × 50 = 12500 J
Student **B** : 150 × 100 = 15000 J
Student **C** : 200 × 200 = 40,000 J
Student **D** : 30 × 250 = 7500 J

9. C Fact.

10. B $K.E. = \frac{1}{2}mv^2$
$400 = \frac{1}{2} \times 2 \times v^2$
$v^2 = 400$ or $v = 20$ m/s

11. B Increase in gravitational P.E. = mgh = w × h, where 'w' is weight of the load and 'h' is the vertical height. So, the weight should be raised through the vertical height shown as **B**.

12. B $\text{Efficiency} = \frac{\text{output energy}}{\text{input energy}} \times 100$
$65 = \frac{\text{output energy}}{12} \times 100$
∴ output energy = 7.8 kJ.

13. D As the ball rolls down along the curved track, its P.E. is mostly converted into K.E. but a small amount of it is also converted into heat energy due to the friction between the ball and the surface of the track. Similarly, on the other side, when the ball rolls up the track, most of its K.E. is converted into P.E. but a small part of it changes into heat energy.

14. B Since work done in raising the barrel against gravity = P.E. gained by the barrel.
So, workdone = $(mg)h$
$= w \times h = 2000 \times 0.80 = 1600$ J

15. A $\text{Efficiency} = \frac{\text{Output energy}}{\text{Input energy}} \times 100$
$= \frac{100}{400} \times 100 = 25\%$

16. B The height of the ball decreases after each bounce because the ball loses a part of its K.E. in the form of heat energy during its each impact with the ground.

17. Where is energy released by the fusion of hydrogen atoms to form helium?

A in a nuclear power station
B in a radioactive isotope
C in the core of the Earth
D in the core of the Sun

[N08/P1/Q11]

18. A crane lifts a weight of 1000 N through a vertical height of 30 m.

It uses 60 000 J of energy.

What is the efficiency of the crane?

A 20 %
B 30 %
C 40 %
D 50 %

[N08/P1/Q12]

19. A rock climber of weight 600 N climbs up a rock face of vertical height 300 m in 3600 s.

What is the average power she generates against gravity during this time?

A 0.020 W **B** 50 W
C 1800 W **D** 7200 W

[N08/P1/Q13]

20. Which process in the Sun produces energy?

A burning
B nuclear fission
C nuclear fusion
D radiation

[J09/P1/Q12]

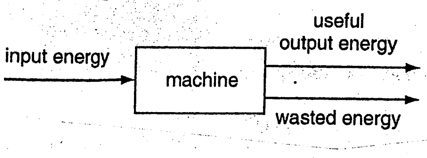
21. A crane lifts a load of 1000 N through a vertical height of 3.0 m in 10 s. The input power to the crane is 500 J / s.

What is the efficiency of the crane?

A 0.17 **B** 0.50
C 0.60 **D** 0.67

[J09/P1/Q13]

22. The diagram shows energy transfer through a machine.



What is the efficiency of the machine?

A $\dfrac{\text{input energy}}{\text{useful output energy}}$

B $\dfrac{\text{useful output energy}}{\text{input energy}}$

C $\dfrac{\text{useful output energy}}{\text{wasted energy}}$

D $\dfrac{\text{wasted energy}}{\text{input energy}}$

[N09/P1/Q12]

23. A man weighs 600 N. He runs up a staircase of total height 4.0 metres in 3.0 seconds.

How much useful power is needed to do this?

A 450 W
B 800 W
C 2400 W
D 7200 W

[N09/P1/Q13]

24. A small emergency generator supplies 432 000 000 J of electrical energy in twenty-four hours.

What is the average power output of the generator?

A 5000 W
B 300 000 W
C 18 000 000 W
D 432 000 000 W

[J10/P1/Q12]

25. A parachutist has opened his parachute and is falling to Earth at constant speed.

What is the principal energy conversion taking place as he falls?

A kinetic energy → potential energy
B kinetic energy → thermal energy (heat)
C potential energy → kinetic energy
D potential energy → thermal energy (heat)

[J10/P1/Q13]

MCQ Answers

17. D Fact

18. D Work done by the crane in lifting the weight = 1000 × 30 = 30,000 J

Input energy used by the crane = 60,000 J

So, efficiency $= \dfrac{\text{output energy}}{\text{input energy}} \times 100 = \dfrac{30{,}000}{60{,}000} \times 100 = 50\%$

19. B Average power $= \dfrac{\text{Work done}}{\text{time}} = \dfrac{F \times S}{t} = \dfrac{600 \times 300}{3600} = 50\text{ W}$

20. C Fact

21. C Efficiency $= \dfrac{\text{Output Power}}{\text{Input Power}}$

where

input power = 500 J/s and output power $= \dfrac{\text{work done}}{\text{time}} = \dfrac{1000 \times 3}{10} = 300\text{ J/s}$. So,

Efficiency $= \dfrac{300}{500} = 0.60$

22. B By definition

23. B Power $= \dfrac{\text{workdone}}{\text{time}} = \dfrac{F \times d}{t} = \dfrac{600 \times 4}{3} = 800\text{ W}$

24. A Average power output $= \dfrac{\text{Energy output}}{\text{time}} = \dfrac{432\,000\,000}{24 \times 60 \times 60} = 5000\text{ W}$

25. D As the parachutist is falling at constant speed, it means that his P.E. is not changing into K.E. but rather it changes into thermal energy due to the air resistance.

The machine is 50% efficient.

Which equation is correct?

A input energy = useful output energy

B useful output energy = input energy + wasted energy

C wasted energy = input energy + useful output energy

D wasted energy = useful output energy

[J13/P1/Q15]

42. When exposed to light, a solar cell generates electrical energy.

Two solar cells of equal area are tested. Each cell is exposed to sunlight of different brightness for the same time.

Which statement could apply to the more efficient cell?

A It generates less electrical energy from light of greater brightness.

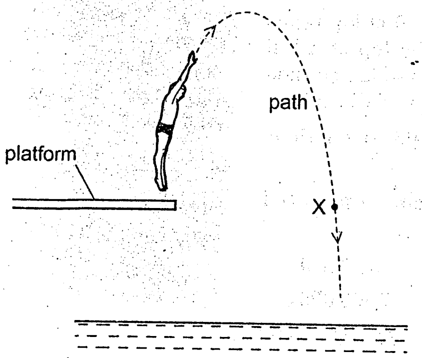
B It generates less electrical energy from light of the same brightness.

C It generates the same electrical energy from light of greater brightness.

D It generates the same electrical energy from light of lower brightness.

[N13/P1/Q13]

43. The diagram shows the path of a diver after leaving a platform and before entering the water in a swimming pool.



The gravitational potential energy of the diver is zero when he is at the surface of the water.

Which statement about the diver's energy along the path is correct?

A At point X he has only gravitational potential energy.

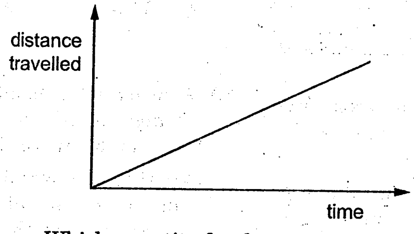
B At point X he has only kinetic energy.

C His gravitational potential energy is always more than his kinetic energy.

D The sum of his gravitational potential energy and kinetic energy is constant.

[N13/P1/Q14]

44. The distance travelled by a car is increasing uniformly as it is driven along a straight road up a hill.



Which quantity for the car is constant but not zero?

A acceleration

B gravitational potential energy

C kinetic energy

D resultant force

[J14/P1/Q6]

45. Which source releases carbon dioxide, a greenhouse gas, when generating electricity?

A fossil fuels

B geothermal

C hydroelectric

D nuclear

[J14/P1/Q16]

46. Where is energy released by the fusion of hydrogen nuclei to form helium?

A in a nuclear power station

B in a radioactive isotope emitting alpha-particles

C in the core of the Earth

D in the core of the Sun

[J14/P1/Q17]

47. A crane lifts a load of 6000 N through a vertical distance of 15 m in 30 s.

What is the average useful power during this operation?

A 200 W **B** 400 W

C 3000 W **D** 12 000 W

[J14/P1/Q18]

MCQ Answers

41. D As the machine is 50% efficient it means that half of the input energy is wasted and half of it is converted into useful out put. Hence, the wasted energy = useful output energy.

42. D It is a fact that a more efficient solar cell will generate the same amount of electrical energy with less bright sun as a less efficient solar cell with the light of more bright sun.

43. D According to the law of conservation of energy, the total amount of the divers energy at all points of the path will be constant.

44. C The slope of the distance time graph is constant. Hence the car travels with a constant velocity, and thus a constant kinetic energy.

45. A Fossil fuels are burnt to generate electricity. In the process, carbon dioxide gas is formed.

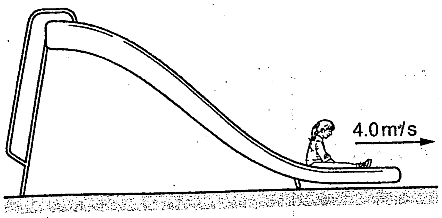
46. D Fact.

47. C $P = \frac{\text{work done}}{\text{time taken}}$

$= \frac{15 \times 6000}{30}$

$= 3000\ W$

48. A child of mass 30 kg is moving at a speed of 4.0 m/s when she reaches the bottom of a slide.

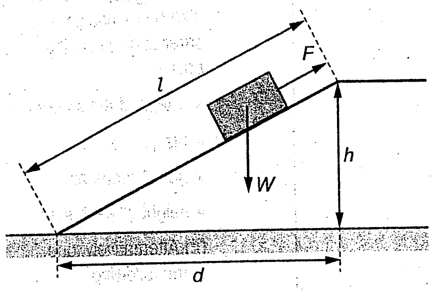


What is her kinetic energy?

A 60 J **B** 120 J
C 240 J **D** 480 J

[N14/P1/Q9]

49. A constant force F pulls a block of weight W up the slope shown.



How much work is done in pulling the block up the slope?

A $F \times h$ **B** $F \times l$
C $W \times d$ **D** $W \times l$

[N14/P1/Q10]

50. A rocket of total mass M is travelling at a speed v. The engine of the rocket is fired and fuel is used up. The mass of the rocket decreases to $M/2$ and its speed increases to $2v$.

What happens to the kinetic energy of the rocket?

A it doubles
B it halves
C it increases by a factor of four
D it stays the same

[J15/P1/Q12]

51. A builder lifts eight slabs from the ground on to the back of a lorry 1.5 m high.

The total time taken is 48 s and each slab weighs 200 N.

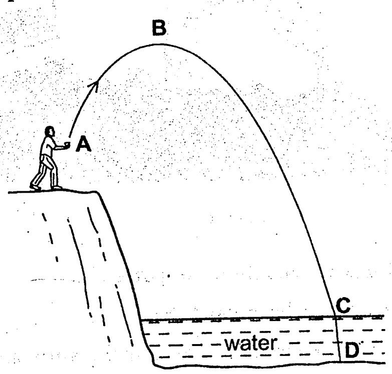
How much useful power does the builder produce?

A 50 W
B 400 W
C 2400 W
D 3200 W

[J15/P1/Q13]

52. A person throws a stone so that it follows the path shown in the diagram.

In which position does the stone have the most gravitational potential energy?



[N15/P1/Q14]

53. A piston of area 10 cm^2 is pushed slowly into a very large cylinder containing gas at a pressure of 10 N/cm^2. The pressure of the gas remains constant as the piston moves a distance of 0.10 m.

What is the force of the gas on the piston and what is the work done by the piston on the gas?

	force / N	work done / J
A	1.0	0.1
B	1.0	10
C	100	10
D	100	1000

[N15/P1/Q15]

MCQ Answers

48. C K.E. $= \frac{1}{2}mv^2$
$= \frac{1}{2} \times 30(4)^2$
$= 240$ J

49. B Work done in pulling the block up the slope = force (F) applied on block × distance (l) moved by block = $F \times l$.

50. A
Initial K.E. $= \frac{1}{2}Mv^2$
New K.E. $= \frac{1}{2} \times \frac{M}{2} \times (2v)^2$
$= Mv^2$
Hence, the K.E. doubles.

51. A Weight of 8 slabs = 200 × 8 = 1600 N
Useful power $= \frac{mgh}{t}$
$= \frac{w \times h}{t}$
$= \frac{1600 \times 1.5}{48}$
$= 50$ W.

52. B G.P.E. $= mgh$ = weight × h
Since the weight of the stone remains constant during the free fall, hence G.P.E. $\propto h$.
As h is maximum at position B, so the G.P.E. is maximum at B.

53. C Force = pressure × area
$= 10 \times 10$
$= 100$ N
Work done $= F \times d$
$= 100 \times 0.10$
$= 10$ J

Topic 4 Work, Energy And Power

THEORY Section

Question 1

A student carries out an experiment to measure the power he produces. He runs up a flight of stairs, as shown in Fig. 1.1.

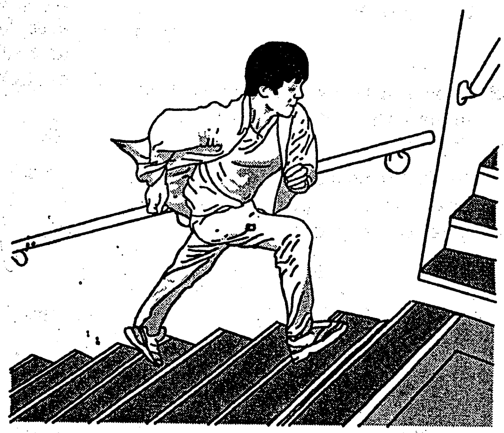


Fig. 1.1

The student takes readings to calculate his power.

(a) (i) List all of the readings he must take. [3]

(ii) State one precaution he should take to make sure one of his readings is accurate. [1]

(b) Write down all of the equations he must use to calculate his power from the readings.

You may use symbols or words in your equations. [2]

[J06/P2/Q1]

Solution

(a) (i) • mass of the student

• time taken to run up the stairs

• height of the stairs

(ii) Measure the time twice and take the average of the two readings in order to reduce the human reaction error.

(b) P.E. $= mgh$, and Power $= \dfrac{\text{P.E.}}{\text{time}}$

COMMENT on ANSWER

" **(a) (i)** Alternatively, the following quantities can also be measured in order to calculate the power:

• weight of the student

• his speed

• no. of steps and

• height of each step.

(ii) Alternatively, one of the following precautions can also be given:

mass: ensure that balance reads zero without person.

time: use a stopclock to better than 0.1 second.

height: use callipers to measure the height of one step or ensure that the rule is vertical or the measuring tape used is taut.

(b) The following equations can also be used to calculate the power:

(i) K.E. $= \frac{1}{2}mv^2$ or

work = weight × height

(ii) Power $= \dfrac{\text{K.E.}}{\text{time}}$ or

$\dfrac{\text{work}}{\text{time}}$ or $\dfrac{w \times h}{\text{time}}$ "

Question 2

Fig. 6.1 shows a device used to generate electricity. Water entering at the top turns the wheel. A generator connected to the wheel produces electric current.

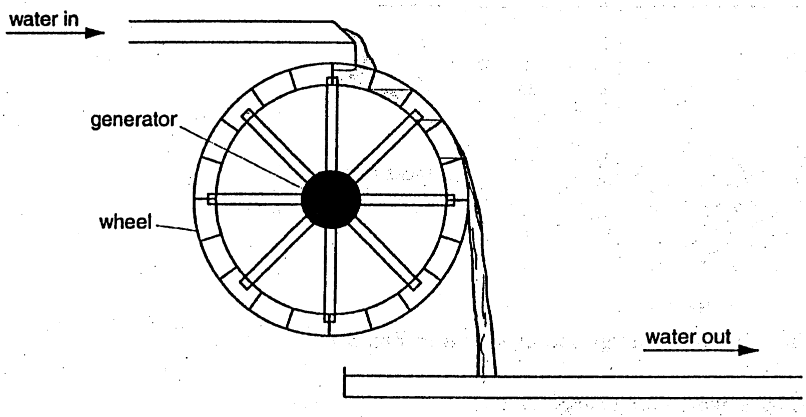


Fig. 6.1

(a) State two main energy changes that take place in this device as water starts to flow. [2]

(b) The water supplies 2000 J of energy every second to the wheel. The electrical energy output is 1200 J every second.

Calculate the percentage of the energy supplied that is wasted. [2]

(c) State two ways in which the device wastes energy. [2]

[N06/P2/Q6]

Solution

(a) 1. Gravitational energy of the water is converted to kinetic energy of the water.

2. Kinetic energy of the water is converted to electrical energy.

(b) Wasted percentage $= \dfrac{(2000-1200)}{2000} \times 100\% = 40\%$

(c) 1. Not all the kinetic energy of the water is used.

2. Friction in the wheel produces internal energy.

COMMENT on ANSWER

"(a) The gravitational energy of the water is converted to kinetic energy of the water to kinetic energy of the wheel and generator and finally to electrical energy and internal energy.

(b) Wasted percentage = $\dfrac{\text{energy wasted}}{\text{energy supplied}} \times 100\%$

Energy wasted = Energy supplied − Energy converted.

(c) From the position of the wheel, the water still has kinetic energy after leaving the wheel. The efficiency is higher if the wheel is in a lower position."

Question 3

One type of renewable energy source is shown in Fig. 3.1.

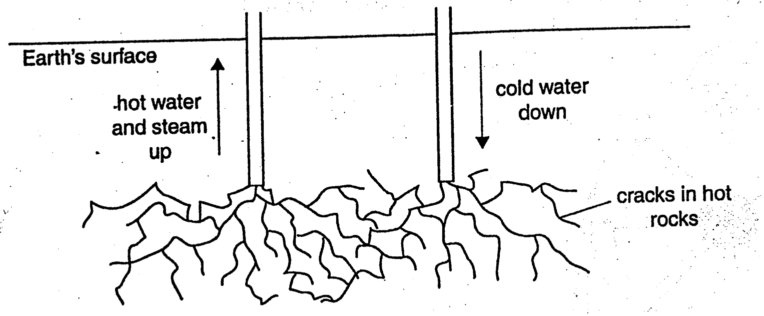


Fig. 3.1

(a) (i) State the name of the renewable energy source shown in Fig. 3.1. [1]

(ii) State what is meant by a *renewable* energy source. [1]

(b) 1000 kg of cold water at a temperature of 20 °C is pumped down to the hot rocks. 1000 kg of water returns as steam and 900 kg as hot water, both at a temperature of 100 °C.

The specific heat capacity of water is 4200 J / (kg °C) and the specific latent heat of vaporisation of water is 2.3×10^6 J /kg.

Calculate

(i) the energy needed to heat 1000 kg of water from 20 °C to 100 °C. [2]

(ii) the energy needed to produce 100 kg of steam from water that is already at 100 °C. [2]

[N07/P2/Q3]

COMMENT on ANSWER

" (a) (ii) Also, a source of energy which is infinite and will never run out is known as the renewable source of energy. "

Solution

(a) (i) Geothermal energy

(ii) A source of energy which can last for ever and if it is once used up it can be replaced, e.g. wind, tides, sunlight, wood.

(b) (i) Energy $= m \times c \times \Delta\theta$

$= 1000 \times 4200 \times 80 = 3.36 \times 10^8$ J

(ii) Energy required $= m\,l$

$= 100 \times 2.3 \times 10^6 = 2.3 \times 10^8$ J

EXTRA INFORMATION

" Note that it is wrong to say that '*renewable energy source*' is a source of energy that can be used again or it can be recycled. Such definitions are not acceptable. "

Question 4

Fig. 1.1 is a block diagram of a power station.

The four boxes represent different parts of the power station. The first box is labelled boiler.

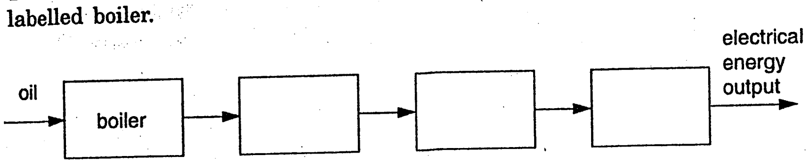


Fig. 1.1

Each of the other three boxes should contain **one** of the labels from the following list.

generator, motor, transformer, turbine, solar panel

(a) On Fig. 1.1, label the boxes using words from the list. [2]

(b) State **one** environmental problem caused by burning oil to produce electricity. [1]

(c) Oil is a non-renewable energy source.

(i) State why oil is described as a non-renewable energy source. [1]

(ii) State **one** renewable energy source. [1]

[J08/P2/Q1]

Solution

(a)

oil → boiler → **turbine** → **generator** → **transformer** → electrical energy output

(b) The burning of oil produces smoke and toxic gases like carbon oxide and sulphur dioxide which pollute the environment.

(c) (i) The underground oil reserves are finite and exhaustible. Once they run out, they can not be replaced.

(ii) Sun (solar energy).

COMMENT on ANSWER

“(b) The release of smoke, fumes and toxic gases into the air causes global warming, greenhouse effect and acid rain.

(c) (i) Any energy source whose available quantity is finite and exhaustible, also, which can not be replaced easily when it runs out is known as a non-renewable energy source. Oil is an example of such energy sources, as it takes millions of years to form.

(ii) Some other renewable energy sources are:

- wind
- tidal
- geothermal
- biomass
- hydro-electric
- wave ”

Question 5

A river flows over a cliff, producing a waterfall. The water, at a temperature of 7.2 °C, falls 700 m into a pool. The gravitational field strength is 10 N/kg.

(a) Calculate the change in the gravitational potential energy of each kilogram of water due to its fall. [2]

(b) Assume that all of this energy is converted into thermal energy (heat) in the water in the pool. Calculate the temperature of this water when it is in the pool. The specific heat capacity of water is 4200 J/(kg °C). [3]

[N08/P2/Q3]

Solution

(a) Change in Potential energy = mgh $= 1\times10\times700 = 7000$ J

(b) Initial temperature of water at the top = 7.2 °C

Increase in its temperature during the fall, $(\Delta\theta) = \dfrac{Q}{mc} = \dfrac{7000}{1\times4200} = 1.7$ °C

Final temperature of this water in the pool $= 7.2 + 1.7 = 8.9$ °C.

Question 6

Fig. 10.1 shows the horizontal forces as a cyclist travels forwards.

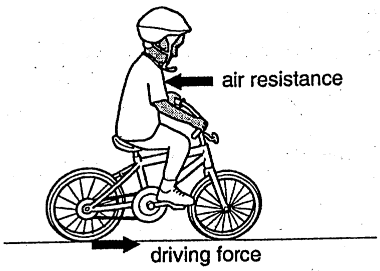


Fig. 10.1

The cyclist produces the driving force that acts on the back wheel.
In this question, you may ignore any frictional force acting on the front wheel.

(a) The bicycle accelerates until a constant speed is reached.

(i) Describe how the size of the air resistance changes during this time. [2]

(ii) Compare the sizes of the two horizontal forces when the bicycle is accelerating. [1]

(b) The total mass of the bicycle and the cyclist is 75 kg. At one instant, the speed of the bicycle is 4.0 m/s, the driving force is 30 N and the air resistance is 20 N.

Calculate

(i) the total kinetic energy of the bicycle and the cyclist, [3]

(ii) the acceleration of the bicycle and the cyclist. [2]

(c) As the bicycle moves, energy is transmitted from the pedals to the back wheel.

Fig. 10.2 shows what happens to the energy input to the pedals.

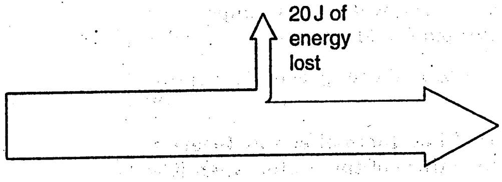


Fig. 10.2

(i) As energy is transmitted to the back wheel, some is lost. Explain how this happens. [2]

(ii) Calculate the efficiency of the bicycle in transmitting energy from the pedals to the back wheel. [2]

(d) Some bicycles are made from low density materials. Explain why this is an advantage. [3]

[J09/P2/Q10]

Solution

(a) (i) As the bicycle accelerates, its speed increases. As a result, the air resistance acting on it also increases and becomes equal to the forward driving force. The bicycle then moves at a constant speed.

(ii) When the bicycle is accelerating, the forward driving force is greater than the backward air resistance acting on it.

COMMENT on ANSWER

“ (a) (ii) When the forward force becomes equal to the backward force of air resistance, then the resultant force becomes zero, and the bicycle moves with zero acceleration and constant speed. ”

(b) (i) $K.E. = \frac{1}{2} m v^2 = \frac{1}{2} \times 75 \times (4.0)^2$

$= \frac{1}{2} \times 75 \times 16 = 600 \text{ J}$

(ii) $a = \frac{F}{m} = \frac{10}{75} = 0.13 \text{ ms}^{-2}$

(c) (i) Some of the energy supplied by the cyclist to the bicycle is lost in the form of heat energy due to the friction at the chain and the axles.

(ii) $\text{Efficiency} = \frac{\text{useful energy output}}{\text{energy input}} \times 100$

$= \frac{380}{400} = 95\%$

(d) A bicycle made from a low density material has a low weight. A light-weight bicycle accelerates more for the some force. Also, it needs a smaller force to climb up a hill. It is more efficient as less energy is wasted due to less friction. It exerts less pressure on ground and sinks less into a soft ground.

COMMENT on ANSWER

"(b) (ii) Resultant force (F) = Forward driving force – backward air resistance = 30 – 20 = 10 N"

Question 7

Fig. 2.1 shows a boat stationary in still water in a narrow tunnel.

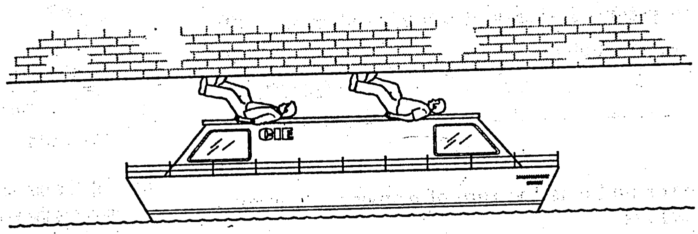


Fig. 2.1

To move the boat, two men lie on the top of it and push against the tunnel roof with their legs.

They exert a total forwards force of 1680 N on the boat.

(a) The men push the boat 50.0 m to the end of the tunnel. Calculate the work done on the boat by the men. [2]

(b) Explain why the kinetic energy of the boat at the end of the tunnel is less than the work done on the boat by the men. [2]

[N09/P2/Q2]

Solution

(a) Work done = Force × distance moved

$= 1680 \times 50.0 = 84000 \text{ J}$

(b) The work done by the men on the boat appears in the form of the kinetic energy of the boat but some of this energy is lost due to the resistance of water.

COMMENT on ANSWER

"(b) When moving through water, the boat has to overcome the water resistance (similar to air resistance). So, some of its energy is lost in the form of internal energy.

Note: The water resistance is also known as the fluid friction of water or the drag force of water."

Question 8

Fig. 2.1 shows a motor used to operate a lift (elevator). There is a man in the lift.

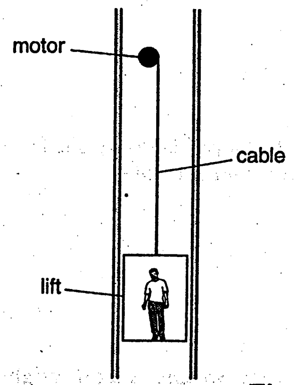


Fig. 2.1 (not to scale)

The input power to the motor is 6200 watts.

(a) Define the *watt*. [2]

(b) The lift and the man have a total mass of 580 kg. The lift moves up a distance of 12 m in 15 s.

(i) Calculate the tension in the cable when the lift is moving at constant speed. [1]

(ii) Calculate the increase in potential energy of the lift and man. [2]

(iii) Calculate the efficiency of the motor. [2]

[J10/P2/Q2]

Solution

(a) The watt is the SI unit of power and it is the rate of transfer of energy of 1 Joule per second, i.e. 1 W = 1 J/s

(b) (i) Tension in cable = weight of the lift = mg

$$= 580 \times 10 = 5800 \text{ N}$$

(ii) Increase in P.E. = $mgh = 580 \times 10 \times 12 = 69600$ J

(iii) Efficiency $= \dfrac{\text{output power}}{\text{input power}} \times 100$

$$= \frac{\frac{69600}{15}}{6200} \times 100 = \frac{4640}{6200} \times 100 = 75\%$$

COMMENT on ANSWER

“(a) By definition

$$P = \frac{\text{work}}{\text{time}}$$

$$= \frac{\text{Energy transfer}}{\text{time}}$$

1 W = 1 J/s

(b) (iii) The output of the motor is the workdone by the motor in raising the lift and the man, which results in the increase in the P.E. Hence, the output power is:

$$\text{power} = \frac{\text{P.E.}}{\text{time}}$$

$$= \frac{69600}{15}$$

$$= 4640 \text{ W}$$ ”

Question 9

Fig. 2.1 illustrates the journey of a cyclist from point A to point B. Points A and B are at the same height.

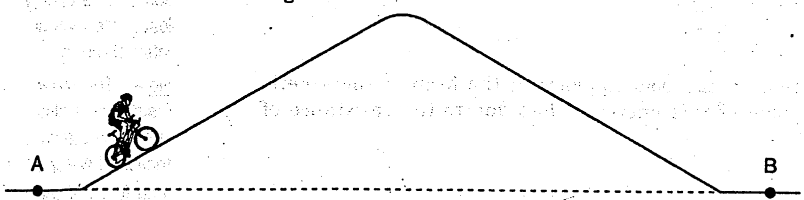


Fig. 2.1

The cyclist starts from rest at A and pedals up and over a hill. Near the bottom of the hill, she starts to brake and comes to rest at B.

(a) Describe the energy changes that take place as she pedals up the hill at constant speed. [3]

(b) Explain how the law of conservation of energy applies to the complete journey from A to B. [1]

(c) At one point in the journey, the gravitational potential energy of the cyclist has increased by 5400 J. The mass of the cyclist is 60 kg. The gravitational field strength is 10 N/kg.

Calculate the height above A of the cyclist at this point. [2]

[J11/P2/Q2]

Solution

(a) During the cyclist's upward movement his chemical energy changes into gravitational potential energy and heat energy.

(b) During the cyclist's movement from $A \rightarrow B$ his energy only changes from one form to another and ends up as heat but the total energy remains constant at all points of his journey.

(c) Gravitational Potential Energy = mgh

$$400 = 60 \times 10 \times h$$

$$h = 9.0$$

$\therefore$ height above A = 9.0 m.

COMMENT on ANSWER

❝ **(b)** Throughout the motion from A to B, no new energy is created nor the present one lost, but only it is converted from one form of energy to another form. ❞

Question 10

Fig. 2.1 shows a skier of mass 85 kg skiing down a very steep slope.

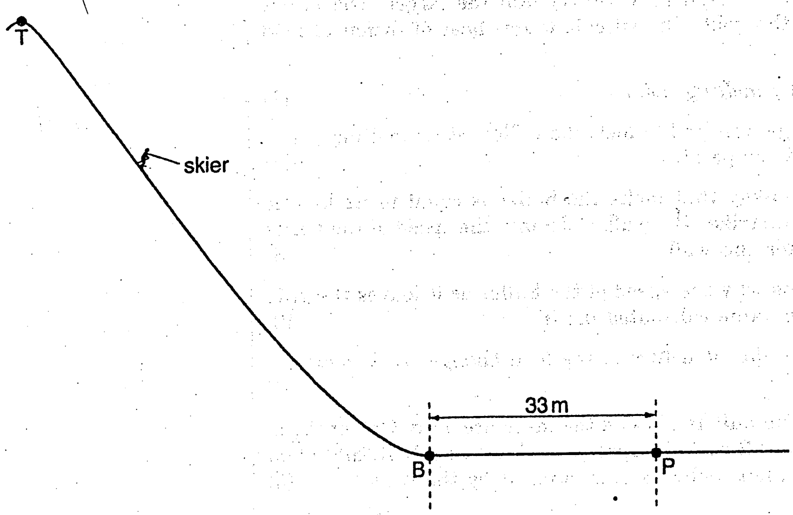


Fig. 2.1 (not to scale)

The skier starts from rest at the top T of the slope. The force of gravity accelerates him down the slope.

When he reaches the bottom B of the slope, his kinetic energy is 5.5×10^4 J.

(a) The gravitational field strength is 10 N/kg. Calculate

(i) the weight of the skier, [1]

(ii) the minimum possible difference in height between T and B. [2]

(b) At B, the skier digs his skis into the snow and stops at the point P after travelling 33 m horizontally.

Calculate the average horizontal force that acts on the skier between B and P. [2]

[N11/P2/Q2]

Solution

(a) (i) $W = mg$

$= 85 \times 10 = 850$ N

(ii) Potential energy at T = Kinetic energy at B

$$mgh = 5.5 \times 10^4$$

$$85 \times 10 \times h = 5.5 \times 10^4$$

$$h = \frac{5.5 \times 10^4}{850} = 64.7 \text{ m}$$

(b) Workdone = Kinetic energy

$$F \times 33 = 5.5 \times 10^4$$

$$F = \frac{5.5 \times 10^4}{33} = 1667 \text{ N}$$

Question 11

A lead bullet of mass 1.9 g is fired from a rifle in a sports club. The bullet misses the target and embeds itself in a wall behind the target. The bullet melts as it is stopped by the wall. The specific latent heat of fusion of lead is 2.2×10^4 J/kg.

(a) State what is meant by *melting point*. [1]

(b) (i) Calculate the energy required to melt the bullet, at its melting point, without raising its temperature. [3]

(ii) Assume that the energy that melts the bullet is equal to its kinetic energy just before it strikes the wall. Calculate the speed of the bullet just before it strikes the wall. [3]

(iii) Suggest two reasons why the speed of the bullet as it leaves the rifle is greater than the value calculated in **(ii)**. [2]

(c) Describe how the molecular structure of the lead changes as it melts. [3]

(d) On another occasion, lead bullets of twice the mass are used. One of these heavier bullets hits the wall with the speed calculated in **(b)(ii)**. State and explain whether this bullet melts as it is stopped by the wall. [3]

[N11/P2/Q10]

Solution

(a) It is the temperature at which a solid starts turning into a liquid.

(b) (i) Energy required, $Q = m \times l$

$$= \frac{1.9}{1000} \times (2.2 \times 10^4)$$
$$= 41.8 \approx 42 \text{ J}$$

(ii) $41.8 = \frac{1}{2}mv^2$

$$41.8 = \frac{1}{2} \times 0.0019 \times v^2$$
$$v^2 = 44000$$
$$v = 209.76 \approx 210 \text{ m/s}$$

(iii) 1. Some energy is lost to do work against air resistance.

2. Some energy is lost to wall as heat energy when the bullet hits the wall.

(c) As the lead melts, the force of attraction between the molecules is reduced. The molecules become further apart and move freely throughout the liquid.

(d) As the mass of the bullets are doubled so they need twice the heat energy to melt. Since the kinetic energy of the bullets is doubled by doubling the mass, so the bullets would melt.

COMMENT on ANSWER

❝ (b) (iii) *Alternatively*:
Some energy is lost to heat the bullet to raise its temperature to melting point.

(d) $ml = \frac{1}{2}mv^2$

or $l = \frac{1}{2}v^2$

therefore the mass is irrelevant. Whatever the mass of bullet, if it is moving with certain speed it melts on hitting the wall. ❞

Question 12

A man of mass 75 kg falls from a platform high above a lake.
Fig. 3.1a shows the man tied to the platform by a long elastic rope (bungee).
Fig. 3.1b shows the man when he has fallen 20 m. After this point the rope begins to stretch.
Fig. 3.1c shows the man at 25 m below the platform where he is first stopped by the rope.

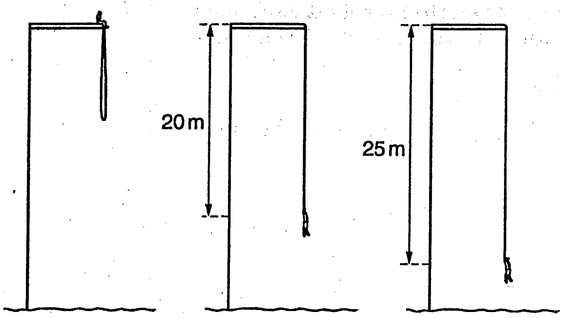


Fig. 3.1 a **Fig. 3.1 b** **Fig. 3.1 c**

(a) As the man falls, his gravitational potential energy changes.

(i) The gravitational field strength is 10 N / kg. Calculate the change in his gravitational potential energy as he falls through 20 m. [2]

(ii) When he is 20 m below the platform, his kinetic energy is equal to the change in his gravitational potential energy calculated in (i). Calculate his speed at this point. [3]

(b) State the energy changes that take place as he falls from 20 m to 25 m below the platform. Ignore the effect of air resistance. [3]

[N12/P2/Q3]

Solution

(a) (i) Change in G.P.E $= mgh$

$$= 75 \times 10 \times 20$$
$$= 15000 \text{ J}$$
$$= 1.5 \times 10^4 \text{ J}$$

(ii) gain in K.E. = loss in P.E

$$\frac{1}{2}mv^2 = 15000$$
$$\frac{1}{2} \times 75 \times v^2 = 15000$$
$$v = 20 \text{ m/s}$$

(b) Gravitational Potential energy changes first into the Kinetic energy and then into the Elastic potential energy.

COMMENT on ANSWER

“(a) (i) & (ii) As the man jumps from the platform, he falls freely till a point 20 m below the platform and his G.P.E. changes into his K.E. After this the elastic rope starts stretching and his K.E. is stored in the elastic rope as the elastic potential energy, till his motion is retarded to a stop at a point 25 m below the platform.”

Question 13

Fig. 10.1 shows an electric train of mass 5.5×10^5 kg.

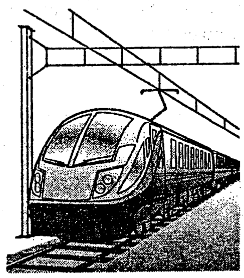


Fig. 10.1

The train is initially at rest. The electric motor exerts a constant force and the train accelerates. Its acceleration decreases until the train reaches a speed of 40 m/s.
The train then continues at this constant speed.

(a) (i) On the axes in Fig. 10.2, sketch a speed-time graph for the train.

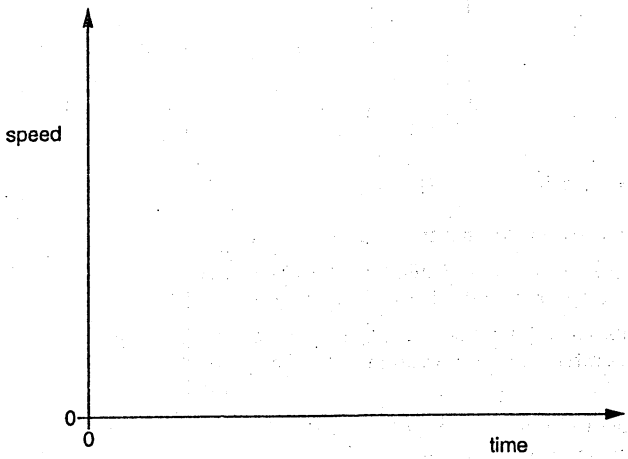


Fig. 10.2 [3]

(ii) Describe how the speed-time graph for the train is used to determine the distance travelled by the train when it is accelerating. [2]

(b) Explain, in terms of the forces acting,

(i) why the acceleration of the train decreases, [2]

(ii) why the train eventually reaches constant speed. [1]

(c) (i) Calculate the kinetic energy of the train when it is travelling at a speed of 40 m/s. [3]

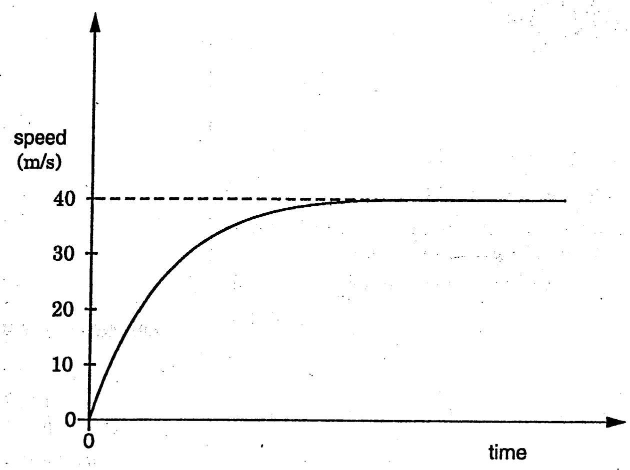
(ii) As the train accelerates to 40 m/s, electrical energy supplied to the motor is converted into kinetic energy of the train. The efficiency of this process is 0.40 (40 %).
Calculate the electrical energy supplied to the motor. [2]

(iii) The electrical energy is generated in an oil-fired power station. Chemical energy in oil is converted into the electrical energy supplied to the motor.
Suggest two places where energy is lost as heat in this process. [2]

[N13/P2/Q10]

Solution

(a) (i)



(ii) The distance travelled by the train when it is accelerating can be found by calculating the area under the graph between t = 0 and the start of the horizontal section.

(b) (i) As the speed of the train increases, the air resistance acting on it also increases. As a result, the resultant force decreases, so the acceleration decreases.

(ii) The air resistance increases until it becomes equal to the forward driving force. The net force then becomes zero and the speed becomes constant.

(c) (i) Kinetic energy $= \frac{1}{2}mv^2$

$= \frac{1}{2} \times (5.5 \times 10^5) \times (40)^2$

$= 4.4 \times 10^8$ J

COMMENT on **ANSWER**

❝ (a) (ii) *Alternative method:* Count the number of squares under the graph from $t = 0$ seconds till the graph is horizontal and multiply it with the area of one square of the graph.
i.e. Distance travelled = No. of squares × area of one square ❞

(ii) $$\text{Efficiency} = \frac{\text{useful energy output}}{\text{total energy input}}$$

$$0.40 = \frac{4.4\times10^8}{\text{total energy input}}$$

$$\text{total energy input} = \frac{4.4\times10^8}{0.40}$$

$$= 1.1\times10^9 \text{ J}$$

(iii) 1. Turbines
2. Transmission cables.

COMMENT on ANSWER

"(c) (iii) *Alternative answer:* The energy is lost as heat at:
— The furnace
— The boiler
— The generator
— The coils of transformer
— The cooling water
— The heat exchanger
— The waste gases
— All parts of the motor."

Question 14

Fig. 4.1 shows a black car going up a hill on a bright, sunny day.

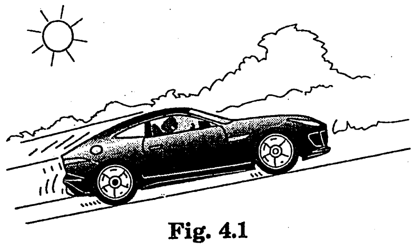


Fig. 4.1

(a) State
 (i) one way in which the car is gaining thermal energy, [1]
 (ii) one way in which the car is losing thermal energy. [1]

(b) The car accelerates up the hill. In addition to the changes in the thermal energy of the car, there are other energy changes taking place.
Describe the other energy changes occurring as the car moves. [3]

[N14/P2/Q4]

Solution

(a) (i) The car is gaining thermal energy by burning fuel and due to friction between its moving parts.
 (ii) Heat is lost to the surroundings.

(b) As the car travels uphill, the chemical energy from its fuel changes into gravitational potential energy and kinetic energy. Because the car is accelerating and gaining height, its kinetic and gravitational potential energy increase.

COMMENT on ANSWER

"(a) (i) The car is also gaining thermal energy by
— the burning of fuel inside engine.
— the friction between tyres and the road.
— radiation coming from the sun."

Question 15

Two different kettles are used to heat water, as shown in Fig. 3.1.

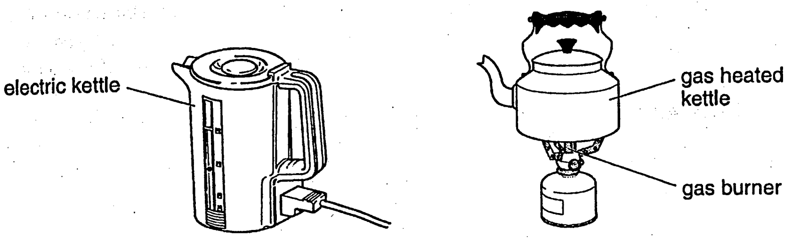


Fig. 3.1

Data for the two kettles is shown in Fig. 3.2.

	energy supplied to the kettle in one minute / J	thermal energy (heat) supplied by the kettle to the water in one minute / J
electric kettle	120 000	95 000
gas heated kettle	130 000	90 000

Fig. 3.2

(a) (i) Calculate the efficiency of the electric kettle. [2]

(ii) Calculate the useful power of the gas heated kettle. [2]

(b) Both kettles contain the same mass of water, at the same initial temperature.
State and explain which kettle brings the water to boiling point first. [1]

(c) The boiling water produces steam at 100 °C.
State one difference between molecules in the steam and molecules in the boiling water. [1]

[J15/P2/Q3]

Solution

(a) (i) Efficiency $= \dfrac{\text{energy output}}{\text{energy input}} \times 100$

$= \dfrac{95000}{120000} \times 100 = 79.17\% \approx 79\%$

(ii) Power $= \dfrac{\text{useful energy}}{\text{time}}$

$= \dfrac{90000}{60} = 1500\text{ W}$

(b) Electric kettle brings the water to boiling point first because its heat energy output per minute which is supplied to the water is more than the gas heated kettle.

(c) The steam molecules have more potential energy than the molecules in the boiling water.

COMMENT on ANSWER

" (a) (i) The energy supplied to the kettle by the electricity = 120,000 J/min (Input).
The energy used by the water = 95000 J/min (output).

(c) Also,
— Steam molecules possess latent heat but the molecules of boiling water do not possess this energy.
— Steam molecules are further apart therefore, they have smaller force of attraction between them as compared to the molecules of boiling water.
— The steam molecules have comparatively less strong bonds between them as compared to molecules of boiling water. "

Question 16

Water is transported to a village in a tank pulled by a tractor.
Fig. 1.1 shows the tank being pulled by a tractor.

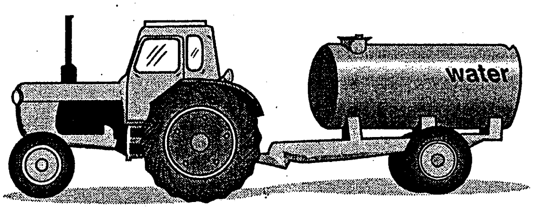


Fig. 1.1

The combined mass of the tractor and the tank is 4100 kg when the tank is empty and 6500 kg when the tank is full of water.

(a) The density of water is 1000 kg/m³.
Calculate the volume of water in the tank when it is full. [2]

(b) At the start of the journey, the tractor and tank accelerate from rest along a straight, horizontal road. As their speed increases, one form of energy is decreasing.

(i) State the name of the form of energy that is decreasing. [1]

(ii) Explain what happens to this energy. [2]

(c) The village is located on a mountain at a vertical height of 850 m above the water supply. The gravitational field strength g is 10 N/kg.
Calculate the gravitational potential energy gained by the water as it is transported from the supply to the village. [2]

[N15/P2/Q1]

Solution

(a) Mass of water = 6500 − 4100 = 2400 kg.

$$\text{volume of water} = \frac{\text{mass}}{\text{density}}$$

$$= \frac{(6500-4100)}{1000} = \frac{2400}{1000} = 2.4\text{ m}^3$$

(b) (i) Chemical energy

(ii) Some of the chemical energy of the fuel is converted into the kinetic energy of the tractor and the rest is converted into the thermal energy which in turn becomes the kinetic energy of the surrounding air.

(c) G.P.E. gained = mgh

$$= 2400 \times 10 \times 850$$

$$= 2.04 \times 10^7\text{ J}$$

COMMENT on ANSWER

❝ (b) (i) As the tractor moves, the quantity of the fuel in the tractor decreases. Hence, the chemical energy of the fuel decreases. ❞

Topic 5 Principles Of Moments

MCQ Section

1. If a nut and bolt are difficult to undo, it may be easier to turn the nut by using a longer spanner.

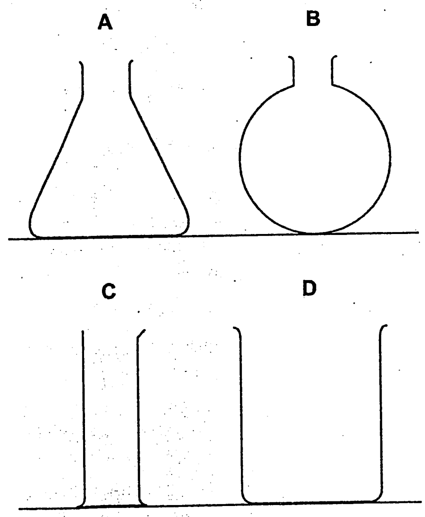
This is because the longer spanner gives

A a larger turning moment.
B a smaller turning moment.
C less friction.
D more friction.

[J06/P1/Q8]

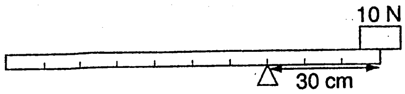
2. Some containers are made from thin glass.

Which empty container is the **most** stable?



[J06/P1/Q9]

3. A uniform bar of length 1.0 m is supported 30 cm from one end. In order to balance the bar, a weight of 10 N is glued on the end.



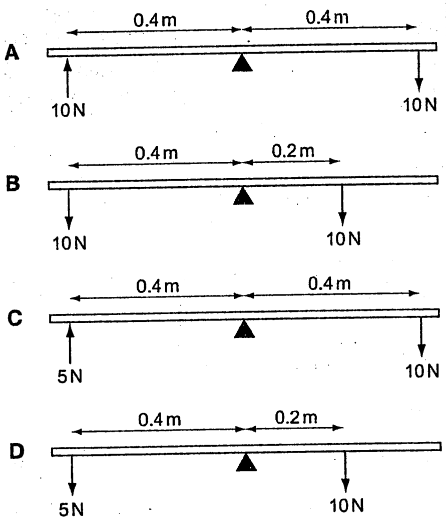
What is the weight of the bar?

A 4.3 N **C** 10 N
B 7.5 N **D** 15 N

[N06/P1/Q7]

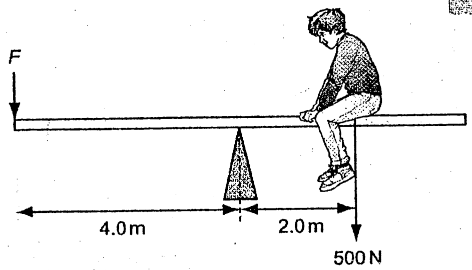
4. Forces are applied to a uniform beam pivoted at its centre.

Which beam is balanced?



[J07/P1/Q7]

5. The diagram shows a boy of weight 500 N sitting on a see-saw. He sits 2.0m from the pivot.



What is the force F needed to balance the see-saw?

A 250 N **B** 750 N
C 1000 N **D** 3000 N

[N07/P1/Q7]

6. A flat lamina is freely suspended from point P.

The weight of the lamina is 2.0 N and the centre of mass is at C.

MCQ Answers

1. A As turning moment = Force x perpendicular distance, so turning moment ∝ perpendicular distance. The length of the spanner is the perpendicular distance.

2. A An object is most stable if its centre of gravity is lowest and its base is widest. The container A has lowest C.G. and the base of larger width as compared to the others.

3. D Since the bar is uniform, the weight is at the geometrical centre which is the half-way point. Using the principle of moments and taking moments about the support, clockwise moments = anticlockwise moments. Hence $(W \times (50-30)) = (10 \times 30)$, $W = 15$ N. Note that all distances must be calculated from the support.

4. D The beam is in equilibrium because anticlockwise moment = clockwise moment

$5 \times 0.4 = 10 \times 0.2$

$2.0 \text{Nm} = 2.0 \text{Nm}$

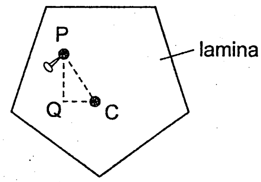
5. A Applying the principle of moments:

$F_1 \times d_1 = F_2 \times d_2$

$F \times 4.0 = 500 \times 2.0$

$F = 250$ N

PC = 0.50 m
PQ = 0.40 m
QC = 0.30 m



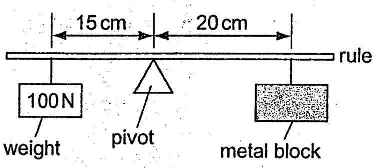
The lamina is displaced to the position shown.

What is the moment that will cause the lamina to swing?

A 0.60 Nm clockwise
B 0.80 Nm anticlockwise
C 1.0 Nm clockwise
D 1.0 Nm anticlockwise

[N05/P1/Q9]/[J08/P1/Q8]

7. The diagram shows a uniform half-metre rule balanced at its mid-point.



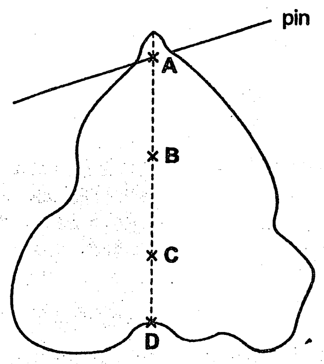
What is the weight of the metal block?

A 50 N	**B** 75 N
C 100 N	**D** 150 N

[N08/P1/Q7]

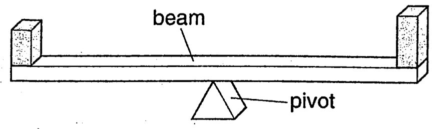
8. A piece of uniform card is suspended freely from a horizontal pin.

At which of the points shown is its centre of gravity?



[N08/P1/Q8]

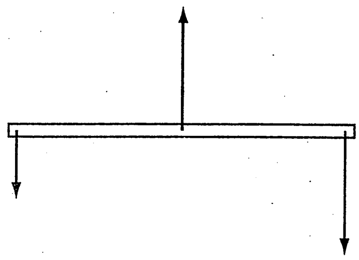
9. Two blocks are placed on a beam which balances on a pivot at its centre. The weight of the beam is negligible.



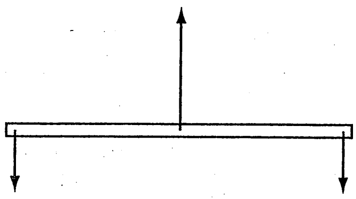
Which diagram shows the forces acting on the beam?

(The length of each arrow represents the size of a force.)

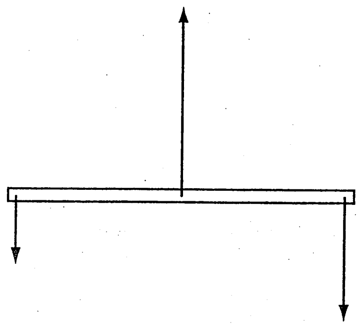
A



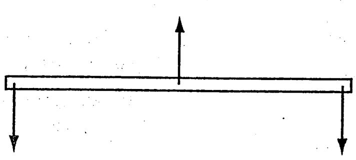
B



C



D



[J09/P1/Q8]

Thinking Process

MCQ Answers

6. A The weight of the lamina acts vertically downwards at the centre of gravity C and the lamina is pivoted at P. Hence, the moment of the weight of the lamina about the pivot P = force × perpendicular distance
= (2.0) (0.30) = 0.60 Nm
Note that QC is the correct perpendicular distance between the line of force (weight) and the pivot.

7. B Anticlockwise moment = clockwise moment

$$100 \times 15 = W \times 20$$

$$W = \frac{1500}{20} = 75\text{ N}$$

8. C Fact.

9. B As the beam is in equilibrium, anticlockwise moment = clockwise moment.

$$F_1 \times d_1 = F_2 \times d_2$$

Since $d_1 = d_2$ (see the diagram) ∴ $F_1 = F_2$

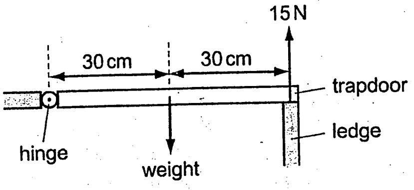
Hence, the arrows of same size represent the forces F_1 and F_2.

Also, total upward force = total downward force.

So, the size of the upward force at the pivot is equal to the total length of the two arrows acting downwards.

MCQ Answers

10. A wooden trapdoor is hinged along one side and, when closed, is supported on the other side by a ledge.



When the trapdoor is closed, the ledge exerts an upward force of 15 N on the trapdoor. The gravitational field strength is 10 N / kg.
What is the mass of the trapdoor?

A 1.5 kg **B** 3.0 kg
C 30 kg **D** 150 kg

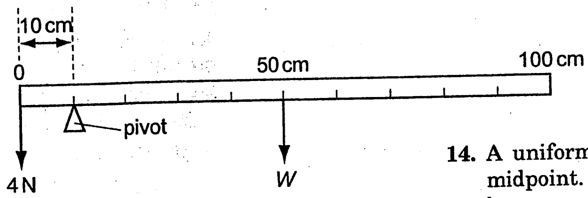
[J10/P1/Q7]

11. What affects the stability of an object?

A only its base area
B only its base area and the location of its centre of mass
C only its weight and its base area
D only the location of its centre of mass

[N10/P1/Q8]

12. A uniform metre rule is balanced by a 4 N weight as shown in the diagram.

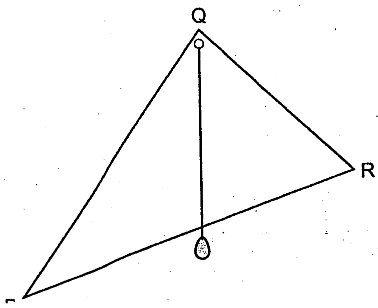


What is the weight *W* of the metre rule?

A 1 N **B** 4 N
C 16 N **D** 40 N

[N10/P1/Q12]

13. A student finds the centre of mass of a triangular lamina PQR.



He drills a small hole at Q. He suspends the lamina from a pin through the hole at Q so that the lamina swings freely. He then hangs a plumb-line from the pin at Q, as shown. He marks the position of the plumb-line on the lamina.

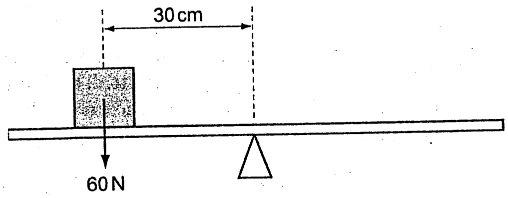
To determine the location of the centre of mass, the student then repeats the experiment but with one change.

What is the change?

A He suspends the lamina from the hole at Q, with R on the left and P on the right.
B He suspends the lamina from a pin through a hole at R.
C He uses a heavier weight on the plumb-line.
D He uses a longer plumb-line.

[J11/P1/Q9]

14. A uniform beam is balanced at its midpoint. An object is placed on the beam, as shown.



Which force will rebalance the beam?

A 30 N acting upwards, 60 cm to the left of the midpoint
B 30 N acting upwards, 60 cm to the right of the midpoint
C 45 N acting downwards, 45 cm to the right of the midpoint
D 90 N acting downwards, 20 cm to the left of the midpoint

[J11/P1/Q7]

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10. B Applying the Principle of moments
Anti-clockwise moment = Clockwise moment

$F_1 \times d_1 = F_2 \times d_2$

$W \times 30 = 15 \times 60$

$W = \frac{15 \times 60}{30} = 30\text{N}$

Hence, the mass of the trap door is:

$m = \frac{W}{g} = \frac{30}{10} = 3.0\text{kg}$

11. B Stability of body $\propto \frac{\text{size of its base area}}{\text{height of its centre of mass}}$

12. A Anticlockwise moment = clockwise moment

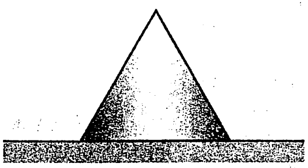
$F_1 \times d_1 = F_2 \times d_2$

$4 \times 10 = W \times 40$

$W = 1\text{ N}$

13. B The experiment can be repeated by suspending the lamina from a hole at R to draw another vertical line so that it intersects the first line drawn from the hole Q to locate the centre of mass of the lamina.

15. A metal cone with a circular base is placed on a flat surface.



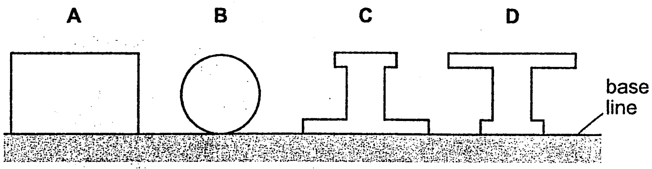
The stability of the cone depends on

A its weight only.
B the diameter of its base and the position of its centre of mass.
C the diameter of its base only.
D the position of its centre of mass only.

[N11/P1/Q12]

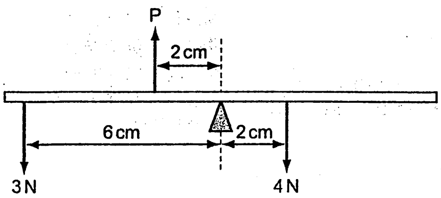
16. The diagram shows four shapes, cut from the same piece of card.

Which shape has its centre of mass nearest to the base line?



[J12/P1/Q8]

17. The diagram shows a uniform balanced beam, pivoted about its centre.

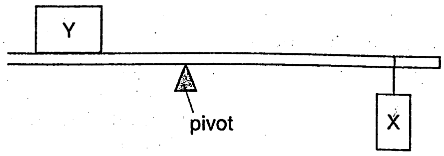


What is the value of force P?

A 5N **B** 7N
C 10N **D** 13N

[J12/P1/Q7]

18. An object Y is in a fixed position on a rod. A weight X is moved and the position of a pivot is adjusted until the rod balances on the pivot, as shown.



The experiment is repeated in a region where the gravitational field strength is lower.

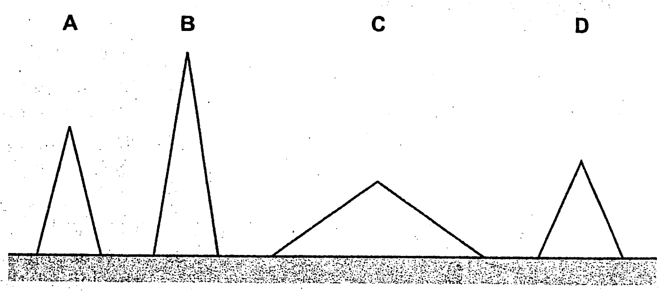
What is done to keep the rod balanced?

	pivot	X
A	move left	no movement
B	move right	move left
C	no movement	move right
D	no movement	no movement

[N12/P1/Q7]

19. Four solid uniform cones have equal weight. They are placed on a bench as shown in the scale diagram.

Which cone is the most stable?



[N12/P1/Q8]

MCQ Answers

14. A The diagram shows a 60 N force causing an anti-clockwise moment of 60 × 30 = 1800 Ncm, which can only be balanced by a clockwise moment of 1800 Ncm caused by a force of 30N acting upwards at 60cm on the left of the pivot.

15. B An object is most stable if its centre of mass is lowest and its base is widest.

16. C Marking the C.M. of all the shapes and comparing, the C.M of the shape 'C' is found to be nearest to the base line. This is because the part of this shape in contact with the base line is wider and more of its mass is concentrated nearest to the base line.

17. A By the principle of moments,

Anticlockwise Moment = Clockwise Moment

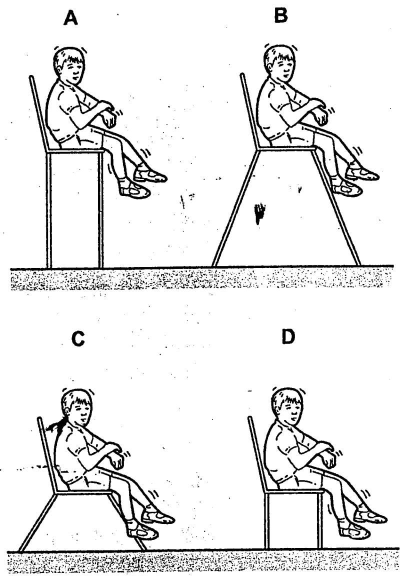
$F_1 \times d_1 = (F_2 \times d_2) + (F_3 \times d_3)$

$3 \times 6 = (4 \times 2) + (P \times 2)$

$18 = 8 + 2P$

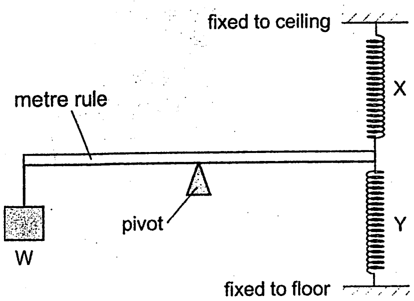
$P = 5\,N$

20. Which chair is the **least** stable if the child moves?



[J13/P1/Q9]

21. Two stretched springs X and Y are attached to one end of a metre rule as shown. A weight W is hung from the other end. A pivot is at the centre of the rule.



The weight W is moved towards the pivot.

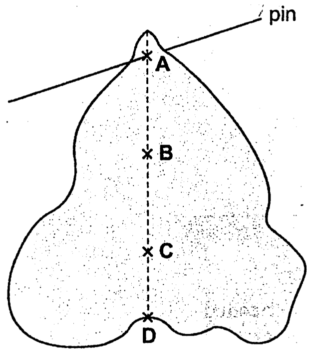
How does the extension of each spring change?

	spring X	spring Y
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

[N13/P1/Q7]

22. A piece of uniform card is suspended freely from a horizontal pin.

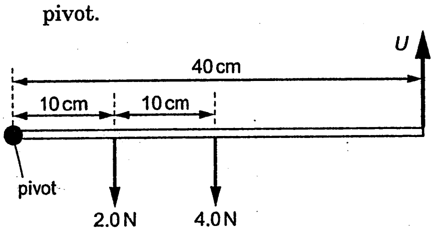
Which point is its centre of mass?



[N13/P1/Q8]

23. A beam of length 40 cm is pivoted at one end.

The weight of the beam is 4.0 N and acts at a point 20 cm from the pivot. A 2.0 N weight hangs 10 cm from the pivot.



An upward force U is needed to keep the beam horizontal.

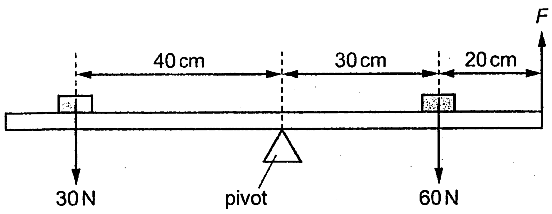
What is the size of U?

A 0.5 N **B** 1.5 N

C 2.5 N **D** 6.0 N

[J14/P1/Q9]

24. A uniform beam is pivoted at its centre. Two weights are placed on the beam in the positions shown and the beam is balanced by an upward force F.



What is the size of F?

A 6 N **B** 12 N

C 30 N **D** 60 N

[J15/P1/Q9]

Thinking Process

MCQ Answers

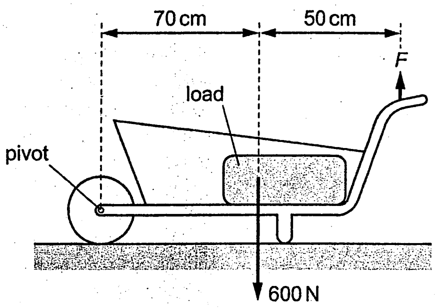
18. D At the new place, the change in the gravitational field strength will have the same affect on the weights of both the objects X and Y. Hence, neither the pivot nor the weight X need any adjustment in their positions and the rod remains balanced as before.

19. C The object **C** is the most stable because its C.G. is the lowest and its base is the widest as compared to the other objects.

20. A An object is most stable if its C.G. is lowest and its base is widest. The chair **A** is least stable because it has the highest C.G. and the base of least width as compared to the others.

21. C Initially, the metre rule is balanced but on moving the weight W towards the pivot, the anticlockwise moment decreases and as a result, the clockwise moment becomes greater than the anti-clockwise moment. Thus, the right end of the metre rule tilts downwards, which increases the extension in the spring X and decreases the extension in spring Y.

25. The total weight of the load and the wheelbarrow shown is 600 N.



What is the size of force F needed just to lift the loaded wheelbarrow?

A 350 N **B** 430 N

C 600 N **D** 840 N

[N15/P1/Q11]

22. C The C.G. always lies on the vertical line drawn from the point of suspension such that the mass of the body is equally divided on the opposite sides of this point.

23. C Sum of clockwise moments = sum of anticlockwise moments.

$2\times10+4\times20=U\times40$

$U=\frac{100}{40}=2.5$ N

24. B As the beam is in equilibrium, so, anticlockwise moments = clockwise moments

$(F_1\times d_1)+(F_3\times d_3)=(F_2\times d_2)$

$(30\times40)+(F\times50)=(60\times30)$

$1200+50F=1800$

$50F=600$

$F=12$ N

25. A Anti-clockwise moment = clockwise moment

$F_1\times d_1=F_2\times d_2$

$F\times120=600\times70$

$F=350$ N

Topic 5 Principles Of Moments

THEORY Section

Question 1

Fig. 9.1 shows a sheet of metal suspended from a hole in one corner at A. The weight of the metal is 0.10 N and the centre of gravity is at B. The diagram is drawn full scale.

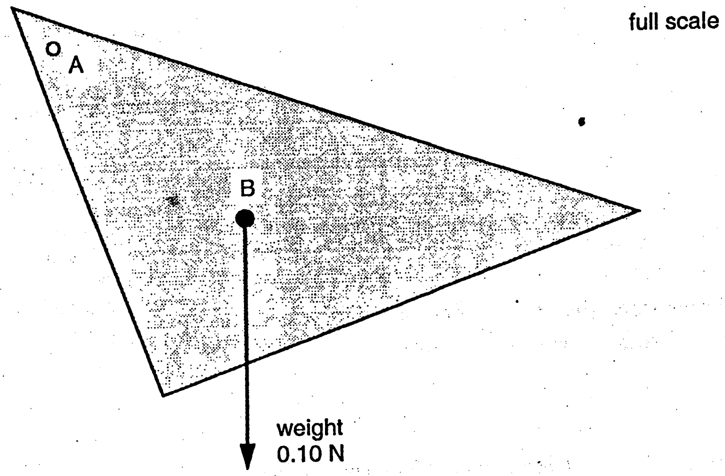


Fig. 9.1

(a) The sheet turns because of the moment of the weight about point A.

  (i) State what is meant by the *moment* of a force. [2]

  (ii) Using a measurement taken from Fig. 9.1, calculate the moment of the weight about point A. On Fig. 9.1, indicate the measurement that you make. Give the unit of your final answer. [3]

(b) The sheet in Fig. 9.1 swings freely and comes to rest.

  (i) Sketch a diagram of the sheet in its final rest position. Mark points A and B on your diagram. [1]

  (ii) Explain why the sheet remains at rest in this position. [2]

(c) The metal sheet is placed on a table. State two reasons why it is more stable when it is placed flat on the table than when it is placed on the table in a vertical position. [2]

[N06/P2/Q9]

Solution

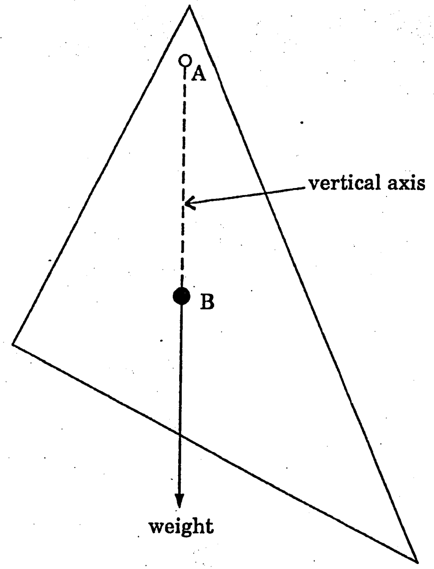
(a) (i) Moment of a force refers to the turning effect of the force and is equal to the product of the force and perpendicular distance from a point to the line of action of the force.

(ii) moment = $0.10 \times 2.7 = 0.27$ N cm

COMMENT on ANSWER

“(a) (ii) Measure the horizontal distance from point A to the line of action of weight of the sheet. This distance is the perpendicular distance. You can use the distance in cm or m.”

(b) (i)



(ii) The upwards force at the pivot A balances the weight of sheet and there is no net moments about the pivot.

(c) 1. The centre of gravity is lower when the sheet is flat on table.
2. The base area of the sheet is larger when flat on table.

COMMENT on ANSWER

" (b) (i) In the final rest position, the centre of the gravity of the sheet is vertically below the hole A.

(c) An object is more stable if its centre of gravity is lowered or its base area is increased. "

Question 2

Fig. 2.1 shows a device for punching holes in a piece of paper. A person applies a force F at the end of the arm. Just before the hole is made in the paper, the arm is at rest.

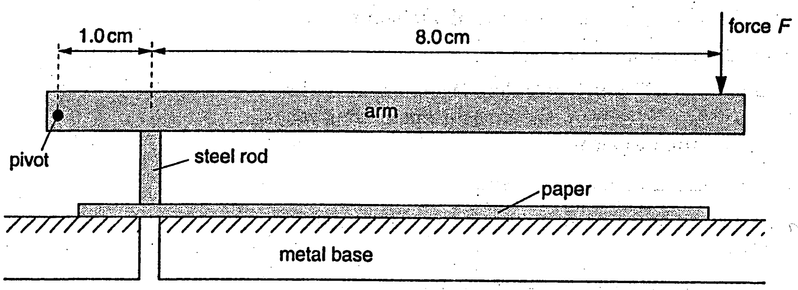


Fig. 2.1

(a) Just before the hole is made, the force upwards on the steel rod is 7.2 N. Calculate the value of F. Use the distances marked on Fig. 2.1. [2]

(b) The steel rod pushes the paper into the hole in the metal base with a force of 7.2 N.
The end of the steel rod has an area of 2.8×10^{-5} m^2.
Calculate the pressure exerted on the paper.
State the formula that you use in your calculation. [2]

(c) The force downwards on the paper due to the rod and the force upwards on the rod due to the paper are related by Newton's third law. State Newton's third law. [1]

[J08/P2/Q2]

Solution

(a) As the arm is in equilibrium

Anticlockwise moment = clockwise moment

$$7.2 \times 0.01 = F \times 0.09$$

$$F = 0.8 \text{ N}$$

(b) $\text{Pressure} = \dfrac{\text{Force}}{\text{Area}}$

$$= \frac{7.2}{2.8 \times 10^{-5}}$$

$$= 2.57 \times 10^{5} \text{ Pa} \approx 2.6 \times 10^{5} \text{ Pa}$$

(c) Every action has a reaction which is equal in magnitude but opposite in direction.

COMMENT on ANSWER

"(a) Take both the distances from the force to the pivot and convert them into metres."

Question 3

Fig. 2.1 shows a wooden walking-stick that has a metal head and a rubber foot. It balances on a pencil placed 0.50 m from its rubber foot.

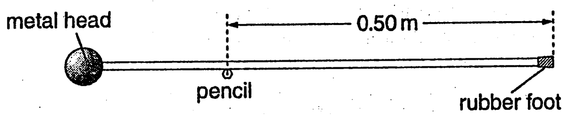


Fig. 2.1

(a) State the distance between the centre of mass of the walking-stick and the end of the rubber foot. [1]

(b) The pencil is moved along the walking-stick towards its rubber foot. State and explain the motion of the walking-stick. [3]

[N08/P2/Q2]

Solution

(a) distance = 0.50 m

(b) When the pencil (pivot) is moved towards the rubber foot of the walking-stick, the moment arm on the left of the pivot increases and on the right it decreases. As a result, the anticlockwise moment acting on the stick becomes greater than the clockwise moment. So the metal head of the stick tilts downwards and the rubber foot moves upwards.

Question 4

Fig. 7.1 shows a rectangular concrete slab of weight 18 000 N. It rests on a brick wall and is the roof of a bus shelter. The concrete slab is 3.0 m wide.

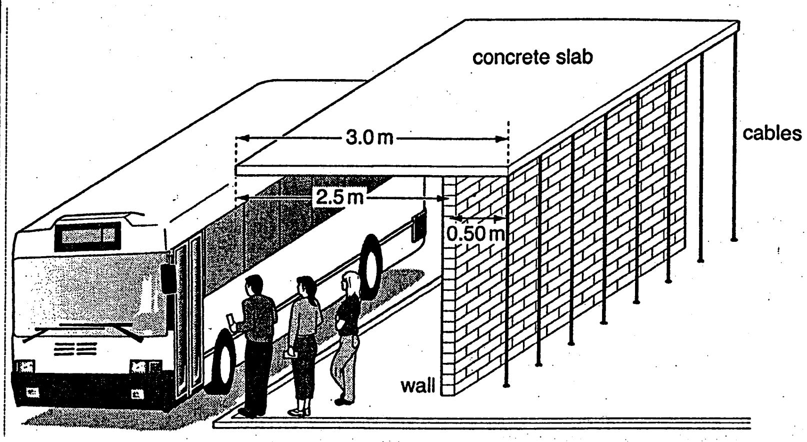


Fig. 7.1

The wall is 2.5 m from the front of the concrete slab and 0.50 m from the back. The cables behind the shelter pull downwards and stop the slab toppling forwards.

(a) The concrete slab is of uniform thickness and density. Determine the perpendicular distance between the wall and the centre of mass of the slab. [1]

(b) (i) State the principle of moments. [2]

(ii) Calculate the total downward force exerted by the cables on the slab. [2]

[N09/P2/Q7]

Solution

(a) distance = 1.0 m

(b) (i) For a body in equilibrium,

Anticlockwise moment = Clockwise moment

i.e. $F_1 \times d_1 = F_2 \times d_2$

(ii) $F_1 \times d_1 = F_2 \times d_2$

$18000 \times 1.0 = F \times 0.5$

$\therefore$ Force exerted by cables $= \dfrac{18000 \times 1.0}{0.5} = 36,000\text{ N}$

226

Question 5

Fig. 3.1 shows a firefighter of total weight 840 N in equilibrium at the top of a ladder that is pivoted at point P.

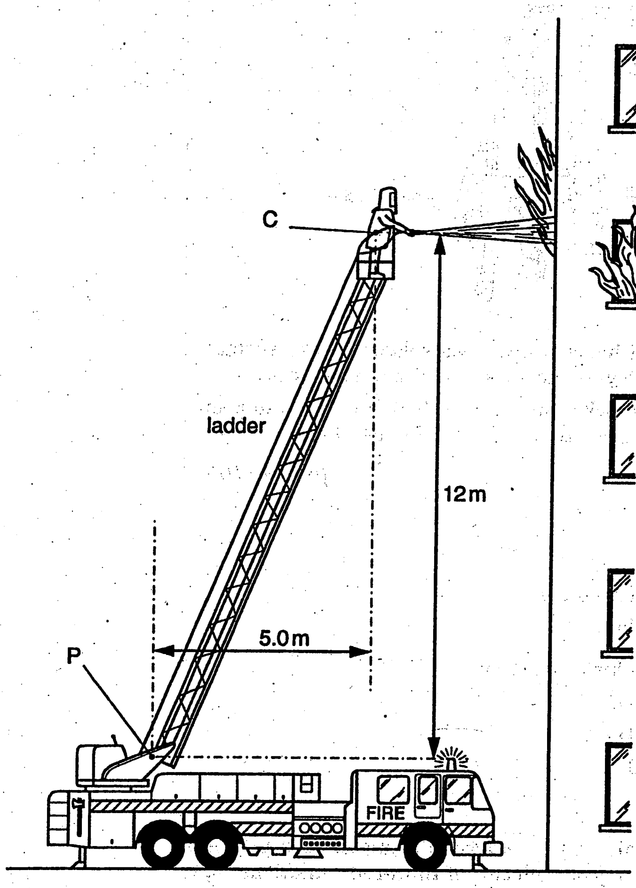


Fig. 3.1

The ladder leans towards a burning building at an angle such that the centre of gravity C of the firefighter is 12 m above and 5.0 m to the right of P. The firefighter holds a hose that directs a high-speed jet of water horizontally into a burning building.

(a) **(i)** Calculate the moment *M* of the firefighter's weight about P. **[2]**

(ii) The jet of water causes a horizontal force *R* on the firefighter that acts towards the left, through C. This opposes the turning effect of his weight. Calculate the size of *R* that, on its own, ensures that *M* is exactly cancelled. **[1]**

(iii) Suggest a third force that has a turning effect about P on the ladder. **[1]**

(b) Fig. 3.2 shows the firefighter.

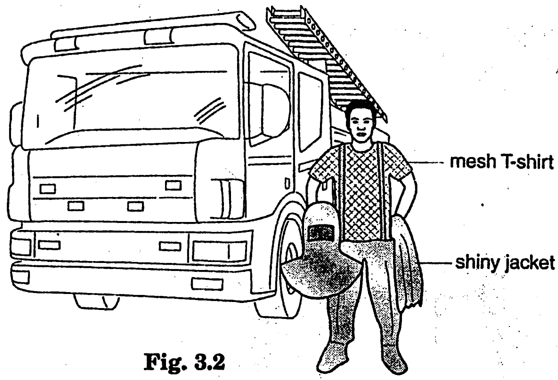


Fig. 3.2

The jacket of his protection suit has a shiny, silver-coloured outer surface. Underneath it he wears a loosely-woven mesh T-shirt (string vest).

Explain how wearing the shiny jacket and the mesh T-shirt helps to keep the firefighter cool when he is close to a source of intense heat. [4]

[N10/P2/Q3]

Solution

(a) (i) Moment = Force × Perpendicular distance

$= 840 \times 5.0 = 4200$ Nm

(ii) Anticlockwise moment = Clockwise moment

$$F_1 \times d_1 = F_2 \times d_2$$
$$R \times 12 = 840 \times 5.0$$
$$R = 350 \text{ N}$$

(iii) Weight of the Ladder.

(b) The mesh of the T-shirt traps air which is a good insulator and prevents convection. The shiny surface is a good reflector of Infra-red radiations so, it reflects the radiant heat away from his body. The shiny surface is also a poor absorber of heat.

Question 6

A builder needs to determine the density of a solid cube of wood.
He places the 50 cm mark of a uniform metre rule on a pivot, so that the rule balances.
He then places the cube on the rule with its centre of gravity directly above the 75 cm mark. A mass of 0.050 kg is moved along the rule until balance is restored. This is shown in Fig. 1.1.

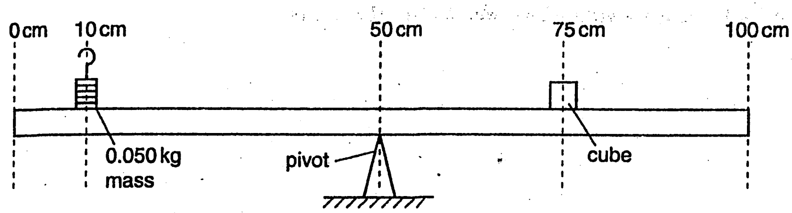


Fig. 1.1 (not to scale)

The rule is balanced when the 0.050 kg mass is at the 10 cm mark.

(a) Calculate the mass of the cube. [3]

(b) The cube has a volume of 1.6×10^{-4} m^3. Determine the density of the wood. [2]

[N11/P2/Q1]

Solution

(a) Applying the principle of moments,

Anticlockwise moment = Clockwise moment

$$W_1 \times x_1 = W_2 \times x_2$$
$$m_1 g \times x_1 = m_2 g \times x_2$$
$$m_1 \times x_1 = m_2 \times x_2$$
$$0.050 \times 40 = m_2 \times 25$$
$$m_2 = \frac{0.050 \times 40}{25} = 0.080\,\text{kg}$$

$\therefore$ mass of the cube = 80 g

(b)
$$\text{Density} = \frac{\text{mass}}{\text{volume}} = \frac{0.080}{1.6 \times 10^{-4}} = 500\ \text{kg/m}^3$$

Question 7

(a) Describe an experiment to verify *the principle of moments*. You may include a diagram in your answer. [4]

(b) Fig. 1.1 shows a spanner tightening a nut.

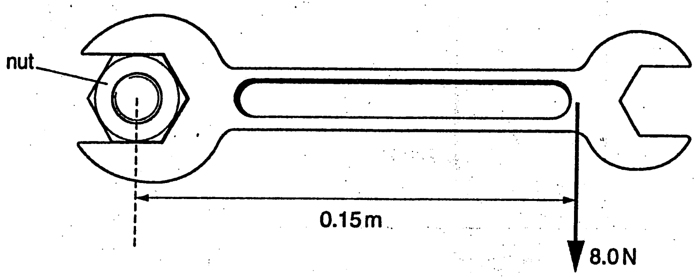


Fig. 1.1

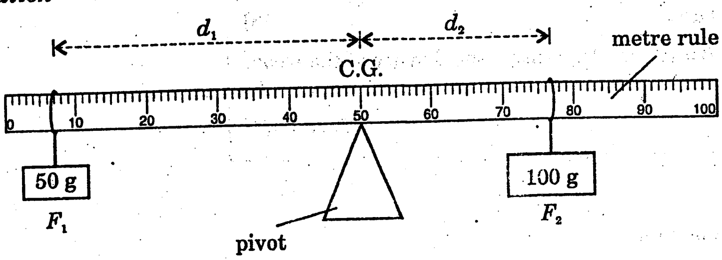
A force of 8.0 N is applied to the spanner at a perpendicular distance of 0.15 m from the centre of the nut.

Calculate the moment of the force acting on the nut. [2]

[N12/P2/Q1]

Solution

(a)



Set up the apparatus as shown with a pivot at 50 cm mark. Balance the metre rule by adjusting the distances d_1 and d_2. Calculate the anticlockwise moment ($F_1 \times d_1$) and the clockwise moment ($F_2 \times d_2$). If it is found that

Anticlockwise moment = clockwise moment

i.e. $F_1 \times d_1 = F_2 \times d_2$

then, it verifies the principle of moments.

At the end, use the weights of different values and repeat the experiment.

(b) Moment = force × moment arm

$= 8.0 \times 0.15$

$= 1.2$ Nm

COMMENT on ANSWER

" (a) In this experiment the pivot is placed under the C.G. of the metre rule which is normally at 50 cm but it should be confirmed by balancing it on a pivot without hanging the weights before starting the experiment. "

Question 8

(a) Explain what is meant by the *moment of a force*. [2]

(b) Fig. 2.1 shows a system for raising a heavy piece of metal into a vertical position.

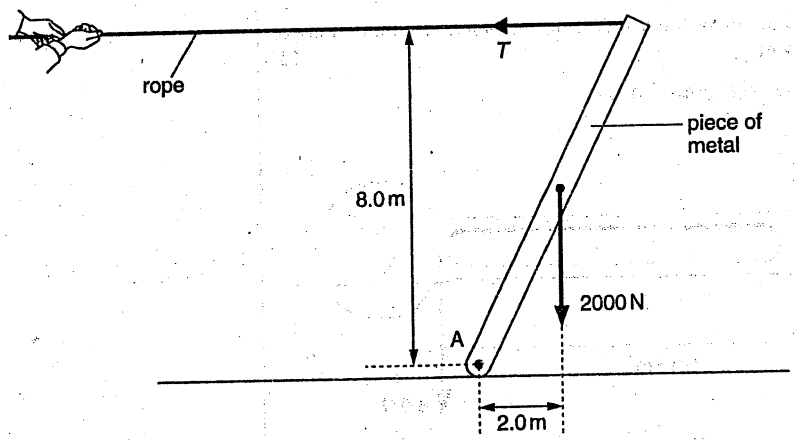


Fig. 2.1 (not to scale)

A man pulls on the rope with a horizontal force *T*. The piece of metal has a weight of 2000 N and is freely pivoted at A. The system is in equilibrium.

(i) By taking moments about A, calculate *T*. [2]

(ii) The force *T* and the force that the rope exerts on the man are related by Newton's third law. State the relationship between these forces. [2]

[J13/P2/Q2]

Solution

(a) The moment of a force means the turning effect of a force which is equal to the magnitude of the force multiplied by the perpendicular distance from the line of action of the force to the pivot.

(b) (i) Anticlockwise moment = clock wise moment

$$T \times 8 = 2000 \times 2$$
$$T = 500 \text{ N}$$

(ii) The two forces are equal in magnitude but opposite in direction.

Question 9

(a) State what is meant by the *moment of a force*. [2]

(b) The anchor of a sailing ship has a mass of 350 kg. Six sailors raise the anchor from the sea-bed by turning a large axle. They push the handles attached to the axle and it rotates. The anchor is on the end of a chain that winds on to the rotating axle.

Fig. 9.1 shows the sailors lifting the anchor.

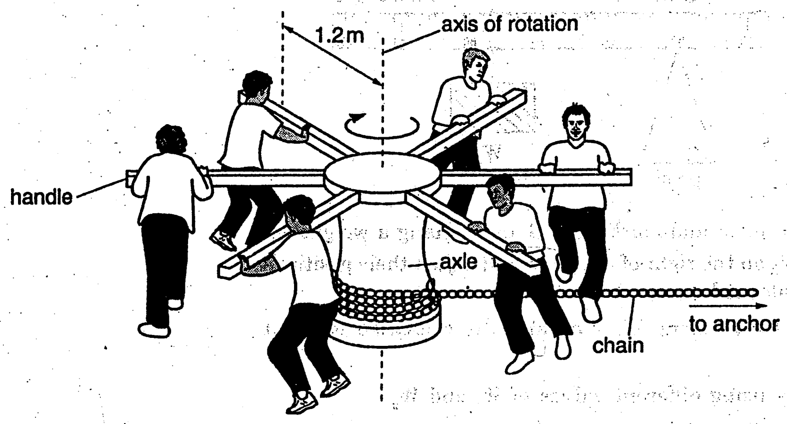


Fig. 9.1

Each of the sailors exerts a force of 750 N on his handle at a distance of 1.2 m from the axis of rotation. The axle rotates through one complete revolution and the anchor is lifted through a distance of 160 cm.

The gravitational field strength g is 10 N / kg.

(i) Calculate

1. the total moment exerted on the axle by the six sailors, [2]
2. the gravitational potential energy gained by the anchor as the axle rotates through one complete revolution. [3]

(ii) The work done on the axle by the sailors is very much larger than the gravitational potential energy gained by the anchor.

State and explain how energy is wasted. [2]

(iii) Explain why the power produced by the sailors is larger when the anchor is lifted at a faster rate. [2]

(c) Describe, with the aid of a labelled diagram, how to verify the principle of moments. [4]

[N13/P2/Q9]

Solution

(a) The moment of a force is the turning effect of a force which is equal to the product of the force and the perpendicular distance between the force and the pivot.

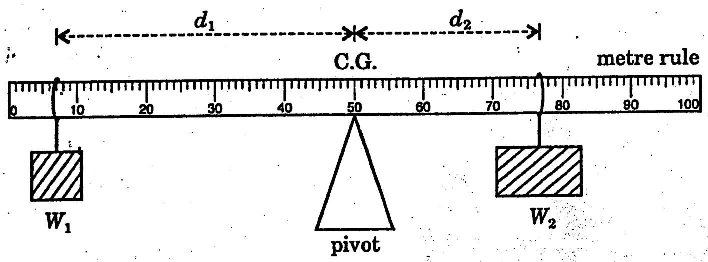
(b) (i) 1. Total moment $= (750 \times 1.2) \times 6$
$= 5400$ Nm

2. Gravitational potential energy $= mgh$
$= 350 \times 10 \times 1.6$
$= 5600$ J

(ii) Some of the work done by the sailors is wasted as heat in overcoming the friction at the axle.

(iii) As power $\propto \frac{1}{\text{time}}$, doing the same amount of work in a shorter time produces a larger power.

(c)



Balance a metre rule on a pivot and mark its C.G. on it. Hang a weight W_1 on the left and a weight W_2 on the right of the pivot and adjust their positions until the metre rule is balanced again as shown.

Calculate the anticlockwise moment $W_1 \times d_1$ and the clockwise moment $W_2 \times d_2$.

Repeat the experiment by using different values of W_1 and W_2

It is found that, $W_1 \times d_1 = W_2 \times d_2$.

COMMENT on ANSWER

" (b) (ii) Alternatively, the following reasons can be given:
— Some work is done against the water resistance.
— Some work has to be done to raise the chain also. "

Question 10

In hospitals, doctors and nurses operate taps with their elbows in order to avoid contamination.

Fig. 2.1 shows a hospital tap with a long handle.

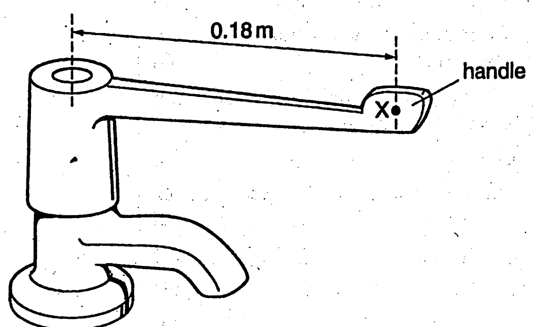


Fig. 2.1

(a) A nurse applies a force of 2.5 N at a point X on the handle, 0.18 m from the axis of the tap.

(i) Calculate the maximum moment about the axis that this force can produce. [2]

(ii) The moment produced by the nurse is less than this maximum value. Suggest one reason why this is so. [1]

(b) State how the force needed to operate the tap is affected by the length of the handle. [1]

[N14/P2/Q2]

Solution

(a) **(i)** Maximum moment $= 2.5 \times 0.18 = 0.45$ Nm

(ii) The force applied by the nurse is not at right angles to the tap.

(b) To produce the same moment, a handle with a longer length would require a smaller force to be exerted on it.

COMMENT on ANSWER

" (a) (i) The maximum moment will be produced when the force exerted on the handle is perpendicular to the tap. "

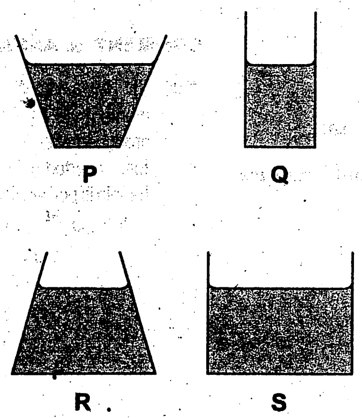
Thinking Process

MCQ Answers

Topic 6 Pressure

MCQ Section

1. The diagrams show, to the same scale, the vertical sections of a set of circular vessels. Each vessel contains the same depth of water.



Which of the following statements is correct?

A The water exerts the greatest pressure on the base of vessel **P**.

B The water exerts the greatest pressure on the base of vessel **S**.

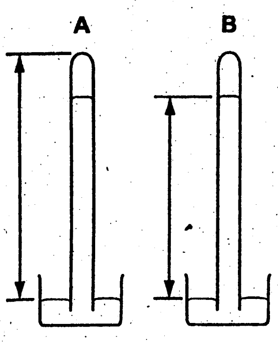
C The water exerts the same force on the base of each vessel.

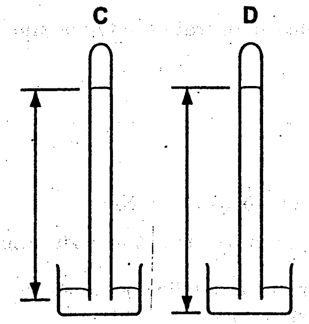
D The water exerts the same pressure on the base of each vessel.

[J06/P1/Q14]

2. The diagrams show a simple mercury barometer.

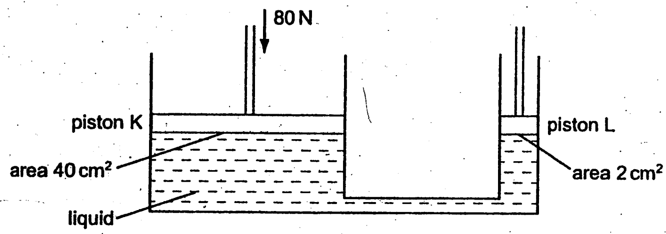
Which diagram shows the distance to be measured to find atmospheric pressure?





[N06/P1/Q10]

3. The system shown in the diagram contains a liquid.



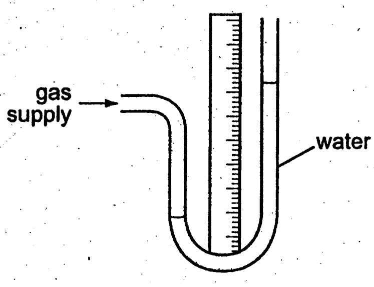
A downward force of 80 N is exerted on the piston K.

What will be the upward force exerted by the liquid on piston L?

A	1 N	**B**	4 N
C	80 N	**D**	1600 N

[N06/P1/Q12]

4. A water manometer is connected to a gas supply. The diagram shows the water levels.



The water is replaced by mercury, which is more dense than water.

1. D The pressure exerted by a liquid depends on the vertical depth of the liquid. Since the water level of each container has the same vertical height so the water exerts the same pressure on the base of each vessel.

2. B The vertical height is measured from the mercury level in the bath to the meniscus level of the mercury in the tube.

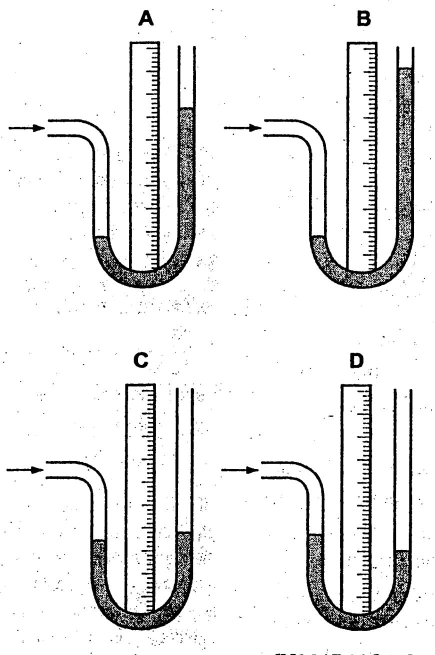
3. B Since pressure at both pistons are the same, $\frac{F_1}{A_1} = \frac{F_2}{A_2}$. Upward force on L, $F_2 = \frac{F_1}{A_1} A_2$

$= \left(\frac{80}{40}\right) 2$

$= 4$ N

4. C Since the water level in the right limb is higher than the that in the left limb, the gas supply pressure is higher than atmospheric pressure. So even if the water is replaced by mercury, the mercury levels must retain the same properties. However density of mercury is greater than the density of water and so the height difference is reduced.

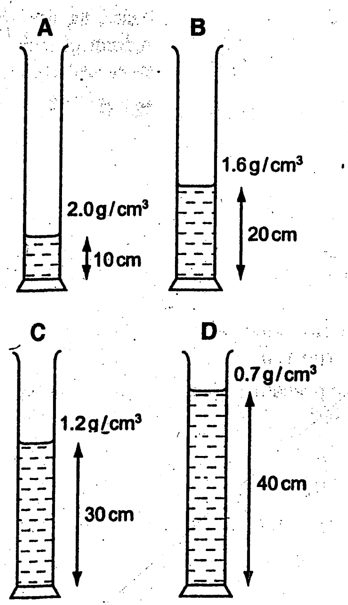
Which diagram shows the mercury levels when the manometer is connected to the same gas supply?



[N06/P1/Q11]

5. Four different liquids are poured into identical measuring cylinders. The diagrams show the depths of the liquids and their densities.

Which liquid causes the largest pressure on the base of its measuring cylinder?



[N07/P1/Q12]

6. Which statement about the pressure in a column of liquid is correct?

A It acts only vertically downwards.

B It increases if the column width increases.

C It increases with depth in the column.

D It is uniform throughout the column.

[J08/P1/Q12]

7. An airtight container holds a fixed quantity of gas. Its pressure and volume are measured on four occasions when the temperature is 20 °C.

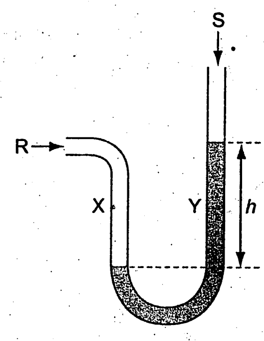
The results are shown in the table.

Which set of readings is **incorrect**?

	pressure / kPa	volume / cm^3
A	120	36
B	100	48
C	80	60
D	60	80

[J08/P1/Q13]

8. The diagram shows a simple manometer.



Side X is connected to a gas supply. Side Y is open to the atmosphere.

What pressure is the length h used to measure?

A the atmospheric pressure S

B the difference between the gas pressure R and the atmospheric pressure S

C the gas pressure R

D the sum of the gas pressure R and the atmospheric pressure S

[N08/P1/Q14]

Thinking Process

MCQ Answers

5. C Pressure = ρgh
Pressure by liquid
A = 2.0 × 10 × 10 = 200
B = 1.6 × 10 × 20 = 320
C = 1.2 × 10 × 30 = 360
D = 0.7 × 10 × 40 = 280
The largest pressure is exerted by the liquid **C**.

6. C As the pressure exerted by a column of a liquid = ρgh, where the values of ρ and g are constant.
So, pressure of liquid column $\propto h$.

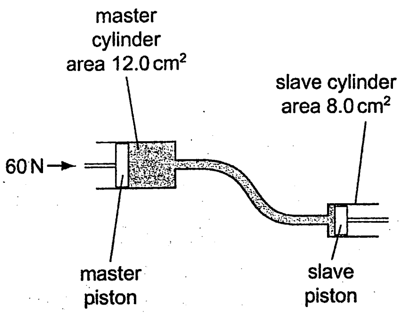
7. A As the pressure exerted by a gas is inversely proportional to the volume of the gas
i.e. $P \propto \frac{1}{V}$
or PV = constant
The product of the values of P and V is constant in each case except **A**.

8. B As, the gas pressure = atmospheric pressure + h
or, R = S + h
So, h = R – S = Gas pressure – Atmospheric pressure

Thinking Process

MCQ Answers

9. The diagram shows the principle of an hydraulic system.



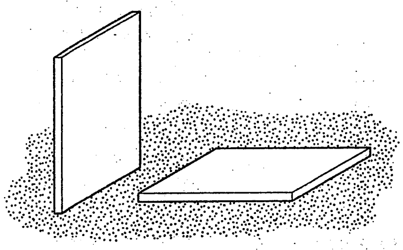
The cross-sectional area of the master cylinder is $12.0\,cm^2$ and the cross-sectional area of the slave cylinder is $8.0\,cm^2$. The force applied to the master piston is 60N, producing a pressure of $5.0\,N/cm^2$.

Which line in the table is correct?

	pressure at slave cylinder N/cm^2	force at slave cylinder N
A	3.3	40
B	3.3	90
C	5.0	40
D	5.0	90

[N08/P1/Q15]

10. A builder leaves two identical, heavy, stone tiles resting on soft earth. One is vertical and the other is horizontal.



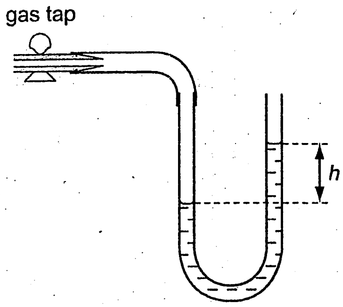
After a few hours, the vertical tile has started to sink into the soft earth, but the horizontal one has not.

Which row correctly compares the forces and the pressures that the tiles exert on the earth?

	forces	pressures
A	different	different
B	different	same
C	same	different
D	same	same

[J09/P1/Q10]

11. A water manometer is connected to a gas supply. One end of the manometer is open to the atmosphere.



Which statement about the pressure of the gas supply is true?

A The pressure is h cm of water.

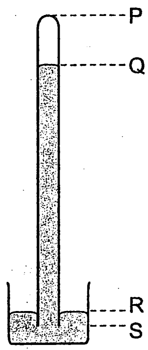
B The pressure is h cm of water below atmospheric pressure.

C The pressure is the same as atmospheric pressure.

D The pressure is h cm of water above atmospheric pressure.

[J09/P1/Q11]

12. A long tube full of mercury is inverted in a small dish of mercury.



The mercury level in the tube falls, leaving a vacuum at the top.

When the atmospheric pressure falls, which length decreases?

A PQ **B** PS

C QR **D** RS

[N09/P1/Q10]

9. C It is a fact that the pressure in a liquid in a hydraulic system is the same at all points.

So, Pressure at the slave cylinder = Pressure at the master cylinder

$= \frac{60}{12} = 5.0\,N/cm^2$.

Hence, the force at the slave cylinder = P × A

$= 5.0 \times 8.0 = 40$ N.

10. C The force (weight) exerted by each tile is the same but the pressure exerted by the vertical tile is greater as a smaller area of this tile is in contact with the ground as compared to the second tile.

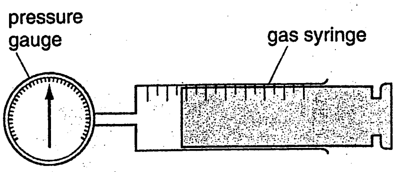
11. D Since the open end of the glass tube is exposed to the atmosphere.

So, the gas pressure = Atmospheric pressure + h cm of water.

Hence, the gas pressure is h cm of water above the atmospheric pressure.

12. C Fact.

13. Some gas is trapped in a large syringe by a piston. The atmospheric pressure is 100 kPa.



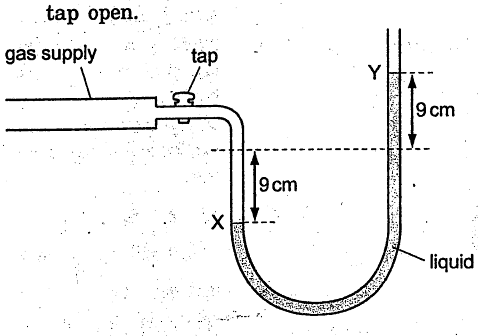
The pressure gauge indicates that the gas pressure is 200 kPa above atmospheric pressure. The piston moves outwards and the volume of the trapped gas doubles. The temperature remains constant.

What is the new gas pressure?

A 100 kPa
B 150 kPa
C 200 kPa
D 400 kPa

[N09/P1/Q11]

14. The diagram shows the levels X and Y in a liquid manometer with the gas tap open.

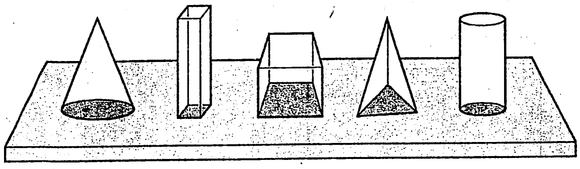


What is the pressure of the gas supply?

A 18 cm of liquid below atmospheric pressure
B 9 cm of liquid below atmospheric pressure
C 9 cm of liquid above atmospheric pressure
D 18 cm of liquid above atmospheric pressure

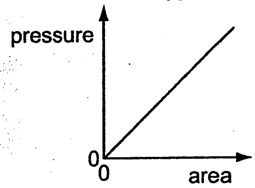
[J10/P1/Q9]

15. Five blocks have the same mass but different base areas. They all rest on a horizontal table.

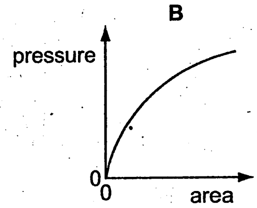


A graph is plotted to show the relationship between the pressure exerted on the table and the base area of the block. Which graph shows this relationship?

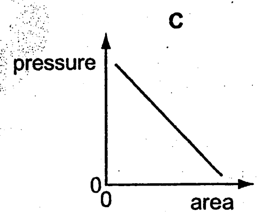
A



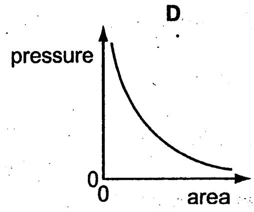
B



C



D



[J10/P1/Q11]

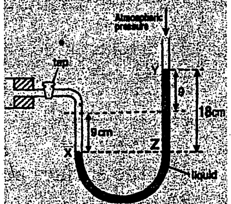
Thinking Process

MCQ Answers

13. B Let the initial volume of gas = V cm³
The initial pressure of the gas = (200 + 100) kPa

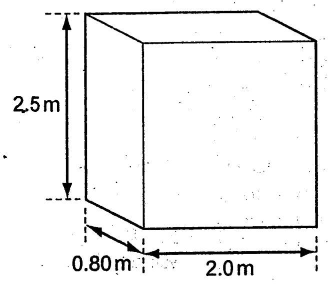
$\therefore P_1V_1 = P_2V_2$
$300 \times V = P_2 \times 2V$
$P_2 = 150$ kPa

14. D The pressure exerted by the gas at point X is equal to the pressure at point Z in the other tube.
∴ Pressure at Z
= Pressure of 18cm of liquid + Atmospheric pressure.
i.e. Pressure at Z is equal to 18 cm of liquid above the atmospheric pressure.



15. D As
$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$
and since all the five blocks have the same force (i.e. weight). Hence,
$$\text{Pressure} \propto \frac{1}{\text{Area}}$$
the graph D represents the inverse proportionality between pressure and area.

16. The base for a statue rests on level ground. It is made from stone and is 2.0 m long, 2.5 m high and 0.80 m wide. It has a weight of 96 000 N.

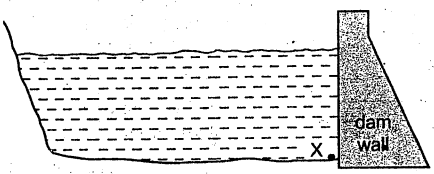


What is the pressure that the base exerts on the ground?

A 19 kPa
B 24 kPa
C 48 kPa
D 60 kPa

[N10/P1/Q7]

17. An engineer designs a dam wall for a reservoir.



Which factor determines the pressure at X?

A the depth of the water in the reservoir
B the surface area of the reservoir
C the length of the reservoir
D the thickness of the dam wall

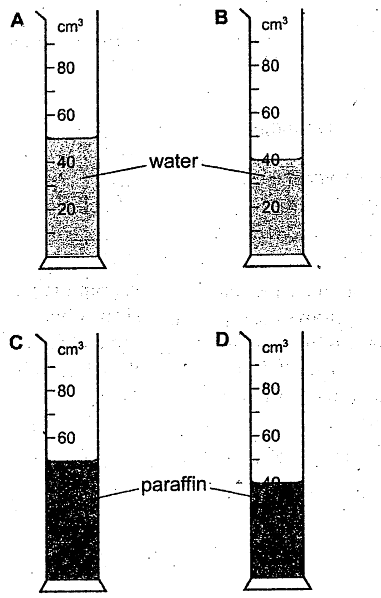
[N10/P1/Q10]

18. Four identical measuring cylinders contain liquid.

Two contain water of density 1000 kg/m^3.

Two contain paraffin of density 800 kg/m^3.

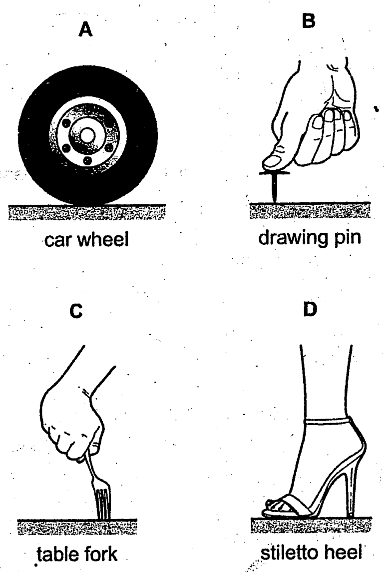
Which cylinder has the **least** pressure exerted on its base by the liquid it contains?



[J11/P1/Q12]

19. The **same** downward force is applied to four objects resting on a horizontal surface.

Which exerts the greatest pressure on the surface?



[J11/P1/Q13]

Thinking Process

MCQ Answers

16. D Pressure $= \dfrac{\text{Weight}}{\text{base area}} = \dfrac{96000}{0.80 \times 2.0} = 60000$ Pa $= 60$ kPa

17. A The pressure exerted by water at the bottom of a dam depends on the depth of water as well as the density of water and the gravitational field strength.

18. D The Pressure exerted by a liquid is given by the equation $P = \rho gh$. Since g is constant in all four cases, hence $P \propto \rho h$. As the values of ρ and h are both the least in diagram D, hence the pressure exerted in this case is the least.

19. B By definition, $P \propto F$ and $P \propto \frac{1}{A}$. Since the value of the force (F) applied is the same and the area (A) on which force is applied is the least in case **B**, hence the greatest pressure is exerted in this case.

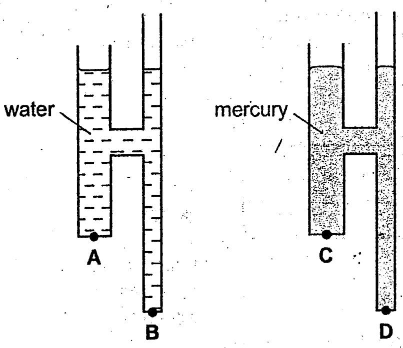
20. Objects with different weights are placed on a rigid, horizontal surface. Which row shows the correct pressure acting on the surface?

	weight/N	area in contact/m^2	pressure N/m^2
A	10	0.1	1
B	20	0.2	0.01
C	30	0.1	300
D	40	0.2	8

[N11/P1/Q13]

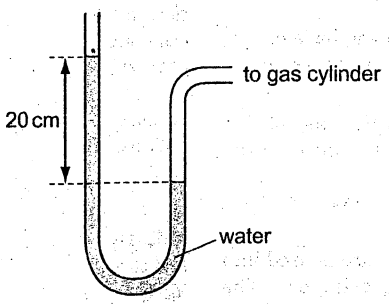
21. The diagram shows two identical pieces of apparatus. One is filled with water and the other is filled with mercury. Water is less dense than mercury.

At which point is the liquid pressure greatest?



[N11/P1/Q14]

22. The pressure of a gas in a cylinder is found using a water manometer.



The density of water is 1000 kg/m^3 and the gravitational field strength g is 10 N/kg.

What is the pressure, above atmospheric pressure, of the gas in the cylinder?

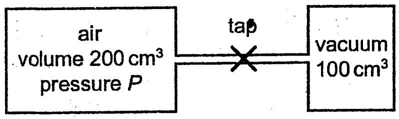
A 200 Pa
B 2000 Pa
C 20 000 Pa
D 200 000 Pa

[J12/P1/Q11]

23. Two cylinders are connected by a thin pipe.

One cylinder has a volume of 200 cm^3 and contains air at pressure P.

The other cylinder has a volume of 100cm^3 and contains a vacuum (no air).



Initially, the tap is closed.

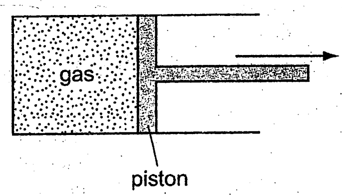
What is the final pressure of the air after the tap is opened?

A $\frac{P}{2}$ **B** $\frac{2P}{3}$

C $\frac{3P}{2}$ **D** 2P

[J12/P1/Q12]

24. A fixed mass of gas is enclosed in a cylinder by a movable piston.



The piston is moved so that the volume occupied by the gas increases. The temperature remains constant.

What happens to the pressure of the gas and why does this happen?

	pressure	reason
A	decreases	the molecules move more slowly
B	decreases	the molecules collide with the piston less frequently
C	increases	the molecules move more quickly
D	increases	the molecules collide with the piston more frequently

[J12/P1/Q15]

25. Four solid blocks with flat surfaces are placed on some soft plasticine, in the positions shown.

Which block sinks the deepest into the plasticine?

MCQ Answers

20. C

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

$$P = \frac{3.0}{0.1} = 300\ N/m^2$$

21. D Liquid pressure, $P = h\rho g$. The density of mercury is greater than water. Also, point **D** has more depth than point C. Therefore liquid pressure is greatest at **D**.

22. B Pressure of gas above atmosphere pressure
$= \rho g h$
$= 1000 \times 10 \times 0.20$
$= 2000$ Pa

Note: Convert the value of h into metres before using it in the formula.

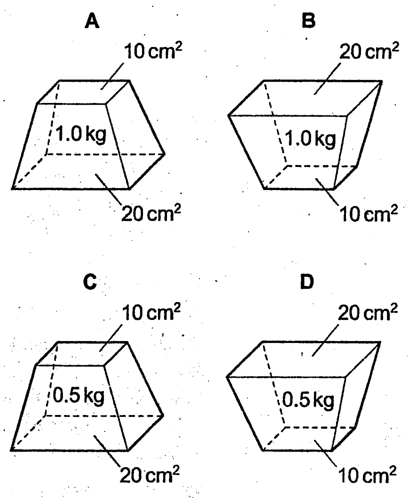
23. B Initially, all the air is confined in the bigger cylinder of volume 200 cm^3. After opening the tap, the gas spreads in both the cylinders so the total volume of the gas becomes 300cm^3.

Hence, $P_1 \times V_1 = P_2 \times V_2$

$P \times 200 = P_2 \times 300$

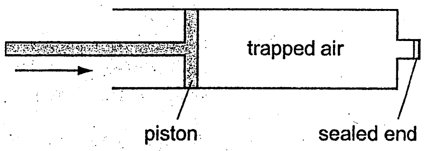
$P_2 = \frac{200}{300} P$

$= \frac{2}{3} P$



[N12/P1/Q11]

26. The end of a bicycle pump is sealed.



The temperature of the air does not change as the piston is pushed in. The final volume of trapped air is $\frac{1}{4}$ of the original volume. How does the pressure of the trapped air change?

A It decreases to $\frac{1}{4}$ of the original value.

B It decreases to $\frac{3}{4}$ of the original value.

C It increases to 3 times the original value.

D It increases to 4 times the original value.

[N12/P1/Q12]

27. A gas in a container of fixed volume is heated.

What happens to the molecules of the gas?

A They collide less frequently.

B They expand.

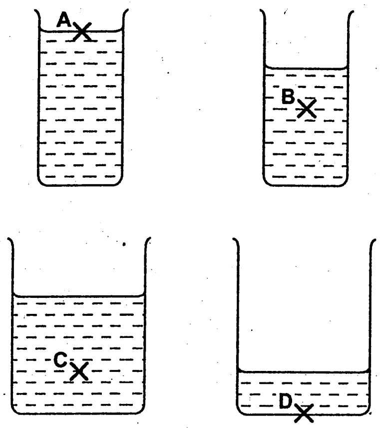
C They move faster.

D They move further apart.

[N12/P1/Q15]

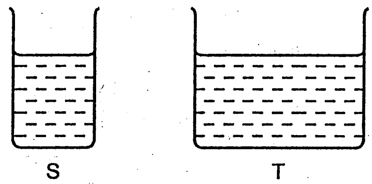
28. Four beakers contain the same liquid.

At which point is the pressure greatest?



[J13/P1/Q11]

29. Two vessels S and T are filled to the same level with the same liquid. The area of the base of S is less than that of T.



Which statement is correct?

A The force on the base of S is greater than the force on the base of T.

B The force on the base of S is the same as the force on the base of T.

C The pressure on the base of S is greater than the pressure on the base of T.

D The pressure on the base of S is the same as the pressure on the base of T.

[N13/P1/Q10]

30. Four different liquids are poured into identical measuring cylinders. The diagrams show the depths of the liquids and their densities.

Which liquid causes the largest pressure on the base of its measuring cylinder?

MCQ Answers

24. B According to the gas law:

$$P \propto \frac{1}{V}$$

On increasing the volume of the gas, the pressure exerted by the gas on the inner walls of the container decreases. This is because with the increased volume, the gas molecules collide less frequently with the cylinder walls and exert a smaller force unit area of the cylinder walls.

25. B The block **B** exerts greatest pressure on its base.

$$\text{Pressure} = \frac{\text{weight}}{\text{area}} = \frac{10\text{ N}}{10\text{ cm}^2} = 1.0\text{ N/cm}^2$$

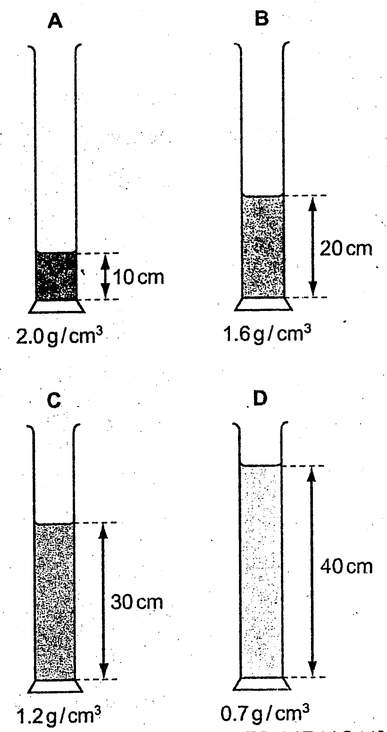
26. D Since $P \propto \frac{1}{V}$

If the volume is reduced by 4 times, the pressure increases by 4 times.

27. C Heating a gas increases the energy of the molecules which will increase their speed and will increase their collisions but the molecules themselves cannot expand and also they cannot move further apart because of the sealed container of a fixed volume.

28. C Liquid pressure = [density × (gravitational field strength) × (height of liquid)]

The values of density and gravitational field strength are the same for all but the height of the liquid above the point is greatest in beaker C amongst the four beakers.



[N13/P1/Q11]

31. The conditions at the bottom and at the surface of a lake are given in the table.

	bottom of lake	surface of lake
temperature	10 °C	10 °C
pressure	500 kPa	100 kPa

A bubble of volume 1.0 cm³ forms at the bottom of the lake.

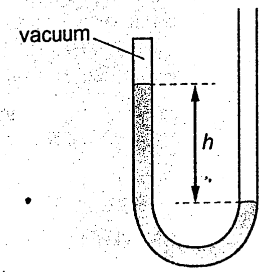
What is the volume of the bubble as it reaches the surface?

A 0.20 cm³ **B** 0.25 cm³

C 4.0 cm³ **D** 5.0 cm³

[N13/P1/Q12]

32. The diagram shows a manometer containing mercury that is sealed at one end.



What happens to the distance h when the manometer is taken to the top of a mountain?

A It decreases, because atmospheric pressure decreases with height.

B It decreases, because atmospheric pressure increases with height.

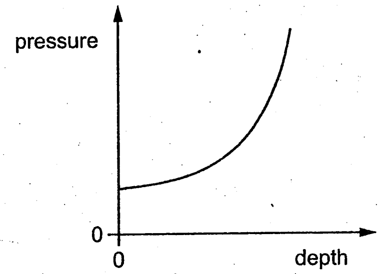
C It increases, because atmospheric pressure decreases with height.

D It increases, because atmospheric pressure increases with height.

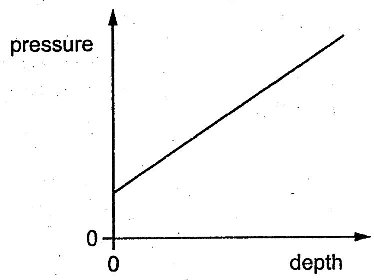
[J14/P1/Q13]

33. Which graph shows the total external pressure acting on a submarine at different depths below the surface of the sea?

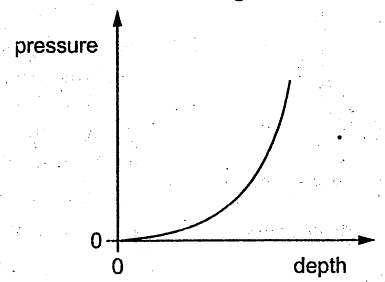
A



B



C



MCQ Answers

29. D As the pressure of a liquid is directly proportional to the height of the liquid (i.e. $P \propto h$), so the pressure exerted by the liquid on the base of S is the same as on the base of T, because the height of the liquid in both vessels is the same.

30. C
Liquid pressure for C
$= h\rho g$
$= \left(\frac{30}{100}\right)(1.2\times10^3)(10)$
$= 3600$ Pa

Which is the greatest as compared to the pressures exerted by the liquids **A**, **B** and **D**.

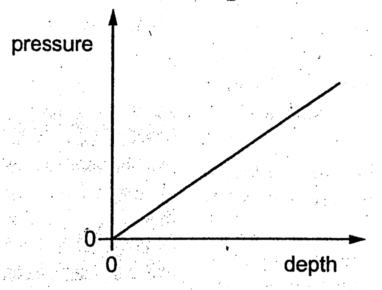
Note: Change the value of h into metres and the value of density into kg/m³.

31. D $P_1V_1 = P_2V_2$
$500\times1.0 = 100\times V_2$
$V_2 = \frac{500\times1.0}{100}$
$V_2 = 5$ cm³

32. A The open end of the tube is subjected to atmospheric pressure. The more the pressure, the greater the distance h and vice versa. Since atmospheric pressure decreases with height, the distance h will decrease if the monometer is taken to the top of a mountain.

33. B $P = \rho gh$ + air pressure.
There is a linear relation between pressure and depth, and the graph does not have a zero intercept due to the atmospheric pressure above the surface of the sea.

D



[J14/P1/Q14]

34. A gas occupies a volume of 2.0 m^3 in a cylinder at a pressure of 240 kPa. A piston compresses the gas until the volume is 0.50 m^3, the temperature remaining constant.

What is the new pressure of the gas?

A 60 kPa **B** 240 kPa
C 480 kPa **D** 960 kPa

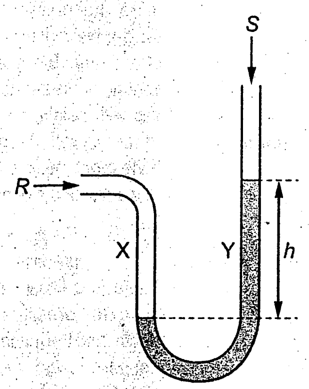
[J14/P1/Q15]

35. Objects of different weights are placed on a rigid, horizontal surface. Which row shows the correct pressure acting on the surface?

	weight/N	area in contact/m^2	pressure/Pa
A	10	0.1	1
B	20	0.2	0.01
C	30	0.1	300
D	40	0.2	8

[N14/P1/Q7]

36. The diagram shows a simple manometer that contains a liquid.



Side X is connected to a gas supply of pressure R.
Side Y is open to the atmosphere at pressure S.

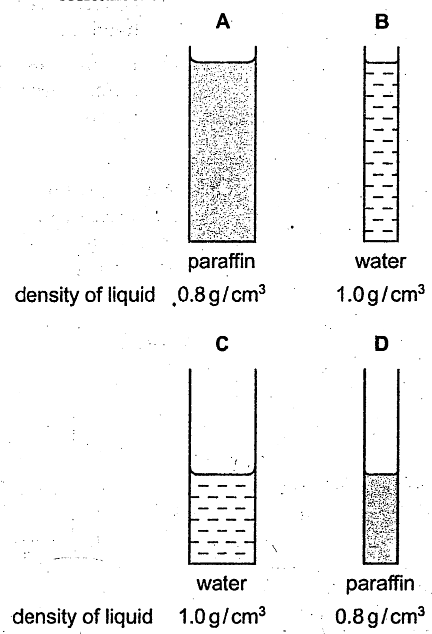
Which pressure is the length h used to measure?

A R **B** S
C $R - S$ **D** $R + S$

[N14/P1/Q8]

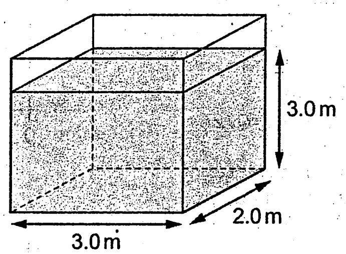
37. The diagrams show liquids in containers.

Which column of liquid exerts the greatest pressure on the base of its container?



[J15/P1/Q10]

38. The base of a rectangular storage tank is 2.0 m by 3.0 m. The tank is filled with paraffin to a depth of 3.0 m.



The density of paraffin is 800 kg/m^3 and the gravitational field strength is 10 N/kg.

What is the pressure at the bottom of the tank due to the paraffin?

A 2400 Pa **B** 14 400 Pa
C 24 000 Pa **D** 144 000 Pa

[N15/P1/Q13]

Thinking Process

MCQ Answers

34. D $P_1V_1 = P_2V_2$

$P_1V_1 = P_2V_2$

$P_2 = \frac{P_1V_1}{V_2}$

$= \frac{240 \times 10^3 \times 2}{0.5}$

$= 960000$ Pa

$= 960$ kPa

35. C

Pressure $= \frac{\text{force}}{\text{area}}$

Option A:

pressure $= \frac{10}{0.1} = 100$ Pa

Option B:

pressure $= \frac{20}{0.2} = 100$ Pa

Option C:

pressure $= \frac{30}{0.1} = 300$ Pa

Option D:

pressure $= \frac{40}{0.2} = 200$ Pa

Hence, only option C is correct.

36. C Since the liquid level in side X is lower than the liquid level in side Y, the pressure R is greater than pressure S and h is used to measure the difference in pressures of R and S.

37. B The value of the pressure exerted by a liquid is given by $P = \rho gh$. As the value of 'g' is the same for all the containers but the value of density and the height of the liquid in container B is greater than the others, so the pressure exerted by the liquid B is the greatest.

38. C Pressure exerted by a liquid is given as $P = \rho gh$

$= 800 \times 10 \times 3.0$

$= 24000$ Pa

Topic 6 Pressure

THEORY Section

Question 1

Fig. 10.1 shows a section through a very old bicycle tyre that is made of solid rubber.

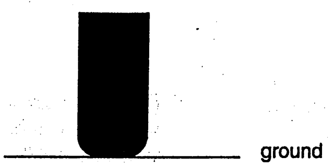


Fig. 10.1

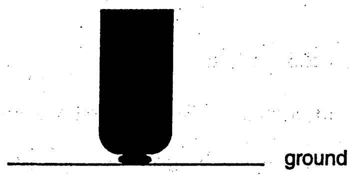


Fig. 10.2

(a) The solid rubber tyre exerts a pressure on the ground.

The unit of pressure is the pascal (Pa).

(i) Define the pascal. [2]

(ii) The mass of the bicycle and rider is 60 kg and the total area of the tyres in contact with the road is 2.4×10^{-3} m^2. The gravitational field strength is 10 N/kg.

Calculate the pressure exerted on the road. [3]

(iii) One of the solid rubber tyres goes over a small stone, as shown in Fig.10.2. Describe and explain how the pressure exerted on the ground changes. [2]

(b) Fig. 10.3 shows a modern tyre that contains air. A heavy person sits on the bicycle and the shape of the tyre changes, as shown in Fig. 10.4.

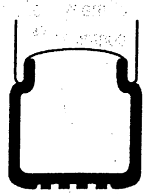


Fig. 10.3

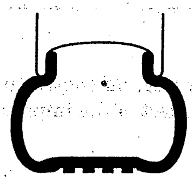


Fig. 10.4

The table contains information about the tyre in Fig. 10.3 and Fig. 10.4.

	tyre in Fig. 10.3	tyre in Fig. 10.4
air pressure in tyre /Pa	1.9×10^5	2.1×10^5
Volume of air /m^3	0.016	V

(i) Calculate the volume V of the air in the tyre in Fig. 10.4. State one assumption that you make in your calculation. [4]

(ii) Another way to change the pressure in the tyre is to raise the temperature.

State what happens to the pressure in the tyre when the temperature rises and explain your answer using ideas about molecules. [4]

[J06/P2/Q10]

Solution

(a) (i) We know that, Pressure $= \frac{\text{Force}}{\text{Area}}$

$\therefore \quad 1\text{ Pa} = \frac{1\text{N}}{1\text{m}^2}$

So, a pressure of 1 Pa is exerted when a force of 1 N acts on a surface of area of 1 m^2.

(ii) Pressure $= \frac{\text{force}}{\text{area}}$

$= \frac{60 \times 10}{2.4 \times 10^{-3}} = 2.5 \times 10^5 \text{ Pa}$

(iii) The area of the tyre in contact with the ground decreases and this increases the pressure exerted on the ground since pressure $\propto \frac{1}{\text{area}}$

(b) (i) We have

$$P_1 \times V_1 = P_2 \times V_2$$

$$(1.9 \times 10^5) \times (0.016) = (2.1 \times 10^5) \times V_2$$

$$V_2 = 0.014$$

$\therefore$ volume of air in the tyre $= 0.014 \text{ m}^3$

It is assumed that the temperature of air (gas) inside the tyre remains constant during this change.

(ii) As the temperature of the air in the tyre increases, the average kinetic energy of the air molecules increases as well. They start moving faster and hit the walls of the tyre more often and with a greater force too. This increases their force exerted per unit area of the wall of the tyre. So the pressure in the tyre increases.

COMMENT on ANSWER

"(a) (iii) As $P = \frac{F}{A}$

but the force (weight of car) exerted on each tyre remains constant with or without the stone under the tyre.

$P = \text{constant} \times \frac{1}{A}$

or $P \propto \frac{1}{A}$

(b) (i) Another assumption which can be made in this case is that the amount of gas (air) in the tyre remains constant with or without the stone under the tyre.

(ii) The pressure exerted by a gas is directly proportional to the number of collisions made by its molecules per unit area of its container per unit time. The pressure increases with the increase in the number of collisions per unit area of the wall of the container."

Question 2

Many cars are fitted with an air-bag, as shown in Fig. 9.1. In a collision, the air-bag inflates and reduces the effect of the impact between the passenger and the dashboard.

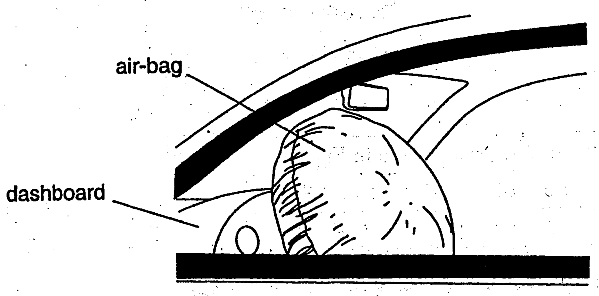


Fig. 9.1

(a) In a test of the air-bag, a heavy ball is used instead of the passenger.

The car is travelling at 14 m/s when it hits a wall. The air-bag inflates and the ball takes 3.0 s to come to rest. The ball has mass 5.0 kg.

(i) Calculate the average deceleration of the ball. [3]

(ii) Calculate the average force exerted on the ball. [2]

(iii) Using ideas about acceleration, explain how the air-bag reduces the force on the ball during the test. [2]

(b) If there was no air-bag, a large pressure would be exerted on the ball at the point where it hits the dashboard.

(i) Define *pressure*. [1]

(ii) The inflated air-bag reduces the pressure exerted on the ball. State **two** reasons why the pressure is reduced. [2]

(c) Compressed gas from a small cylinder inflates the air-bag. The cylinder contains a volume of 600 cm^3 of gas at a pressure of 1.4×10^7 Pa. The cylinder and the inflated air-bag have a volume of 30000 cm^3.

(i) Calculate the pressure of the gas in the inflated air-bag, assuming that the temperature is constant. [3]

(ii) The pressure inside the cylinder decreases as the air-bag is inflated. Explain, using ideas about molecules, why the pressure decreases. [2]

[N07/P2/Q9]

Solution

(a) (i) $a = \dfrac{v-u}{t}$

$= \dfrac{0-14}{3} = -4.67 \text{ m/s}^2$

Hence, deceleration = 4.7 m/s^2

(ii) $F = ma$

$= 5.0 \times 4.67 = 23.3 \approx 23 \text{ N}$

(iii) As, acceleration $= \dfrac{\text{change in velocity}}{\text{time}}$, so $a \propto \dfrac{1}{t}$

The air-bag increases the time interval during which the ball comes to rest after the impact so the value of the acceleration is reduced. As a result the force (impulse) on the ball is also reduced during the impact because $F \propto a$.

(b) (i) Pressure is the force acting per unit area i.e. $P = \dfrac{F}{A}$

(ii) The pressure exerted on the ball during the impact is reduced by the air-bag because

1. The area in contact between the ball and the air-bag increases, so the force acting per unit area of the ball decreases. Hence the pressure exerted on the ball decreases.
2. Some of the force of the impact is absorbed by the air-bag. So the force exerted per unit area of the ball i.e. the pressure exerted on the ball is reduced.

(c) (i) $P_1 \times V_1 = P_2 \times V_2$

$(1.4 \times 10^7)(600) = P_2 \times (30\,000)$

$P_2 = 2.8 \times 10^5 \text{ Pa}$

(ii) Some of the air from the cylinder is used to inflate the air-bag. The remaining air in the cylinder then has less number of molecules. They make less number of collisions per unit area of the wall of the cylinder. So less pressure is exerted by the remaining air on the wall of the cylinder.

COMMENT on ANSWER

“(a) (iii) A longer time of impact slows down the ball gradually so less acceleration is produced.

(b) (ii) The two factors that reduce the pressure are:

– larger area $\left(P \propto \dfrac{1}{A}\right)$

– smaller force $(P \propto F)$ ”

Question 3

A diver holds his breath and dives into the sea from a boat to a depth of 25.0 m. The atmospheric pressure is 1.05×10^5 Pa.

(a) (i) Explain why the pressure at this depth is greater than the atmospheric pressure. [1]

(ii) Other than the depth and the atmospheric pressure, state **one** quantity that affects the pressure in a liquid. [1]

(b) (i) The pressure due to 25.0 m of sea-water is 2.55×10^5 Pa. Calculate the total pressure at this depth. [1]

(ii) As the diver holds his breath and descends to a depth of 25.0 m, the greater pressure causes the volume of the air trapped in his lungs to change.

When he is on the boat, the total volume of the air in his lungs is 6000 cm^3. Calculate the volume of this air at a depth of 25.0 m. [2]

[N09/P2/Q1]

Solution

(a) (i) The weight of the water above the diver exerts extra pressure on him in addition to the atmospheric pressure.

(ii) Density of the sea-water.

(b) (i) Total pressure = Atmospheric pressure + Pressure due to sea-water

$$= (1.05 \times 10^5) + (2.55 \times 10^5)$$

$$= 3.60 \times 10^5 \text{ Pa}$$

(ii)

$$P_1 \times V_1 = P_2 \times V_2$$

$$(1.05 \times 10^5) \times 6000 = (3.60 \times 10^5) \times V_2$$

$$V_2 = \frac{1.05 \times 10^5 \times 6000}{3.60 \times 10^5}$$

$$= 1750 \text{ cm}^3$$

COMMENT on ANSWER

“ **(a) (ii)** *Alternative Answer*: Gravitational field strength. ”

Question 4

A U-shaped tube, of constant cross-sectional area, contains some water of density 1000 kg/m^3. Oil that does not mix with water is then poured into the right-hand side of the tube. Fig. 2.1 shows the levels of the water and the oil when equilibrium is reached.

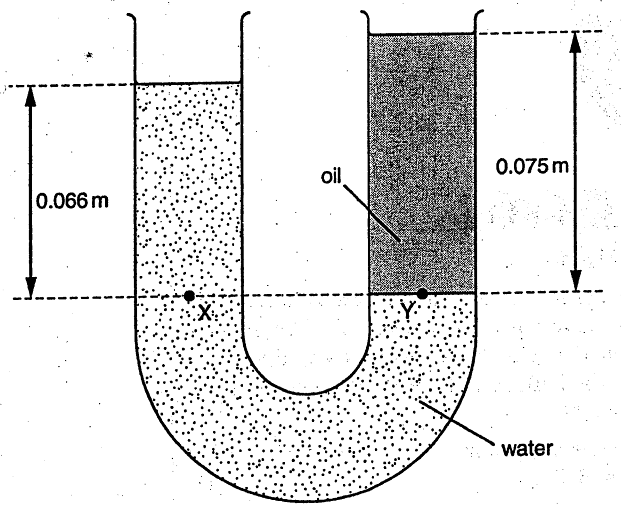


Fig. 2.1

Points X and Y are at the same horizontal level. X is 0.066 m below the top surface of the water. Y is 0.075 m below the top surface of the oil.

(a) State two quantities that influence the pressure beneath the surface of a liquid. [2]

(b) The cross-sectional area of the tube is $5.0 \times 10^{-4} \text{ m}^2$.

(i) Calculate the mass of water above the level of X. [2]

(ii) The pressure caused by 0.066 m of water at X is equal to that caused by 0.075 m of the oil at Y.
Determine the density of the oil. [2]

[N10/P2/Q2]

Solution

(a) 1. Height of the liquid.
2. Density of the liquid.

(b) (i) Mass = density × volume

$$= 1000 \times (5.0 \times 10^{-4} \times 0.066) = 0.033 \text{ kg}$$

(ii) Oil pressure at Y = Water pressure at X

$$\rho \times 10 \times 0.075 = 1000 \times 10 \times 0.066$$

$$\rho = 880$$

∴ density of oil = 880 kg/m^3

COMMENT on ANSWER

"(a) Since the pressure exerted by a liquid is given by the equation

$P = \rho g h$.

Hence, the pressure of a liquid depends on

— density (ρ) of the liquid.

— gravitational field strength (g).

— height of the liquid (h)."

Question 5

A helium balloon carries scientific instruments high up in the atmosphere. Fig. 3.1 shows the partially inflated helium balloon leaving the ground.

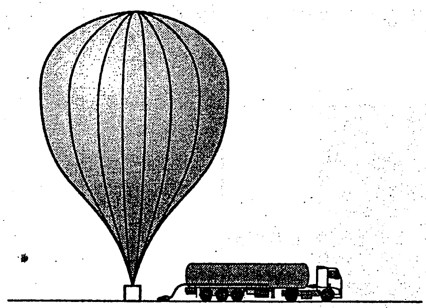


Fig. 3.1

(a) A completely deflated balloon contains no gas. The helium to inflate it is stored in a very large cylinder at a pressure p_1 of 2.5×10^7 Pa. Helium that occupies a volume V_1 of $18\,m^3$ in the cylinder is slowly released into the balloon until the pressure p_2 in the balloon is 1.0×10^5 Pa. The temperature of the helium remains constant.

(i) State the equation that relates the volume V_2 of the helium in the balloon at launch to p_1, p_2 and V_1. [1]

(ii) Calculate V_2. [2]

(b) When it leaves the ground, the balloon is only partially inflated. Suggest and explain why this is necessary. [2]

[N11/P2/Q3]

Solution

(a) (i) $p_1V_1 = p_2V_2$

(ii) $2.5 \times 10^7 \times 18 = 1.0 \times 10^5 \times V_2$

$$V_2 = \frac{2.5 \times 10^7 \times 18}{1.0 \times 10^5} = 4500\ m^3$$

(b) The balloon is not fully inflated on the ground because it will burst as it goes higher up due to the pressure difference between the gas in the balloon and the outside air. This is because atmospheric pressure decreases with height.

Question 6

Fig. 4.1 shows gas trapped in a cylinder by a piston.

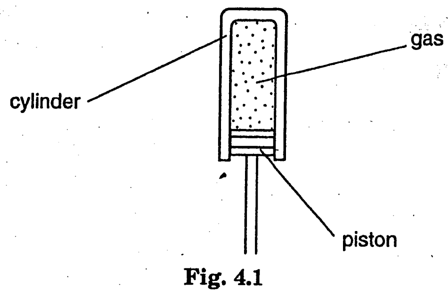


Fig. 4.1

The piston has a cross-sectional area of 0.0050 m². It moves upwards, through a distance of 0.074 m, compressing the gas. During this compression, the average pressure of the gas is 4.6×10^5 Pa .

(a) Calculate

(i) the average force exerted on the piston by the gas during compression, [2]

(ii) the work done on the gas during compression. [2]

(b) The gas in the cylinder has a heat capacity of 0.27 J/°C and heats up as it is compressed.

(i) Calculate the maximum possible temperature rise of the gas. [2]

(ii) Suggest a reason why the actual temperature rise of the gas is less than the value calculated in (i). [1]

[N12/P2/Q4]

Solution

(a) (i) $F = P \times A$

$= (4.6 \times 10^5) \times (0.0050)$

$= 2300$ N

(ii) Work done $= F \times d$

$= 2300 \times 0.074$

$= 170.2$ J

(b) (i) $Q = C\Delta\theta$

$$\Delta\theta = \frac{Q}{C} = \frac{170.2}{0.27} = 630.37 \approx 630 \text{ °C}$$

(ii) It is due to the heat lost to the cylinder and the atmosphere.

COMMENT on ANSWER

" (b) (i) The workdone during compressing the gas causes an increase in the collisions between the gas molecules, which increases the temperature of the gas. "

Question 7

Fig. 9.1 shows a diver working below the surface of a lake. The density of the water in the lake is 1000 kg/m³, the atmospheric pressure at the surface is 1.0×10^5 Pa and the gravitational field strength is 10 N/kg.

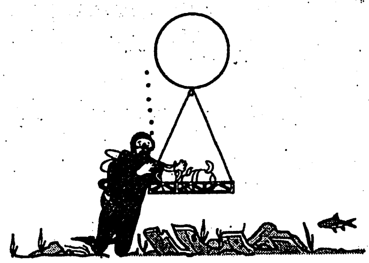


Fig. 9.1

The diver inflates a balloon with air at a depth of 15 m and attaches the balloon to a tray of objects.

(a) Calculate

(i) the pressure due to 15 m of water, [2]

(ii) the total pressure at 15 m below the surface of the lake. [1]

(b) The air in the balloon occupies a volume of 0.048 m^3 at the pressure calculated in **(a)(ii)**.
The diver releases the tray and the balloon, and they begin to rise. The temperature of the air in the balloon does not change.

(i) Calculate the volume occupied by the air in the balloon at atmospheric pressure. [2]

(ii) The pressure of the air inside the balloon is less at the surface than at a depth of 15 m. Explain, in terms of the air molecules inside the balloon, why the pressure is less. [3]

(c) State one difference between the arrangement of the molecules of water in the lake and the molecules of air in the balloon. [1]

(d) When the diver releases the tray, the balloon accelerates upwards and reaches a constant speed before it arrives at the surface.

(i) Explain how the forces acting on the balloon cause it to behave in this way. [3]

(ii) On the axes in Fig. 9.2, sketch the distance-time graph for the balloon as it travels 15 m to the surface.

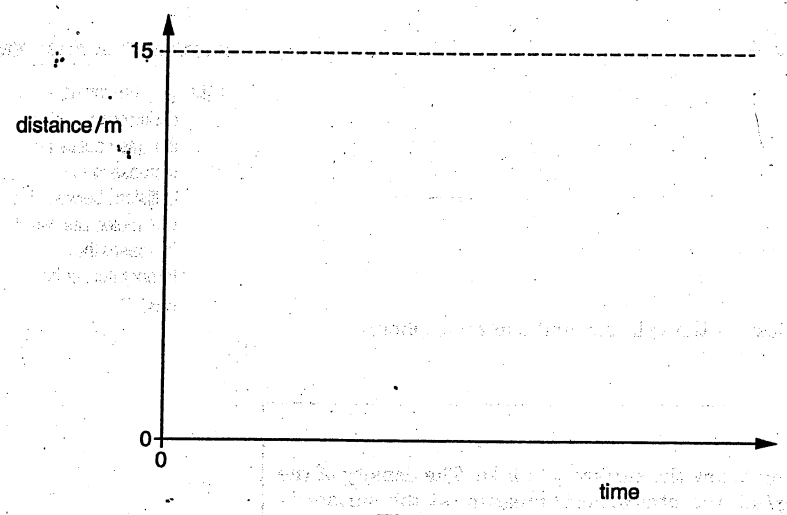


Fig. 9.2 [3]

[N12/P2/Q9]

Solution

(a) (i) $P = \rho g h$

$= 1000 \times 10 \times 15$

$= 1.5 \times 10^5$ Pa

(ii) Total pressure = atmospheric pressure + pressure due to water

$= (1.0 \times 10^5) + (1.5 \times 10^5)$

$= 2.5 \times 10^5$ Pa

(b) (i)

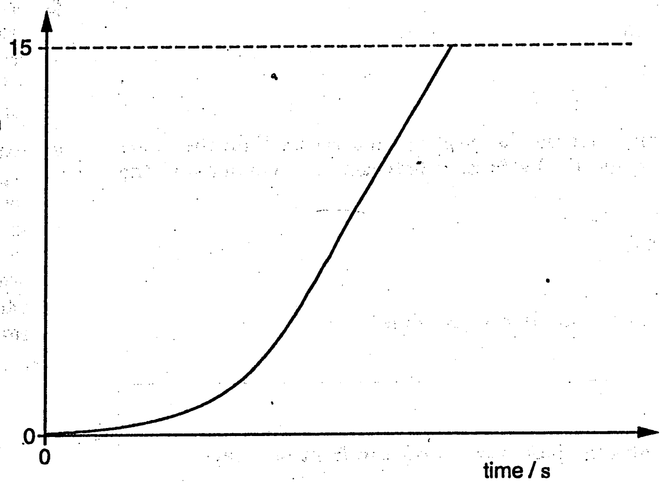
$$P_1V_1 = P_2V_2$$
$$(2.5\times10^5)\times(0.048) = (1.0\times10^5)\times V_2$$
$$V_2 = 0.12\text{ m}^3$$

(ii) At the surface, the volume of the balloon becomes greater than its volume at the bottom. The air molecules now have to travel greater distances to make collisions with the wall of the balloon. As a result, the air molecules make less number of collisions per unit area of the wall of the balloon. Hence there is a less pressure in the balloon at the surface of water.

(c) The water molecules are closer to each other and move randomly in clusters but remain within the liquid whereas the air molecules are far apart and move randomly and independently throughout the container.

(d) (i) Initially, the upthrust of water is greater than the force of gravity. So, a resultant force acts in the upward direction. As a result, the balloon and the tray accelerate upwards. As its speed increases, the drag force of the water also increases till the total downward force (including the force of gravity and the drag force) become equal to the upthrust of water. The resultant force then becomes zero and the balloon moves upwards with a constant speed.

(ii)



COMMENT on ANSWER

“(b) (ii) The volume of the balloon becomes larger at the surface due to the decrease in the pressure above the balloon.

(d) (i) The drag force of water on the balloon increases as it moves upwards due to

1. the increase in its speed,
2. the increase in its surface area as its volume increases.

(ii) The slope of a distance-time graph gives the speed of the balloon. Initially, the increasing slope (gradient) shows the increasing speed (i.e. acceleration) of the balloon. Later, the graph of constant gradient shows that balloon is moving at a constant speed.”

Question 8

A farmer uses a hydraulic system to operate machinery that is pulled behind a tractor.

Two cylinders and the flexible pipe that joins them contain oil. Two pistons keep the oil in the cylinders. The arrangement is shown in Fig. 3.1.

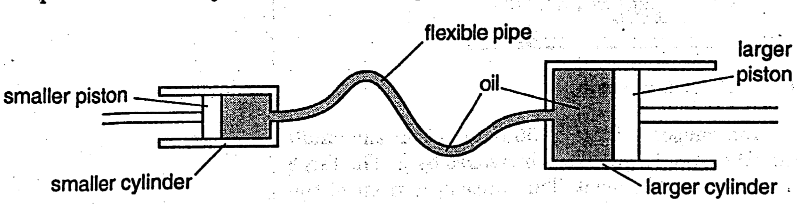


Fig. 3.1

The cross-sectional area of the smaller cylinder is 0.048 m^2.
The cross-sectional area of the larger cylinder is 0.14 m^2.
The smaller piston exerts a force of 12 000 N on the oil.

(a) Calculate

(i) the pressure in the oil, [2]

(ii) the force exerted by the oil on the larger piston. [1]

(b) Suggest why the resultant force on the larger piston is less than the value obtained in **(a)(ii).** [1]

(c) The smaller piston moves a distance of 0.065 m into the cylinder. Calculate the work done on the oil by the smaller piston. [2]

(d) Suggest one advantage of using oil rather than air in the system. [1]

[N13/P2/Q3]

Solution

(a) (i) $\text{Pressure} = \dfrac{\text{force}}{\text{area}}$

$= \dfrac{12000}{0.048} = 250\,000 \text{ Pa}$

(ii) $\text{Force} = \text{pressure} \times \text{area}$

$= 250\,000 \times 0.14$

$= 35000 \text{ N}$

(b) The value of the resultant force on the larger piston is less than the value calculated above. This is due to the friction between the cylinder and the piston.

(c) $\text{Work done} = 12000 \times 0.065$

$= 780 \text{ J}$

(d) Oil is incompressible whereas air is compressible.

COMMENT on ANSWER

" **(a)** (ii) The force applied on the smaller piston develops a pressure in the oil in smaller cylinder. This pressure is transmitted to the larger cylinder and hence the same value of this pressure acts on the larger piston.

(b) Another factor that reduces the value of the resultant force on the larger piston is the atmospheric pressure.

(d) Some of the force applied is wasted in compressing the air, so lesser pressure will be produced, with the remaining force, in the cylinder and the above arrangement will not work effectively. "

Question 9

Fig. 2.1 shows part of a hydraulic jack used to lift the front of a car.

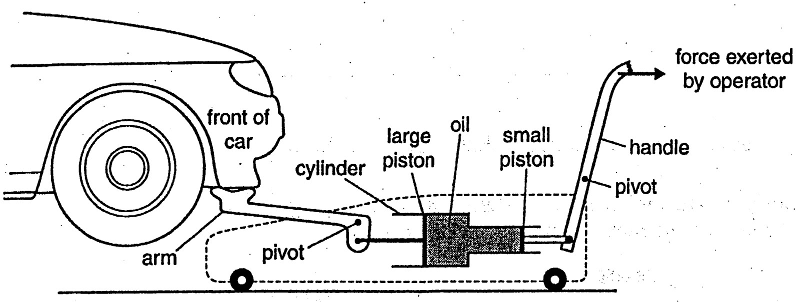


Fig. 2.1 (not to scale)

The operator pulls the handle and causes a force of 50 N to act on the small piston. The force exerted by the oil on the large piston increases by *F*. The large piston moves and rotates the arm about the pivot. This raises the front of the car.

The cross-sectional area of the small piston is 1.5 cm².
The cross-sectional area of the large piston is 5.0 cm².

(a) Calculate

(i) the pressure in the oil caused by the force on the small piston, [2]

(ii) the value of *F*. [1]

(b) Explain why the large piston moves through a shorter distance than the small piston. [1]

(c) The efficiency of the jack is 75%. Explain what is meant by *efficiency*. [2]

[J14/P2/Q2]

Solution

(a) (i) $\text{Pressure} = \dfrac{\text{force}}{\text{area}}$

$$= \frac{50}{1.5} = 33.333 \approx 33.3 \text{ N/cm}^2$$

(ii) $F = \text{pressure} \times \text{area}$

$$= 33.33 \times 5$$
$$= 166.65 \approx 167 \text{ N}$$

(b) The volume of oil is constant inside the cylinder. Oil moves from a smaller area to a larger area which causes the larger piston to move a smaller distance than the smaller piston.

(c) Efficiency is the ratio of the useful output energy to the total input energy supplied to a system. It is often expressed as a percentage.

Question 10

Fig. 2.1 shows two engineers measuring the length of a wall made from concrete.

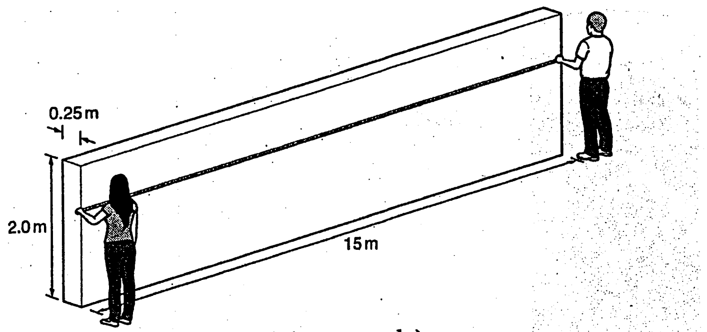


Fig. 2.1 (not to scale)

The wall is 2.0 m high, 15 m long and 0.25 m thick.
The weight of the wall is 180 000 N and the mass of the wall is 18 000 kg.

(a) The engineers measure the length of the wall in one single measurement. State the name of the measuring instrument they use. [1]

(b) The engineers state that the density of the concrete affects the pressure exerted by the wall on the ground but that the length of the wall does not affect this pressure.

(i) Define *density*. [1]

(ii) Calculate the density of the concrete. [2]

(iii) Calculate the pressure exerted by the wall on the ground. [2]

(iv) Without further calculation, explain why doubling the length of the wall does not change the pressure that the wall exerts on the ground. [1]

[J15/P2/Q2]

Solution

(a) Tape measure.

(b) (i) The mass per unit volume is called the density i.e. density $= \frac{\text{mass}}{\text{volume}}$.

(ii) $$\text{density} = \frac{\text{mass}}{\text{volume}} = \frac{18000}{15 \times 2 \times 0.25} = \frac{18000}{7.5} = 2400 \text{ kg/m}^3$$

(iii) $$\text{pressure} = \frac{\text{Weight}}{\text{Area}} = \frac{180000}{15 \times 0.25} = 48000 \text{ Pa}$$

(iv) An increase in the length of the wall causes both its weight and its area to increase by the same proportion. Consequently, the pressure exerted by the wall on the ground remains constant.

COMMENT on ANSWER

❝ (b) (iii) Also,

$P = \rho gh$

$= 2400 \times 10 \times 2$

$= 48000$ pa.

(iv) *Alternatively:* Since $P = \rho gh$ and as density, height and the value of g remain the same, so the pressure remains the same. ❞

Question 11

A very deep tank is used when training sailors to escape from submarines. The tank is cylindrical and open to the air at the top. Fig. 3.1 shows the tank.

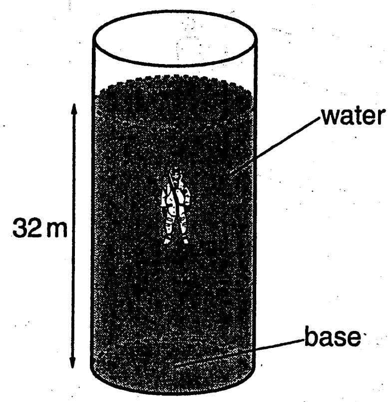


Fig. 3.1 (not to scale)

The area of the base of the tank is 45 m^2 and the tank is filled with water to a depth of 32 m.

(a) The density of water is 1000 kg / m^3 and the gravitational field strength g is 10 N / kg.

Calculate the pressure, due to the water, on the base of the tank. [2]

(b) The pressure in the water at the base of the tank is 4.2×10^5 Pa.

(i) Explain why the pressure in the water at the base of the tank differs from the value calculated in (a). [1]

(ii) Calculate the force exerted on the base of the tank. [2]

(c) Force is a vector quantity and pressure is a scalar quantity.
State how a vector quantity differs from a scalar quantity. [1]

[N15/P2/Q3]

Solution

(a) Pressure, $P = \rho gh$

$= 1000 \times 10 \times 32$

$= 320000$

$= 3.2 \times 10^5$ Pa

(b) (i) The pressure exerted at the base of the tank includes the atmospheric pressure in addition to the pressure exerted by the water.

(ii) Force = pressure × area

$= (4.2 \times 10^5) \times 45$

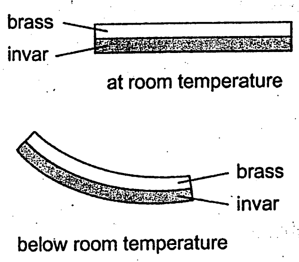
$= 1.89 \times 10^7$ N

(c) A vector quantity has direction as well as magnitude whereas a scalar quantity has magnitude only.

Topic 7 Heat Capacity, Expansion

MCQ Section

1. The diagrams show a bimetallic strip when it is at room temperature and after it has been cooled.



The change in shape occurs because

A brass contracts more than invar.
B brass expands when it cools down.
C invar and brass contract by equal amounts.
D invar contracts more than brass.

[J06/P1/Q19]

2. What is the definition of *heat capacity*?

A the quantity of heat required to raise the temperature of an object through 1°C
B the quantity of heat required to raise the temperature of 1 kg of a substance through 1°C
C the quantity of heat required to convert an object from solid to liquid without a change in temperature
D the quantity of heat required to change 1 kg of a substance from solid to liquid without a change in temperature

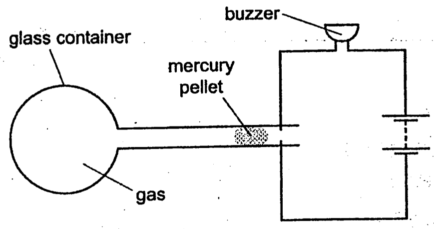
[J07/P1/Q16]

3. Fillings in teeth should be made from a material which

A expands more than the tooth when heated.
B expands by the same amount as the tooth when heated.
C expands less than the tooth when heated.
D does not expand when heated.

[J07/P1/Q17]

4. The diagram shows the design for an alarm.

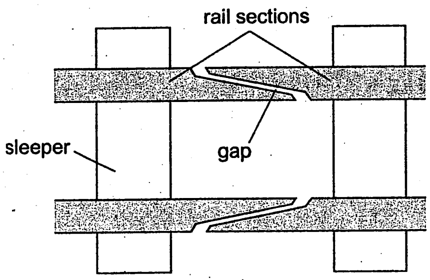


The mercury pellet moves and completes the circuit.
Why does this happen?

	temperature	gas
A	falls	contracts
B	falls	expands
C	rises	contracts
D	rises	expands

[N07/P1/Q17]

5. At regular intervals along a railway line there is a gap between the rail sections.



What is the reason for the gap between the rail sections?

A to allow for expansion of the rail sections during hot weather
B to allow for vibrations of the rail sections as the train passes over them
C to allow rain water to drain from the rail sections
D to keep the wheels of the train and carriages on the rail sections

[J08/P1/Q16]

MCQ Answers

1. A It is a fact that brass contracts more than invar. The length of the brass strip becomes less than that of the invar strip on cooling the bimetallic strip. So the brass strip being shorter will be in the inner curve and the invar strip being the longer strip will be in the outer curve of the bent bimetallic strip.

2. A The heat capacity of a body is the quantity of heat energy required to raise the temperature of the body by 1°C.

3. B The material used for the fillings in teeth should be such that it expands or contracts by the same amount as the tooth due to a change in temperature.

4. D The gas expands due to a rise in its temperature. The mercury pellet moves to the right completes the circuit and activates the buzzer.

5. A Fact

6. Some air is trapped inside a small balloon. The average kinetic energy of the air molecules in the balloon is increased.

What remains the same?

A the density of the air in the balloon

B the mass of the air in the balloon

C the temperature of the air in the balloon

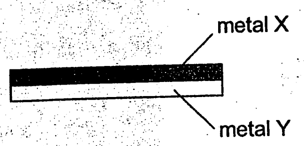
D the volume of the air in the balloon

[J08/P1/Q18]

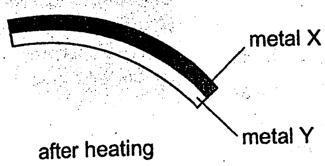
7. The table shows the increase in length of four metals when heated through the same temperature rise. Each metal initially has the same length.

metal	increase in length /m
aluminium	0.000030
copper	0.000020
platinum	0.000009
steel	0.000010

A bimetallic strip is made from two of the metals. When heated, it bends in the direction shown.



at room temperature



after heating

Which metals produce the above effect?

	metal X	metal Y
A	aluminium	platinum
B	copper	aluminium
C	steel	copper
D	platinum	steel

[N08/P1/Q19]

8. What happens when a metal bar is heated?

A The distance between the molecules increases, making the bar longer.

B The molecules get larger, making the bar longer.

C The molecules vibrate more quickly, making the bar denser.

D The speed of the molecules increases, making the bar thinner.

[J09/P1/Q17]

9. A block of metal has a mass of 2.0 kg. Its specific heat capacity is 800 J/(kg°C).

The block is supplied with 2400 J of energy.

What is the rise in temperature?

A 0.17 °C

B 0.67 °C

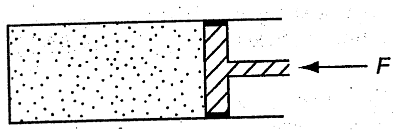
C 1.5 °C

D 6.0 °C

[N09/P1/Q16]

10. A quantity of gas is trapped in a container by a piston exerting a force *F*.

The temperature of the gas is raised while *F* remains unchanged.



Which statement is correct?

A The gas expands.

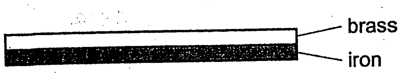
B The molecules get larger.

C The piston remains in the same place.

D The speed of the molecules decreases.

[N09/P1/Q17]

11. A bimetallic strip made from brass and iron is used as a thermostat.



When the strip is heated, the brass expands more than the iron.

MCQ Answers

6. B It is the fact that the mass always remains constant while the temperature, the density and the volume of the air in the balloon changes on increasing the average kinetic energy of air molecules in the balloon.

7. A A bimetallic strip bends on heating and the metal strip in the outer curve is always the one which expands more than the metal strip in the inner curve. The table shows that aluminium expands the most and platinum expands the least among the metals given in the table. Hence, the best pair of metals that can be used for this bimetallic strip is aluminium as metal X and platinum as metal Y.

8. A Heating a metal bar causes thermal expansion by increasing the inter molecular spacing due to their increased amplitudes of vibration which increases the length of the metal bar.

9. C

$Q = mc\Delta\theta$

$2400 = 2.0 \times 800 \times \Delta\theta$

$\Delta\theta = 1.5\ °C$

10. A Fact

11. B As the brass expands more than iron so after bending the brass strip will be in the outer curve whose length is longer than that of the inner curve.

Which shape will the strip become?

A

B

C

D

[J10/P1/Q16]

12. What is caused by the thermal expansion of a substance when heated?

A a decrease in the resistance of a tungsten-filament lamp when switched on

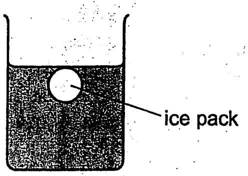
B a rise in the pressure of the gas trapped in a gas cylinder placed in hot water

C the blowing of the fuse in a circuit when the current becomes too large

D the upward movement of the air above a Bunsen burner when it is lit

[N10/P1/Q16]

13. An ice pack is used to cool 0.25 kg of water. The specific heat capacity of water is 4.2 kJ / (kg °C).



How much thermal energy (heat) must the ice pack extract from the water to reduce the water temperature by 15 °C?

A 0.070 kJ **B** 1.1 kJ
C 16 kJ **D** 250 kJ

[J11/P1/Q17]

14. Fillings in teeth should be made from a material which

A does not expand when heated.

B expands by the same amount as the tooth when heated.

C expands less than the tooth when heated.

D expands more than the tooth when heated.

[J11/P1/Q18]

15. To raise the temperature of a 2.0 kg block of metal by 20 °C, energy of 5.2 kJ is needed.

What is the value of the specific heat capacity of the metal?

A 0.13 J / (kg °C)

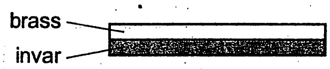
B 52 J / (kg °C)

C 130 J / (kg °C)

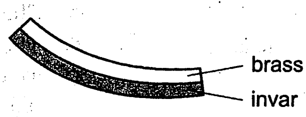
D 52 000 J / (kg °C)

[N11/P1/Q16]

16. A strip is made from two metals joined together. The diagrams show the strip at room temperature and after it has been cooled.



at room temperature



below room temperature

The change in shape occurs because

A brass contracts more than invar.

B brass expands when it cools down.

C invar and brass contract by equal amounts.

D invar contracts more than brass.

[N12/P1/Q20]

Thinking Process

MCQ Answers

12. D The air above a bunsen burner is heated. It expands, becomes less dense and rises up.

13. C
$Q = mc\Delta\theta$
$= 0.25 \times 4200 \times 15$
$= 15750$ J
≈ 16000 J $= 16$ kJ

14. B For the filling to remain in the tight fit, its material must expand by the same amount as the tooth when heated.

15. C Specific heat capacity
$= \dfrac{\text{thermal energy}}{\text{mass} \times \text{temp. change}}$
$c = \dfrac{Q}{m\Delta\theta}$
$= \dfrac{5200}{2 \times 20} = 130$ J/kg °C

16. A It is a fact that brass expands more than invar on heating and contracts more than invar on cooling.
So, on cooling, the length of brass strip becomes shorter than invar. Hence, after bending, it will be along the inner curve of the bimetallic strip.

17. Thermal energy of 12 000 J is supplied to a 2.0 kg mass of copper.

The specific heat capacity of copper is 400 J / (kg °C).

What is the rise in temperature?

A 15 °C **B** 30 °C
C 60 °C **D** 100 °C

[J13/P1/Q18]

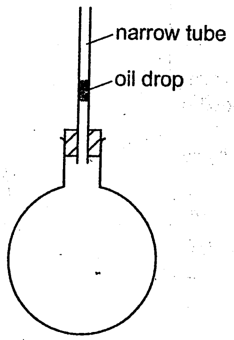
18. Different amounts of energy are supplied to copper blocks of different masses.

Which block experiences the greatest temperature change?

	mass of block / kg	energy supplied / J
A	0.1	200
B	0.2	200
C	0.4	600
D	0.8	400

[N13/P1/Q18]

19. The diagram shows a flask containing air. The air is trapped by a drop of oil in a narrow tube.



When the flask is heated the oil drop rises up the tube.

Which statement is **not** correct?

A The air molecules each get larger.
B The air molecules hit the container with greater force.
C The air molecules move faster.
D The air molecules move further apart.

[J14/P1/Q21]

20. The heat capacity of an object, of mass 2.0 kg, is C. The energy needed to

A increase the temperature of the whole object by Δt is $C\Delta t$.
B increase the temperature of unit mass of the object by Δt is $C\Delta t$.
C melt the whole object is C.
D melt unit mass of the object is C.

[J15/P1/Q23]

21. An insulated beaker contains 300 g of water, initially at 30 °C. Water at 100 °C is added until the temperature of the mixture reaches 50 °C.

The specific heat capacity of water is 4.2 J/(g °C).

How much water is added?

A 60 g **B** 120 g
C 180 g **D** 750 g

[N15/P1/Q19]

MCQ Answers

17. A $Q = mc\Delta\theta$
$12{,}000 = 2.0 \times 400 \times \Delta\theta$
$\Delta\theta = \frac{12000}{2.0 \times 400} = 15°C$

18. A As $Q = mc\Delta\theta$ but c is constant, so, $\Delta\theta \propto \frac{Q}{m}$

For **A**: $\Delta\theta = \frac{200}{0.1} = 2000$ J
For **B**: $\Delta\theta = 1000$ J
For **C**: $\Delta\theta = 1500$ J
For **D**: $\Delta\theta = 500$ J

19. A Heating the flask would cause the air molecules to move faster and further apart. As they would have more kinetic energy, they would hit the container with greater force. However, the air molecules do not get larger or smaller.

20. A By definition, $Q = C\Delta t$. Where Q is the energy needed to increase the temperature of the whole object by Δt, is equal to $C\Delta t$. C is the heat capacity of the object.

21. B Heat lost by hot water $= mc\Delta\theta$
$= m(4.2)(100-50)$
$= 210m$
Heat gained by cold water
$= (300)(4.2)(50-30)$
$= 25200$
Heat lost by hot water = heat gained by cold water
$\therefore 210m = 25200$
$m = 120$ g

Topic 7 Heat Capacity, Expansion

THEORY Section

Question 1

Liquid air contains a mixture of oxygen and nitrogen.

The boiling point of nitrogen is –196 °C and the boiling point of oxygen is –183 °C.

A sample of liquid air in a beaker is allowed to warm up slowly.

Fig. 4.1 shows how the reading of a thermometer in the beaker varies with time *t*.

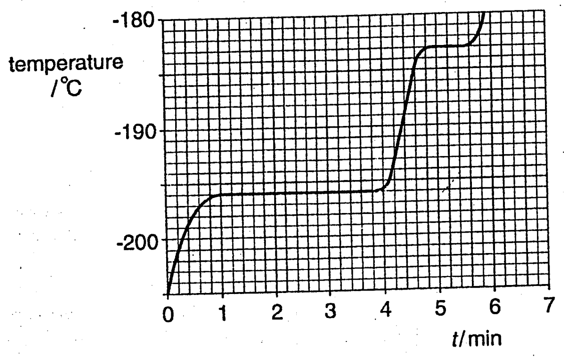


Fig. 4.1

(a) Describe the two changes of state that occur and state when they occur. [3]

(b) The liquid air contains 200 g of liquid oxygen and 800 g of liquid nitrogen. The specific heat capacity of liquid oxygen is 1.7 J / (g °C) and the specific heat capacity of liquid nitrogen is 2.0 J / (g °C).
Calculate the thermal energy needed to warm the liquid from –205 °C to –196 °C.
State the formula that you use in your calculation. [4]

[J08 / P2 / Q4]

Solution

(a) The nitrogen changes from its liquid state to gaseous state between 1 and 4 minutes whereas the oxygen changes from its liquid state to gas between 4.8 min and 5.6 min.

(b) Total heat energy needed = heat energy needed to warm oxygen + heat energy needed to warm nitrogen

$$= mc\Delta\theta + mc\Delta\theta$$
$$= (200 \times 1.7 \times 9) + (800 \times 2.0 \times 9)$$
$$= 3060 + 14400 = 17460 \text{ J.}$$

Question 2

Fig. 9.1 shows an electric boiler in a school kitchen.

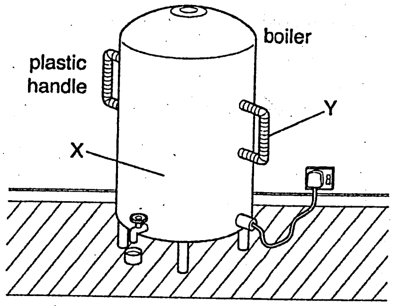


Fig. 9.1

The boiler contains 35 kg of water at 22 °C. The specific heat capacity of water is 4200 J / (kg °C).

(a) (i) Calculate the thermal energy (heat) needed to raise the temperature of the water from 22 °C to its boiling point. [3]

(ii) The water in the boiler is heated with a 2600 W immersion heater. Calculate the minimum time for the heater to bring the water to its boiling point. [2]

(iii) Suggest **one** reason why the actual time is greater than the time calculated in **(ii)**. [1]

(b) (i) The immersion heater is placed in the water at the bottom of the boiler. Explain in detail how this ensures that the thermal energy (heat) is transferred throughout the water. [4]

(ii) The boiler is made of steel and has two large plastic handles. When the water is boiling, the steel surface at X is hot while the plastic handle at Y is cool. Explain why. [2]

(c) Before the water reaches boiling point, water vapour is seen escaping from the boiler.

(i) State the name of the process that produces this water vapour. [1]

(ii) State **two** differences between this process and boiling. [2]

[N09/P2/Q9]

Solution

(a) (i) Since, the change in temperature of water $(\Delta\theta) = 100 - 22 = 78$ °C.

So, $Q = mc\Delta\theta$

$= 35 \times 4200 \times 78$

$\therefore$ Thermal energy needed $= 1.15 \times 10^7$ J

(ii) Power $= \dfrac{\text{energy}}{\text{time}}$

$\Rightarrow$ time $= \dfrac{\text{energy}}{\text{Power}} = \dfrac{1.15\times10^7}{2600} = 4.41\times10^3$ sec

(iii) The actual time is greater than the time calculated above in part (ii) because not all the heat supplied by the heater ends up in the water. Some heat is used to heat the boiler and some of it is also lost to the surroundings.

COMMENT on ANSWER

“(a) (iii). Some heat is also used as latent heat to cause evaporation which takes place while heating the water.”

(b) (i) The immersion heater is placed at the bottom of the boiler so that it heats the water at the bottom of the boiler. The hot water expands and becomes less dense. The less dense water rises up and the cold and denser water sinks down to replace it. This sets up convection currents in the water. Which transfers the thermal energy throughout the water in the boiler.

(ii) The steel being a metal is a good conductor of heat so, more heat is transferred through steel whereas plastic is an insulator material. So, a very small heat is transferred through plastic.

(c) (i) Evaporation.

(ii) 1. The evaporation occurs at any temperature while the boiling occurs at a fixed temperature.

2. The evaporation takes place at the surface of the liquid whereas the boiling takes place in the entire body of the liquid.

Question 3

(a) In an experiment to measure the specific heat capacity of water, an electric heater heats water in a glass beaker. The temperature of the water is measured at regular intervals of time.

Fig. 11.1 shows how the temperature varies with time t.

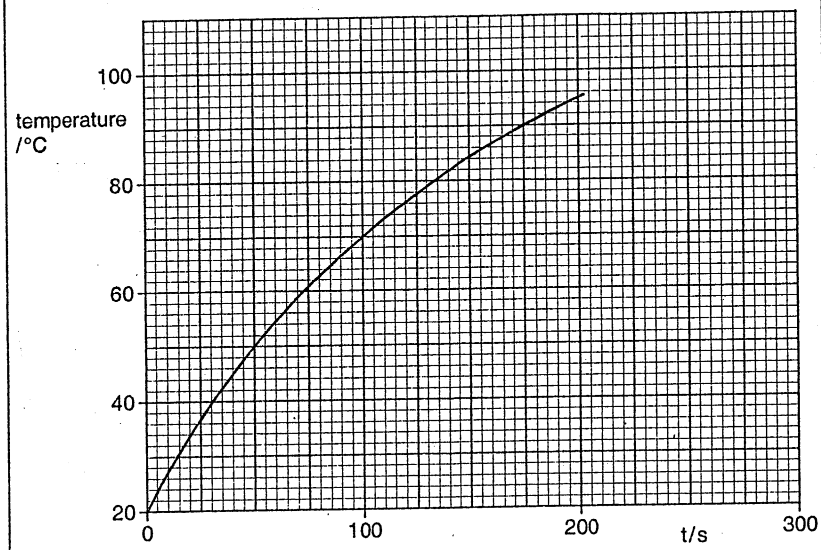


Fig. 11.1

(i) Use Fig. 11.1 to determine the change in temperature between
$t = 0$ and $t = 100$ s,
$t = 100$ s and $t = 200$ s. [1]

(ii) State and explain why the values in **(i)** are different. [2]

(iii) Describe and explain what happens to the water if the heating is continued. [2]

(b) (i) The experiment in **(a)** is repeated using 72 g of water. The heater supplies 7400 J of thermal energy (heat) to the water and the temperature rise of the water is 23 °C.

Calculate the specific heat capacity of water. [2]

(ii) A bullet of mass 72 g is fired from a gun at a speed of 450 m/s. Calculate the kinetic energy of the bullet. [3]

(iii) The amount of internal energy gained by the water and the amount of kinetic energy gained by the bullet are approximately equal.

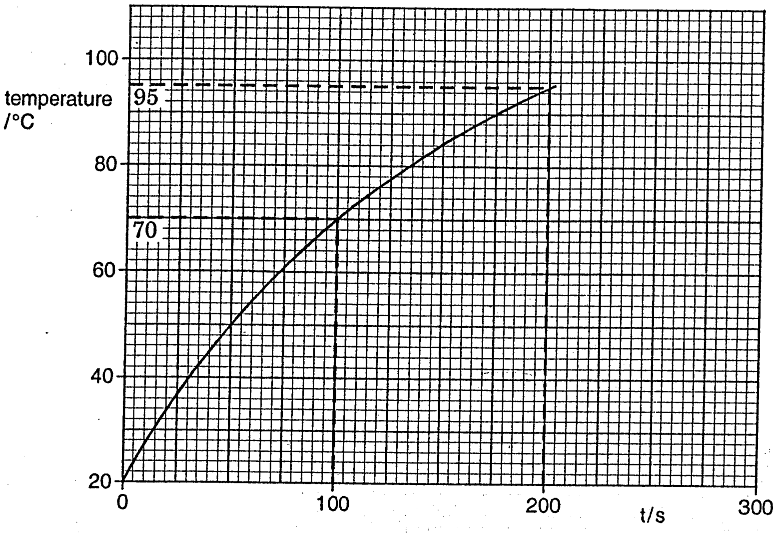
Describe the change in the motion of the molecules of the water and of the molecules of the bullet that this addition of energy has caused. [3]

(c) A thermocouple is used in the experiment in **(a)**. In the space below, draw a labelled diagram of a thermocouple thermometer. Show clearly the part of the thermocouple that is placed in the water in this experiment. [2]

[J11/P2/Q11]

Solution

(a) (i)



$t = 0$ and $t = 100$ s: Change $= 70°C - 20°C = 50°C$

$t = 100$ s and $t = 200$ s: Change $= 95°C - 70°C = 25°C$

(ii) At higher temperatures between $t = 100$ s and $t = 200$ s, the rate of heat loss and rate of evaporation also becomes higher. So more of the heat supplied to the water is lost to the surroundings and remaining less amount of heat energy causes a smaller increase in temperature of water.

(iii) The temperature of water becomes 100°C. It starts boiling and turns into steam. Since all the heat energy supplied is now used as the latent heat of vaporisation so the temperature of water becomes steady.

(b) (i) $Q = mc\Delta\theta$

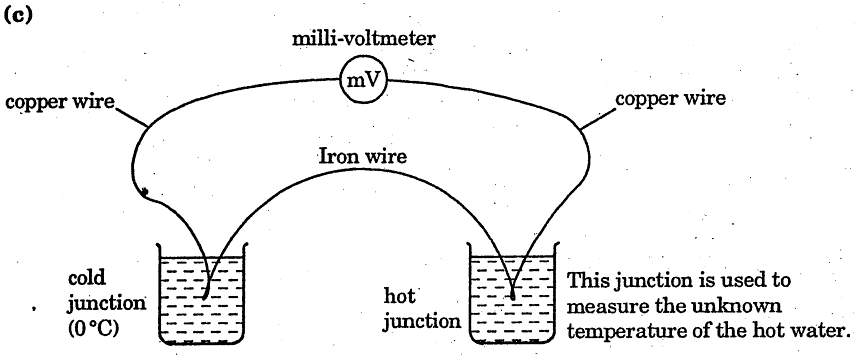
$7400 = 72 \times c \times 23 \Rightarrow c = 4.47$ J/g°C

(ii) $KE = \frac{1}{2}mv^2 \Rightarrow KE = \frac{1}{2} \times (0.072) \times (450)^2 = 7290$ J

(iii) water: On heating, the water molecules start moving more vigorously and more randomly at different speeds in all directions throughout the water. During their random motion, they slide past each other and move slightly further apart.

bullet: On gaining the additional energy, all the molecules of the bullet move in one direction away from the gun at the same speed.

(c)



Question 4

A beaker contains 60 g of a hot substance, initially in the liquid state. Fig. 4.1 shows how the temperature of the substance changes with time t as it cools in a laboratory.

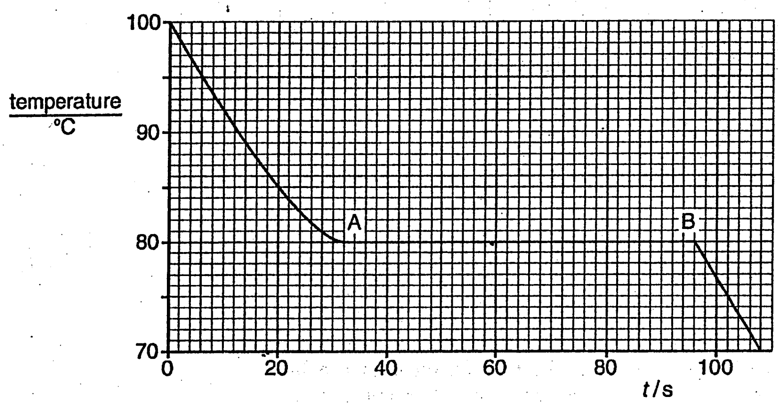


Fig. 4.1

(a) Use Fig. 4.1 to determine the melting point of the substance. [1]

(b) The specific heat capacity of the liquid is 1.7 J / (g °C). Calculate the loss of thermal energy (heat) from the liquid between t = 0 and t = 20 s. [2]

(c) Between points A and B on Fig. 4.1, the temperature is constant as the substance changes from liquid to solid.

(i) Explain why the temperature stays constant, even though thermal energy is lost by the substance. [2]

(ii) Describe the change in the arrangement of the molecules as the substance changes from a liquid to a solid. [2]

[J12/P2/Q4]

Solution

(a) 80°C

(b) $Q = mc\Delta\theta$

$= 60 \times 1.7 \times 15 = 1530$

$\therefore$ loss of thermal energy = 1530 J

(c) (i) The thermal energy lost is the latent heat given out by the substance when the intermolecular bonds are formed and the liquid molecules come together to form a solid.

(ii) In a liquid, molecules move randomly throughout the liquid while in a solid, they move into fixed positions and vibrate about these positions. Hence the molecules arrangement changes from random in a liquid to regular arrangement in a solid.

COMMENT on ANSWER

" **(c) (i)** The release of latent heat does not affect the K.E. of the molecules. It only decreases the P.E. of the molecules. Hence the temperature remains constant during the change of state from liquid to solid. "

Question 5

Most substances expand when they are heated.

(a) (i) State one example where expansion is useful. [1]

(ii) State one example where expansion causes a problem. [1]

(b) Explain, using ideas about molecules, why solids expand when heated. [2]

(c) When equal volumes are heated through the same temperature rise, the expansions of solids, liquids and gases are different.

Complete each of the two sentences using one of these expressions:

much larger **slightly larger** **much smaller** **slightly smaller**

1. The expansion of a solid is .... than the expansion of a liquid.
2. The expansion of a gas is .... than the expansion of a liquid. [2]

[J14/P2/Q3]

Solution

(a) (i) Expansion is useful in bimetallic strips, which are used in electric thermostats.

(ii) Expansion of railway lines and concrete bridges on hot days.

(b) When heated, molecules of a solid have more potential and kinetic energy. Therefore, they vibrate faster than before and with a larger amplitude. The distance between the molecules increases and the solid expands.

(c) 1. The expansion of a solid is **slightly smaller** than the expansion of a liquid.

2. The expansion of a gas is **much larger** than the expansion of a liquid.

Question 6

Two metal saucepans contain the same mass of hot water at the same initial temperature. Pan A is white and pan B is black, but otherwise the two saucepans are identical.
Both saucepans are uncovered and cool under the same conditions.
The cooling curves for the two saucepans are shown in Fig. 10.1.

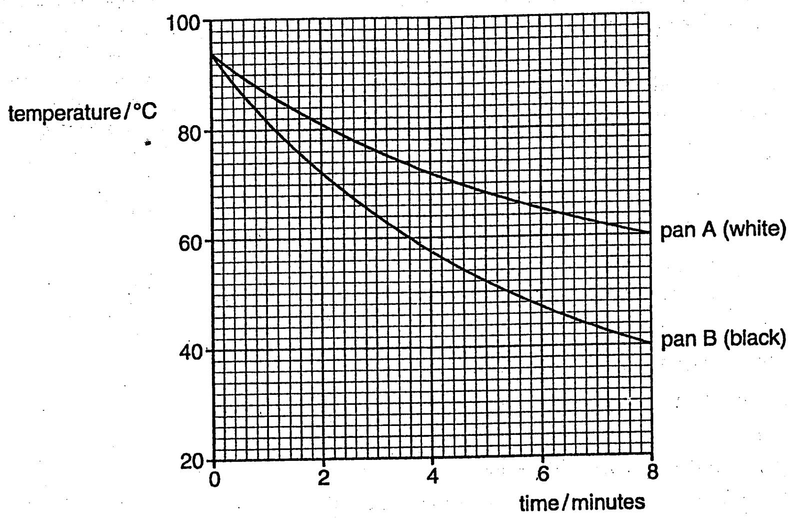


Fig. 10.1

(a) Describe how the water in a pan loses heat by

(i) conduction, [2]

(ii) convection. [2]

(b) (i) Explain why pan B cools faster than pan A. [1]

(ii) Describe and explain how Fig. 10.1 is different when the pans are covered and the experiment is repeated. [2]

(c) The specific heat capacity of water is 4200 J/(kg °C).

(i) Explain what is meant by *specific heat capacity*. [2]

(ii) The specific heat capacity of water is very high. Suggest one disadvantage of this when water is used for cooking. [1]

(iii) The water in pan A cools for 8 minutes, as shown in Fig. 10.1. During this time, the water loses an average of 9000 J of thermal energy per minute.

1. Calculate the mass of water in pan A. [3]

2. The mass of water in pan B is the same as that in pan A. Calculate the thermal energy lost from the water in pan B during the 8 minutes. [2]

[J14/P2/Q10]

Solution

(a) **(i)** Molecules vibrate and collide, and energy is passed from one molecule to another. Thus energy from water molecules is passed onto the metal saucepan which further dissipates the energy into the environment.

(ii) Heat energy is passed onto the air above the hot water. This hot air expands, becomes less dense and rises. The denser colder air, from the surroundings, moves in to replace the hot air that has risen. This sets up convection currents that transfer heat into the surrounding area.

(b) **(i)** Black objects are better emitters of radiation compared to white objects. Therefore pan B cools faster than pan A.

(ii) Due to lesser evaporation and convection, the graph will show that the decrease in temperature will be lesser than before in the same time period.

(c) **(i)** The specific heat capacity of a substance is the amount of energy needed to change the temperature of 1 kg of the substance by 1°C.

(ii) Water takes longer time to boil.

(iii) **1.** Total heat energy lost $= 9000 \times 8 = 72000$ J

$$Q = mc\Delta\theta$$

$$\Rightarrow \quad m = \frac{Q}{c\Delta\theta}$$

$$= \frac{72000}{4200(94-60)}$$

$$= 0.5042 \approx 0.50 \text{ kg}$$

2. Loss of thermal energy, $Q = mc\Delta\theta$

$$= 0.5042 \times 4200 \times (94-40)$$

$$= 114352.56 \approx 114000 \text{ J}$$

Topic 8 *Transfer Of Heat*

MCQ Section

1. Density changes are responsible for which method of thermal energy transfer?

A conduction only
B convection only
C radiation only
D conduction, convection and radiation

[J06/P1/Q20]

2. The heat from the hot water in a metal radiator passes through the metal and then spreads around the room.

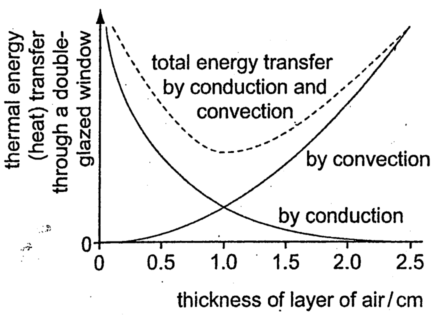
What are the main processes by which the heat is transferred through the radiator and then spread around the room?

	through the metal radiator	around the room
A	conduction	conduction
B	conduction	convection
C	radiation	conduction
D	radiation	convection

[N06/P1/Q18]

3. A double-glazed window has two sheets of glass separated by a layer of air.

Thermal energy is conducted and convected through the layer of air. The amount of conduction and convection varies with the thickness of the layer of air, as shown in the graph.

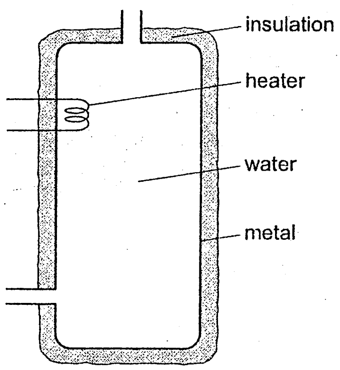


Which thickness of air produces the smallest energy transfer, and why?

A 0.5 cm because there is little convection
B 1.0 cm because the total thermal energy transfer is least
C 1.5 cm because the total thermal energy transfer is small and conduction is low
D 2.0 cm because there is little conduction

[J07/P1/Q18]

4. Water at the top of a hot-water tank is heated and the water becomes hot. No water enters or leaves the tank.



Water at the bottom of the tank stays cold for some time.

Why is this?

A Cold water at the top of the tank falls to the bottom.
B Hot water at the bottom of the tank rises to the top.
C Water is a poor conductor of heat.
D The insulation is a poor conductor of heat.

[N07/P1/Q18]

MCQ Answers

1. B The convection requires density changes resulting in bulk movement of fluids whereas Radiation involves infra-red radiations and conduction uses collision mechanisms.

2. B Since metal is a solid, it can only transfer heat by conduction. In the room, heat is transferred via convection currents in the air.

3. B The graph shows that 1 cm thick layer of air between the two sheets of glass in a double-glazed window allows the minimum transfer of heat by conduction and convection together.

4. C On heating, the hot less dense water remains at the top and no convection current occurs. The transfer of heat energy from top to bottom takes place only by conduction but as water is a poor conductor of heat so it takes some time before the heat energy reaches the bottom.

5. In a vacuum flask, which methods of heat transfer are prevented by the vacuum?

A conduction only

B convection only

C conduction and convection only

D conduction, convection, and radiation

[J08/P1/Q14]

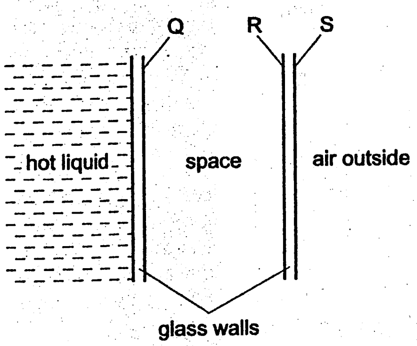
6. Ice is taken from a freezer and left in a room. The ice melts and eventually the water reaches room temperature.

Which energy transfers take place?

	energy transfer **during** melting	energy transfer **after** melting
A	from ice to room	from water to room
B	from ice to room	from room to water
C	from room to ice	from room to water
D	from room to ice	from water to room

[J08/P1/Q17]

7. A student needs a double-walled glass vessel to contain a hot liquid.



What reduces heat losses by radiation?

A a vacuum in the space between the walls

B painting surface Q black

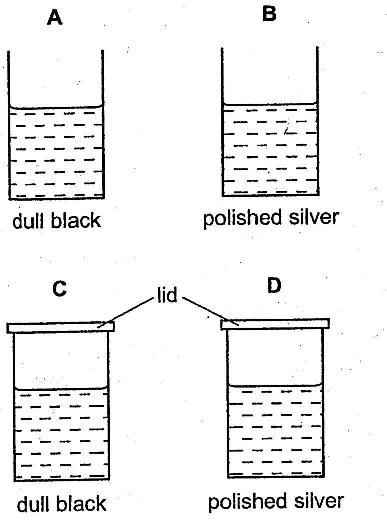
C painting surface R black

D painting surface S silver

[N08/P1/Q16]

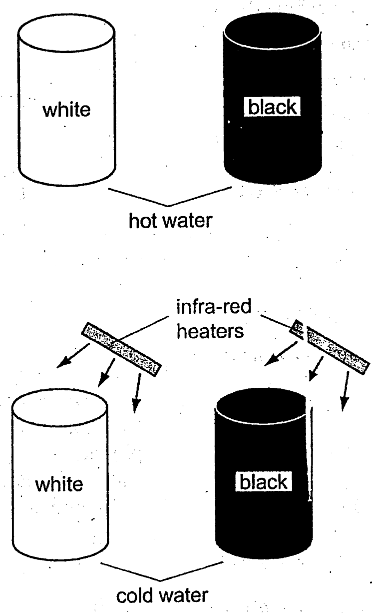
8. The diagrams show four identical cans with their outside surfaces painted either dull black or polished silver. Each can contains the same volume of water, initially at 80 °C.

After five minutes in a cool room, which can contains the **coolest** water?



[J09/P1/Q14]

9. The diagrams show four cans in a cool room. They are painted as shown. One pair is filled with hot water and left to cool down. The other pair is filled with cold water and placed near infra-red heaters.



The hot water in the black can cools more quickly than the hot water in the white can. The cold water in the black can heats up more quickly than the cold water in the white can.

Which row shows the reasons for this?

MCQ Answers

5. C The vacuum between the double glass walls prevents heat transfer by conduction and convection because these two processes require a medium. However, heat transfer by radiation can still take place in a vacuum because this process does not need a medium.

6. C The heat transfer takes place due to the temperature difference from a higher to a lower temperature. As the ice is at a lower temperature than the room temperature, so heat transfer takes place from room to ice during its melting. Also, the water formed from the melting of ice is at 0 °C which is lower than the room temperature, so the heat transfer takes place from the room to the water.

7. D The silver surface S being a poor emitter of infra-red radiations reduces the heat losses from the hot liquid inside the glass vessel to the surroundings by the process of radiation.

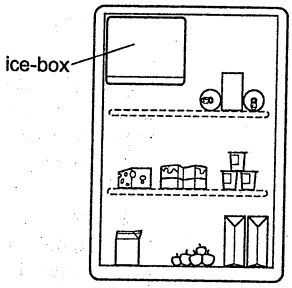
8. A The heat is lost from the cans by the emission of infra-red radiations. The dull-black outer surface of the can **A** is a better emitter of infra-red radiations and more over it is not covered with a lid. So it loses heat energy by evaporation and convection also.

9. A It is a fact that a black surface is a better absorber as well as a better emitter of infra-red radiations.

	better emitter of infra-red	better absorber of infra-red
A	black	black
B	black	white
C	white	black
D	white	white

[N09/P1/Q14]

10. When a refrigerator is switched on for the first time, the air surrounding the ice-box is cooled.



What happens to the density of this air and to its position inside the refrigerator?

	density	position of the air
A	decreases	sinks to the bottom
B	decreases	stays at the top
C	increases	sinks to the bottom
D	increases	stays at the top

[J10/P1/Q17]

11. The tubes inside solar heating panels use the Sun's radiation to warm water.
Why are the tubes painted black?

A Black surfaces absorb radiation well.

B Black surfaces conduct heat well.

C Black surfaces emit radiation well.

D Black surfaces reflect radiation well.

[N10/P1/Q13]

12. How does heat transfer through a vacuum take place?

A by conduction, convection and radiation

B by conduction only

C by convection only

D by radiation only

[N11/P1/Q19]

13. How is heat conducted in a metal?

A by movement of electrons through the metal only

B by movement of atoms through the metal only

C by vibration of atoms and movement of electrons through the metal

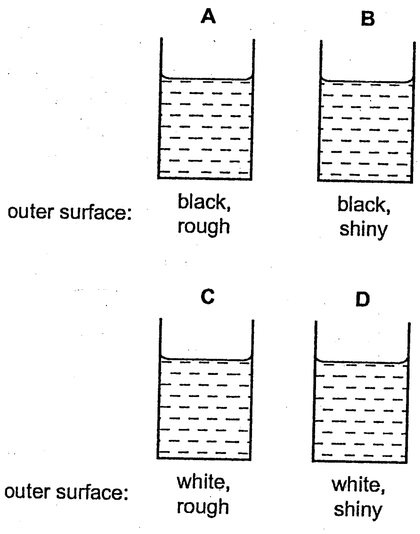
D by vibration of atoms only

[J12/P1/Q17]

14. Four metal cans are identical except for the colour and the texture of their outer surfaces.

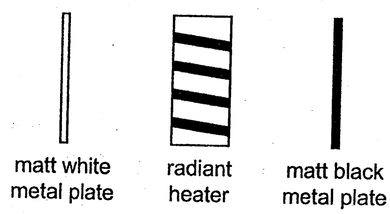
100 cm^3 of water at 70 °C is poured into each can.

Which cools the most rapidly?



[N12/P1/Q17]

15. Two identical metal plates are painted, one matt (dull) white and the other matt black. These are placed at equal distances from a radiant heater as shown. The heater is turned on for five minutes.



MCQ Answers

10. C Fact.

11. A It is a fact that all dull and black surfaces are better absorbers of infra-red radiations.

12. D As there is no matter in a vacuum, so heat travels as waves in radiation.

13. C It is a fact that heat is conducted in a metal by vibration of atoms which pass energy from one atom to the other in the form of waves (slow process) as well as by the movement of free electrons. The free electrons gain energy at the hot end and drift towards the cooler parts of the metal. They transfer their extra energy by collision to the metal molecules there and return to repeat this process (fast process).

14. A This metal cools most rapidly because its outer dull black surface is a better emitter of infra-red radiations than the other shiny and white surfaces.

15. A It is a fact that a dull black surface is a good absorber as well as a good emitter of radiant heat energy.

Which metal plate absorbs more energy and which plate emits more energy in this time?

	absorbs more	emits more
A	black	black
B	black	white
C	white	black
D	white	white

[J13/P1/Q16]

16. Energy can be transferred in many different ways.

In which situation is energy transferred by wave motion?

A colliding atoms in a heated copper rod

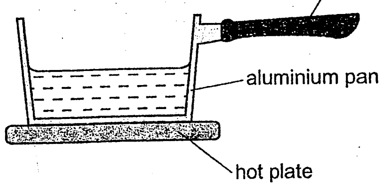
B fast-moving electrons in a cathode-ray oscilloscope

C hot water rising in a heated saucepan

D ripples passing across water in a ripple tank

[J13/P1/Q22]

17. A saucepan is used to heat up some water.



How is heat transferred through the aluminium pan and through the plastic handle?

	heat is transferred through the aluminium pan by	heat is transferred through the plastic handle by
A	the movement of free electrons and the vibration of atoms	the movement of free electrons and the vibration of molecules
B	the movement of free electrons and the vibration of atoms	the vibration of molecules only
C	the movement of free electrons only	the movement of free electrons and the vibration of molecules
D	the movement of free electrons only	the vibration of molecules only

[N13/P1/Q15]

18. A silver cup is filled with boiling water from a kettle.

A man touches the outside surface of the cup and finds that it is extremely hot.

Why is the surface so hot?

A Convection takes place in the boiling water.

B Silver is a good conductor of heat.

C The boiling water gives out latent heat.

D The shiny surface is a good emitter of infra-red radiation.

[N13/P1/Q16]

19. Which statement about copper explains why it is a better conductor of heat than glass?

A Atomic vibration is passed on to neighbouring copper atoms quickly.

B Atoms move through the copper and pass on kinetic energy.

C There are density changes within the copper.

D There are free electrons in the copper.

[N14/P1/Q11]

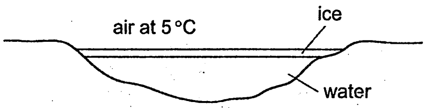
16. D Fact

17. B As aluminium contains free electrons so heat is transferred through it by the movement of free electrons and the vibrations of atoms but as plastic does not contain free electrons so heat is transferred through it by the vibration of molecules only.

18. B Since silver is a good conductor of heat, so heat is quickly transferred from the hot water to the outer surface of the silver cup.

19. D Metals have free mobile electrons which can move through the metal, collide with neighbouring free electrons and pass heat energy from hotter parts of the metal, to cooler parts. Glass, being an insulator, does not have free electrons and therefore does not conduct heat as good as metals.

20. The diagram shows a frozen pond with the surface of the ice slowly melting as heat is transferred from the warmer air above it.



By which processes is heat transferred from the air to the ice ?

A conduction, convection and radiation
B conduction and convection only
C convection and radiation only
D radiation and conduction only

[N14/P1/Q12]

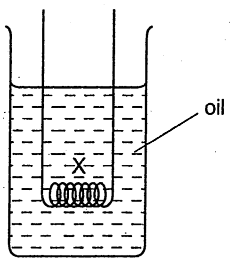
21. A solid bar is heated at one end.

How is thermal energy transferred to the other end of the bar?

A Heated molecules move along the bar, carrying energy to the other end.
B Heated molecules move along the bar, giving energy to others along the bar.
C Heated molecules stay completely still, but give energy to other molecules.
D Heated molecules vibrate more rapidly and pass energy to other molecules.

[J15/P1/Q14]

22. An electrical heater is placed in a beaker of cold oil, as shown.



The heater is switched on.

What happens to the liquid at X?

A It becomes less dense and falls.
B It becomes less dense and rises.
C It becomes more dense and falls.
D It becomes more dense and rises.

[J15/P1/Q15]

23. The tubes inside solar heating panels use the Sun's radiation to warm water.

Why are the tubes painted black?

A Black surfaces absorb radiation well.
B Black surfaces conduct heat well.
C Black surfaces emit radiation well.
D Black surfaces reflect radiation well.

[J15/P1/Q16]

MCQ Answers

20. D Air molecules in contact with the surface of ice transfer heat to the ice by means of conduction. As the air in contact with ice becomes cooler and dense, no convection current occurs. Heat is also transferred from the air to the ice via radiation.

21. D It is a fact that during conduction of heat energy through a solid bar, the heated molecules vibrate more rapidly and transfer their energy to the neighbouring molecules by colliding with them.

22. B The oil at X heats up and expands. It then becomes less dense and rises up.

23. A It is a fact that black surfaces are good absorbers of heat radiations.

Topic 8 *Transfer Of Heat*

THEORY Section

Question 1

Two metal teapots are identical except that one is black on the outside and the other is white on the outside, as shown in Fig. 3.1.

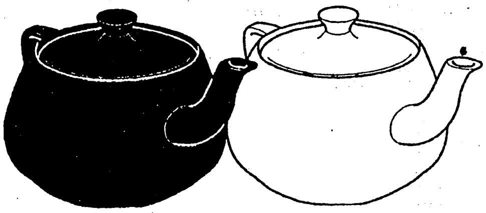


Fig. 3.1

(a) Initially the teapots are in thermal equilibrium with each other.

(i) State what is meant by *thermal equilibrium*. [1]

(ii) State why the teapots are initially in thermal equilibrium. [1]

(b) Initially, the teapots were filled with the same amount of boiling water. They are cooling down.

(i) Explain why thermal energy is lost to the air. [1]

(ii) State and explain which teapot will cool down more quickly. [2]

[N06/P2/Q3]

Solution

(a) (i) There is no net heat transfer between the teapots.

(ii) Both teapots are at the same temperature.

(b) (i) The teapots are at a higher temperature compared to the air and thermal energy flows from the hotter teapots to the cooler surrounding air.

(ii) The black teapot cools down more quickly since black surfaces are better emitter of radiation compared to white surfaces.

COMMENT on **ANSWER**

“ **(a)** There is no heat transfer between two bodies at the same temperature. This is known as thermal equilibrium.

(b) (i) Thermal energy always transfers from hotter bodies to cooler bodies.

(ii) The surfaces of an object can transfer thermal energy using infra-red radiation. As a result, the temperature of the object decreases. ”

Question 2

Fig. 4.1 shows equipment placed on top of a house that uses solar energy to produce hot water.

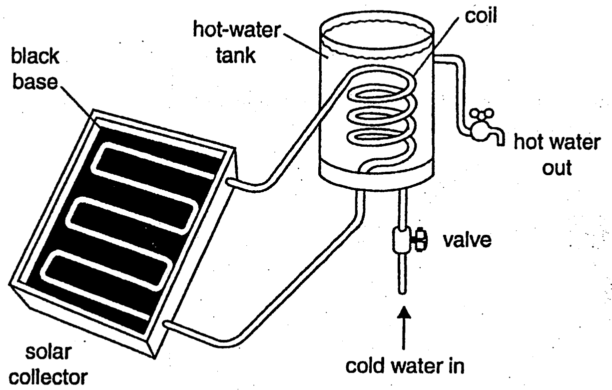


Fig. 4.1

(a) Explain why the solar collector has a black base. [2]

(b) State and explain why the hot water in the solar collector travels to the hot-water tank. [2]

(c) Fig. 4.1 does not show any insulation.

(i) Explain why it is important to insulate the hot-water tank. [1]

(ii) Explain how the hot-water tank is insulated. [1]

[N07/P2/Q4]

Solution

(a) Black surface is a good absorber of infrared radiation, so the black base of the solar collector increases the rate of absorption of solar energy.

(b) The water entering into the solar collector is heated, expands and becomes less dense. It then rises up and travels to the hot water tank.

(c) (i) The insulation of hot water tank is important to prevent heat losses from the tank in order to keep the water hot for a longer time.

(ii) The tank is lagged with an insulating material. e.g. expanded polystyrene.

COMMENT on ANSWER

" **(a)** Here, it is wrong to say that black surface is good absorber and emitter.

Also, it is not correct that a black surface attracts infra-red more.

Similarly, use the word either "radiation" or "infra-red" and not heat.

(b) *Alternatively:*

The hot water rises by convection currents. Note that it is wrong to say that heat rises.

(c) (ii) The glass-fibre is another good insulating material that can be used for the lagging of the hot water tank. "

Question 3

Fig. 2.1 shows a metal pan containing water on a cooker. The hotplate heats the water.

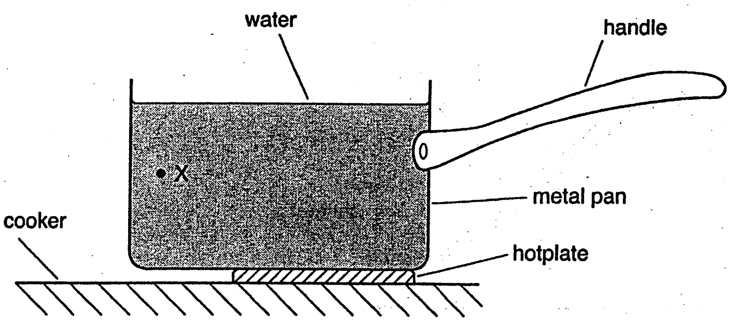


Fig. 2.1

(a) (i) State the method of heat transfer through the metal pan. [1]

(ii) Describe how the molecules transfer heat through the metal pan. [1]

(b) (i) On Fig. 2.1, draw an arrow to show the direction of movement of the water at point X. [1]

(ii) Explain why the water moves in this direction. [3]

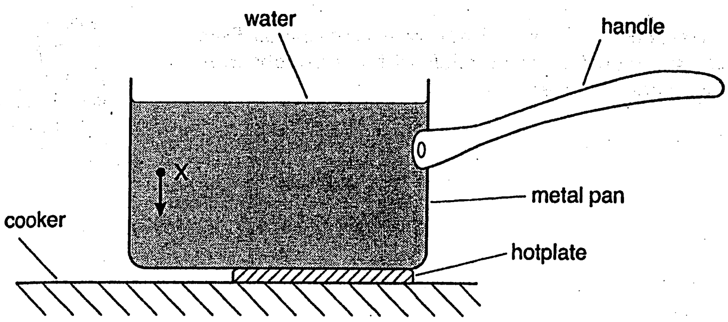
[J09/P2/Q2]

Solution

(a) (i) Conduction

(ii) On gaining heat from the hot plate, the molecules of the base of metal pan start vibrating more vigorously. This increase in vibrations is passed from the molecules of one layer to the molecules of the next layer by hitting until it reaches the water inside the pan.

(b) (i)



(ii) The water in the pan on its right gains heat from the hot plate. It becomes hot, less dense and rises up. The cold and denser water near the point X moves downwards to replace it. This sets up anticlockwise convection currents, which spread the heat energy throughout the water.

COMMENT on ANSWER

“ **(a) (i)** The transfer of thermal energy in a solid takes place through conduction.

(ii) The transfer of heat energy in a metal also takes place by the diffusion of free electrons from the hot end towards the cold end. ”

Question 4

Fig. 3.1 shows a metal roof. One side is facing the Sun.

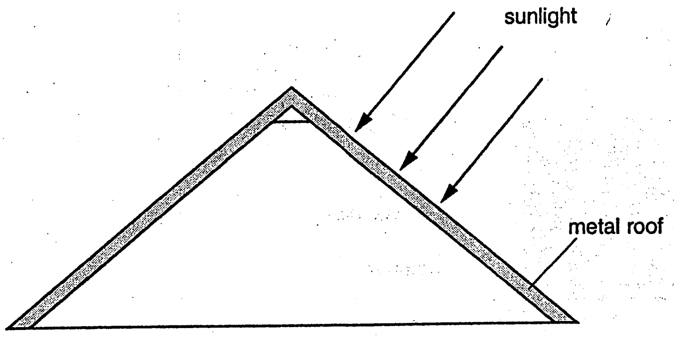


Fig. 3.1

(a) State the means by which thermal energy (heat) is transferred from the Sun to the Earth and explain why other means of thermal energy transfer are not involved. [2]

(b) Describe how thermal energy is transferred through the metal roof from the heated surface. [2]

(c) During the night, the metal roof loses 1.2×10^6 J of thermal energy and its temperature falls by 20 °C.

The specific heat capacity of the metal in the roof is 400 J / (kg °C).

Calculate the mass of metal in the roof. [2]

[J10/P2/Q3]

Solution

(a) Thermal energy is transferred from the sun to the earth by the process of radiation. Conduction or convection is not possible because of the vacuum between the sun and the earth.

(b) The molecules of the outer surface of the metal roof gain heat energy from the sun and start vibrating vigorously. They then collide with the neighbouring molecules and conduct this energy to them.

(c)
$$Q = mc\Delta\theta$$
$$1.2\times10^6 = m\times400\times20$$
$$m = 150 \text{ kg}$$

COMMENT on **ANSWER**

❝ **(a)** The conduction and convection processes, both need a material medium to transfer heat energy from one place to another but there is no material or medium in the space. ❞

Question 5

Fig. 3.1 shows the plan of a bedroom and part of the main room of a house. Other rooms are not shown.

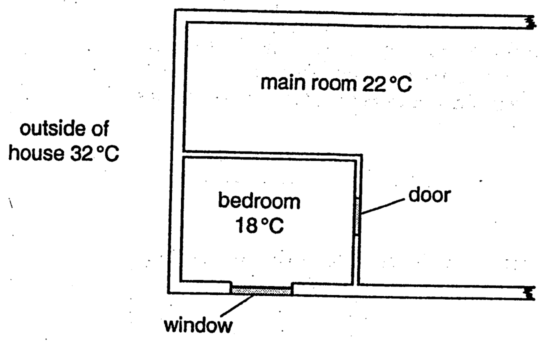


Fig. 3.1

The temperatures of the main room, the bedroom and the outside of the house are shown on Fig. 3.1.

Fig. 3.2 shows all the thermal energy (heat) inputs to the bedroom in one hour.

thermal energy input to bedroom	
through door and walls from main room	50 000 J
through walls from outside of house	2000 000 J
through window	1000 000 J
from person sleeping in bedroom	250 000 J

Fig. 3.2

(a) Suggest why more thermal energy enters the bedroom from the outside of the house than from the main room. [1]

(b) An air conditioner keeps the temperature constant in the bedroom by removing thermal energy.

(i) Calculate the total thermal energy that the air conditioner removes from the bedroom in one hour. [1]

(ii) The electrical power input to the air conditioner is 300 W. Calculate the electrical energy input into the air conditioner in 1 hour. [2]

(c) The air conditioner cools the air at the top of the room. This causes a convection current in the room. [3]

Explain how the cold air gives rise to the convection current.

[J12/P2/Q3]

Solution

(a) This is because the temperature difference between the outside and the bedroom is greater than the temperature difference between the main room and the bedroom.

(b) (i) Total heat energy removed = 50000 + 2000000 + 1000000 + 250000

= 3300000

∴ Thermal energy = 3300000 J

COMMENT on ANSWER

“ (a) Temperature difference between outside and bedroom = 32 – 18 = 14°C

Temperature difference between main room and bedroom = 22 – 18 = 4°C

(b) (i) *Alternative Answer:*

$E = P\text{(Kilowatts)} \times t\text{(hours)}$

$= \frac{300}{1000} \times (1.0)$

= 0.3 kWh. ”

(ii) $E = P \times t$

$= 300 \times 60 \times 60$

$= 1080000$

$\therefore$ energy $= 1.08 \times 10^6 J$

(c) The cold air being denser, sinks while the warm air below, being less dense, rises. This warm air is cooled by the air conditioner and hence sinks again. In this way, the recirculation of air takes place and convention currents are set up in the room.

Question 6

(a) No thermal energy (heat) is transferred from the surface of the Sun to the Earth by either conduction or convection.

Explain why this is so. [2]

(b) In a certain country, the climate is very sunny and hot during the day and extremely cold during the night.

Explain how painting the houses white helps to maintain a comfortable temperature both during the day and during the night. [3]

[N12/P2/Q5]

Solution

(a) The transfer of thermal energy by conduction and convection is not possible through space between the sun and the earth. Both of these processes need a material medium to transfer thermal energy whereas there is a vacuum in the space.

(b) during the day: White surfaces are poor absorbers and good reflectors of infra-red radiations. So, a white painted house absorbs less heat energy from the sun and most of it is reflected back.

during the night: White surfaces are poor emitters of radiant heat. So, at night, the loss of heat energy from a white house is reduced and a comfortable temperature inside the house is maintained.

Question 7

(a) State what happens to the molecules of a gas as its temperature increases. [1]

(b) Fig. 6.1 shows a runner in a long distance race. He tips water over himself to keep cool.

Fig. 6.1

(i) Explain, in terms of molecules, how the evaporation of water keeps the runner cool. [3]

(ii) At one point in the race, a strong breeze blows past the runner and the water evaporates more quickly.
Suggest one reason why the water evaporates more quickly in the breeze. [1]

[N14/P2/Q6]

Solution

(a) The molecules gain more kinetic energy and, hence, move faster.

(b) (i) Water molecules absorb heat from the runner's body. This increases their kinetic energy. Water molecules that are more energetic escape into the air, leaving behind the slower less energetic molecules. This helps in decreasing the temperature of the runners body and keeping him cool.

(ii) In a breeze, the surrounding air becomes less humid thereby increasing the rate of evaporation.

COMMENT on ANSWER

“(b) (ii) The relative humidity of a certain location directly affects the rate of evaporation. If the air is already filled with water vapour i.e. is humid, it will not have any space to hold excess vapour and therefore, evaporation will occur at an extremely slow rate.”

Question 8

A metal can and a plastic bottle, both containing liquid, are cooled by placing them in a jug of melting ice, as shown in Fig. 4.1.

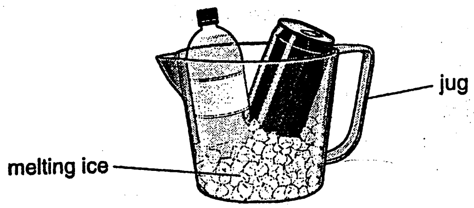


Fig. 4.1

The can and bottle each contain 330 g of the same liquid at 15 °C.

(a) The specific heat capacity of the liquid is 4.2 J / (g °C).
Calculate the thermal energy released when 330 g of the liquid at 15 °C cools to 2 °C. [2]

(b) When water at 0 °C is used in the jug, instead of the melting ice, the cooling is slower.
Explain why cooling is faster when using melting ice in the jug, rather than water at 0 °C. [2]

(c) The liquid in the metal can cools down faster than the liquid in the plastic bottle.
Suggest why this happens. [1]

[J15/P2/Q4]

Solution

(a) $Q = mc\Delta\theta$

$= 330 \times 4.2 \times 13$

$= 18018 \text{ J} \approx 18000 \text{ J}$

(b) The melting ice absorbs heat from the liquid twice, in the form of latent heat while melting and then in order to achieve thermal equilibrium with the liquid after melting. In contrast, the water at 0 °C only takes heat from the liquid to raise its temperature in order to achieve thermal equilibrium with the liquid.

(c) A metal is a good conductor and plastic is an insulator of heat. So the liquid in the metal can loses its heat energy faster than the plastic bottle.

COMMENT on ANSWER

“ **(c)** *Alternatively:*

As the metal can has a lower heat capacity so, it heats up quickly gaining heat energy from the liquid inside and loses it to the melting ice which makes the heat loss faster from the can. ”

Question 9

A copper saucepan with a wooden handle contains cold water. The saucepan is placed on a red-hot heating element that is a part of an electric cooker.

Fig. 4.1 shows the saucepan on the heating element.

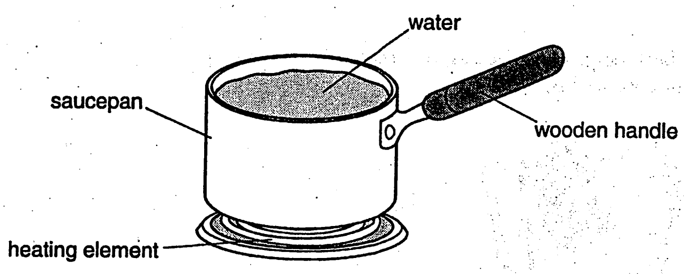


Fig. 4.1

(a) Explain why wood is a suitable material for the handle of the saucepan. [1]

(b) (i) Describe and explain, in terms of free electrons, how thermal energy is transferred through the copper base of the saucepan. [3]

(ii) Describe and explain how thermal energy is transferred upwards through the water. [3]

[N15/P2/Q4]

Solution

(a) Wood is a good insulator of heat.

(b) (i) The atoms at the lower layer of copper base gain energy from the heating element and begin vibrating more vigorously. They hit free electrons and transfer energy to them. On gaining the extra energy, the fast moving electrons diffuse into the upper cooler parts of the metal base and transfer energy to distant atoms. They then return to the hotter metal layer to repeat the process.

(ii) The lowest layer of water gains heat energy from the hot copper base. This water then expands, becomes less dense and rises up. The cooler, denser water sinks down to replace it. This sets up convection currents helping in spreading heat energy throughout water.

COMMENT on ANSWER

“ **(a)** *Alternative answer:*

wood is a poor conductor of heat.

(b) (i) The words like particles, ions or molecules can also be used instead of atoms. ”

Topic 9 Temperature

MCQ Section

MCQ Answers

1. Which thermometer is the best for measuring rapidly changing temperatures?

   A a clinical thermometer
   B a liquid-in-glass thermometer
   C a thermocouple
   D all thermometers are equally good

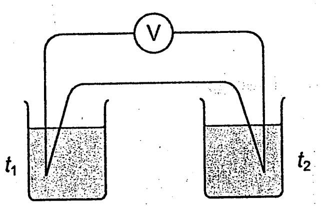
   [J06/P1/Q17]

2. The temperature shown by a mercury-in-glass thermometer increases. Which of the following is constant?

   A the density of the mercury
   B the internal energy of the mercury
   C the mass of the mercury
   D the volume of the mercury

   [N06/P1/Q15]

3. A thermocouple thermometer uses a voltmeter to measure the e.m.f. generated between two junctions. The junctions are at temperatures t_1 and t_2. To calibrate the thermometer, fixed points are needed.



   What are the values of t_1 and t_2 when the thermometer is calibrated at the steam point?

	t_1	t_2
A	0 °C	0 °C
B	0 °C	100 °C
C	25 °C	0 °C
D	25 °C	125 °C

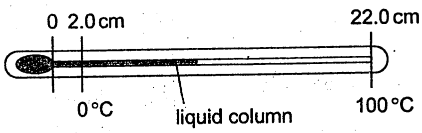
   [J07/P1/Q15]

4. Which instrument is most suitable for measuring a rapidly changing temperature?

   A alcohol-in-glass thermometer
   B clinical thermometer
   C mercury-in-glass thermometer
   D thermocouple

   [N07/P1/Q15]

5. The diagram shows a liquid-in-glass thermometer.



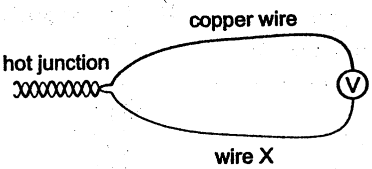
   At 0 °C, the length of the liquid column is 2.0 cm. At 100 °C, the length of the liquid column is 22.0 cm.

   What is the length of the liquid column at 40 °C?

   A 6.0 cm   **B** 8.0 cm
   C 8.8 cm   **D** 10.0 cm

   [J08/P1/Q15]

6. A thermocouple thermometer is made from two wires connected to a voltmeter.



   Which arrangement gives a reading on the voltmeter?

	temperature of voltmeter	wire X
A	colder than hot junction	copper
B	colder than hot junction	iron
C	same as hot junction	copper
D	same as hot junction	iron

   [N08/P1/Q17]

1. C A thermocouple has a low heat capacity which makes it suitable for measuring rapidly changing temperatures. The other two thermometers have a glass exterior which is a poor conductor of heat so they take a longer time to measure a change in temperature.

2. C When the mercury is heated, the density of the mercury decreases. The volume and internal energy of the mercury both increases.

3. B Fact.

4. D Fact.

5. D

$$\theta = \frac{l_\theta - l_0}{l_{100} - l_0} \times 100$$

$$40\text{ °C} = \frac{l_\theta - 2.0}{22.0 - 2.0} \times 100$$

$$l_\theta = 10.0 \text{ cm}$$

6. B Fact.

7. What makes a liquid-in-glass thermometer sensitive to a small change of temperature?

   A a bulb with a thin glass wall
   B a shiny liquid in its bore
   C a stem with a thick glass wall
   D a very narrow bore

   [J09/P1/Q15]

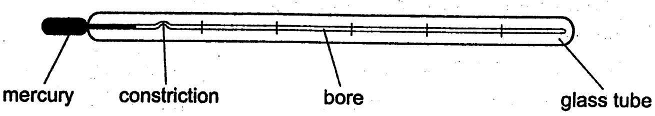
8. To calibrate a thermometer, without using another thermometer, fixed points are required.

   Which statement is correct?

   A Any temperatures can be used as fixed points.
   B Both a lower fixed point and an upper fixed point are required.
   C Only a lower fixed point is required.
   D Only an upper fixed point is required.

   [N09/P1/Q15]

9. The diagram shows a clinical thermometer.



   Which factor affects the sensitivity of the thermometer?

   A the constriction
   B the diameter of the bore
   C the length of the glass tube
   D the thickness of the glass tube

   [N10/P1/Q17]

10. A certain liquid is used in a liquid-in-glass thermometer. It does not expand uniformly with temperature.

    What effect will this have on the scale of the thermometer?

    A It will be non-linear.
    B It will have a small range.
    C The markings will be close together.
    D The markings will be far apart.

    [J11/P1/Q19]

11. What makes a clinical thermometer suitable for measuring small changes in body temperature?

    A The amount of mercury in the bulb is small.
    B The bore of the capillary tube is narrow.
    C The capillary tube is long.
    D The glass bulb has a thin wall.

    [N11/P1/Q17]

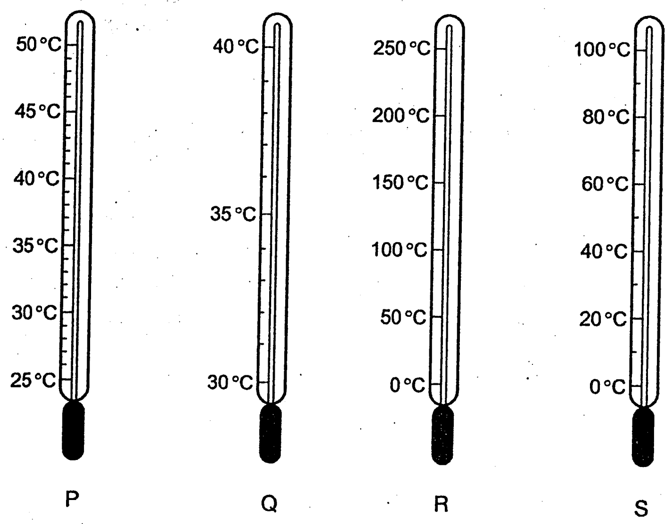
12. A substance has a melting point of –17°C and a boiling point of 117°C.

    In which state does the substance exist at –10°C and at 110°C?

	at –10°C	at 110°C
A	solid	liquid
B	solid	gas
C	liquid	liquid
D	liquid	gas

[J12/P1/Q20]

13. The diagram shows four thermometers.



MCQ Answers

7. D The liquid (mercury) rises more in a narrow bore for a small change in temperature.

8. B Fact

9. B The diameter of the bore affects the change in the length of the mercury column per unit change in temperature.

10. A As the liquid does not expand uniformly so the rate of expansion of the liquid and its rising in the thermometer will also not be uniform. Hence, its scale will be non-uniform and non-linear.

11. B The sensitivity of a liquid-in-glass thermometer is inversely proportional to the size of the bore of thermometer i.e.

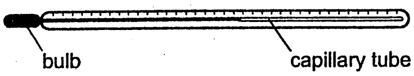
$$\text{sensitivity} \propto \frac{1}{\text{size of bore}}$$

Which thermometer has the greatest sensitivity and which thermometer has the greatest range?

	greatest sensitivity	greatest range
A	P	R
B	P	S
C	Q	R
D	Q	S

[J12/P1/Q18] & [N15/P1/Q17]

14. A liquid-in-glass thermometer consists of a bulb containing a liquid which expands into a very thin capillary tube.



The liquid in the thermometer is replaced by the same volume of a different liquid that expands more for the same temperature rise.

The new thermometer will have

A greater sensitivity and a greater range.

B greater sensitivity but a smaller range.

C the same sensitivity and the same range.

D the same sensitivity but a greater range.

[N12/P1/Q18]

15. A liquid-in-glass thermometer contains mercury.

Which physical property of the mercury varies with temperature, enabling the thermometer to operate?

A mass **B** melting point

C resistance **D** volume

[J13/P1/Q17]

16. The temperature shown by a mercury-in-glass thermometer increases.

Which of the following is constant?

A the density of the mercury

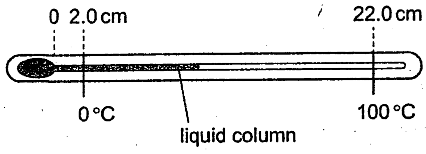
B the internal energy of the mercury

C the mass of the mercury

D the volume of the mercury

[N13/P1/Q17]

17. The diagram shows a liquid-in-glass thermometer.



At 0 °C, the length of the liquid column is 2.0 cm. At 100 °C, the length of the liquid column is 22.0 cm.

What is the length of the liquid column at 40 °C?

A 6.0 cm

B 8.0 cm

C 8.8 cm

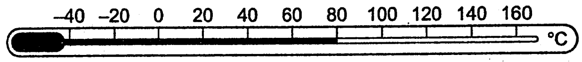
D 10.0 cm

[J14/P1/Q19]

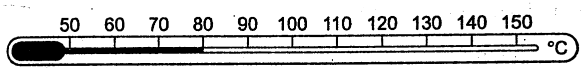
18. A thermometer is used to measure a temperature of 80 °C.

Which thermometer is the most sensitive?

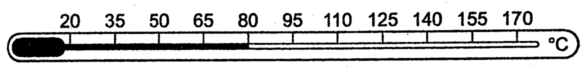
A



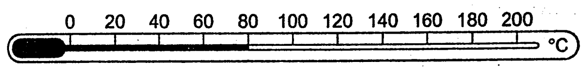
B



C

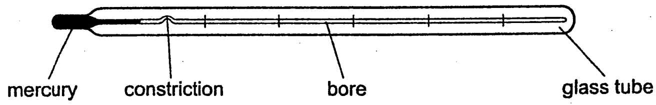


D



[J14/P1/Q20]

19. The diagram shows a clinical thermometer.



Which factor affects the sensitivity of the thermometer?

A the constriction

B the diameter of the bore

C the length of the glass tube

D the thickness of the glass tube

[N14/P1/Q13]

ThinkinG ProcesS

MCQ Answers

12. C Since –10 °C is a higher temperature than –17 °C, so after the substance has melted at –17 °C, it remains liquid at –10 °C as well as at 110 °C, until it boils at 117 °C.

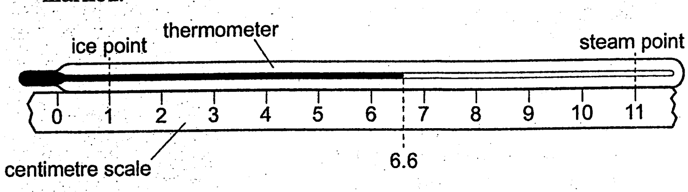
13. C Sensitivity is directly proportional to the change in the length of mercury column per unit change in temperature, i.e. $S \propto \Delta L$

So, thermometer Q is the most sensitive and thermometer R has the greatest range i.e. 0 °C – 250 °C.

14. B Fact.

20. A centimetre scale is fixed next to an unmarked mercury-in-glass thermometer.

The ice point and the steam point are marked.

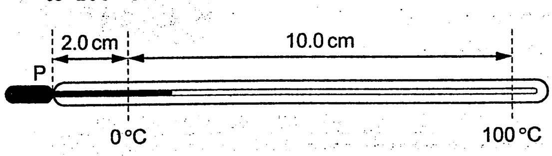


What is the temperature shown on the thermometer?

A 44 °C　　**B** 56 °C
C 60 °C　　**D** 66 °C

[N14/P1/Q14]

21. In a liquid-in-glass thermometer, the liquid column is 2.0 cm long at 0 °C and it expands 10.0 cm when heated to 100 °C.



Measuring from P, how long is the liquid column at 30 °C?

A 2.3 cm　　**B** 3.0 cm
C 5.0 cm　　**D** 7.0 cm

[J15/P1/Q17]

22. Which substance in the table is liquid at 20 °C?

	melting point / °C	boiling point / °C
A	–218	–183
B	–39	357
C	44	280
D	119	444

[J15/P1/Q18]

MCQ Answers

15. D Fact

16. C Fact

17. D

$$\theta = \frac{l_\theta - l_0}{l_{100} - l_0} \times 100$$

$$40\ °C = \frac{l_\theta - 2.0}{22.0 - 2.0} \times 100$$

$$l_\theta = 10.0 \text{ cm}$$

18. B The most sensitive thermometer is the one with the smallest interval.

19. B The sensitivity of a liquid in glass thermometer is inversely proportional to the bore of the thermometer, i.e.

$$\text{sensitivity} \propto \frac{1}{\text{bore}}$$

Therefore, the mercury in a clinical thermometer rises more in a narrow bore for a small change in temperature.

20. B Temperature

$$= \frac{l_\theta - l_0}{l_{100} - l_0} \times 100$$

$$= \frac{6.6 - 1}{11 - 1} \times 100$$

$$= 56\ °C$$

21. C

$$\theta\ °C = \frac{l_\theta - l_0}{l_{100} - l_0} \times 100$$

$$30 = \frac{l_\theta - 2}{12 - 2} \times 100$$

$$30 = 10(l_\theta - 2)$$

$$3 = l_\theta - 2$$

$$l_\theta = 5.0 \text{ cm}$$

22. B Fact

Topic 9 Temperature

THEORY Section

Question 1

Fig. 3.1 shows a thermometer.

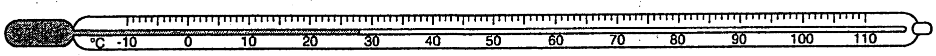


Fig. 3.1

(a) Explain how to calibrate a thermometer. [3]

(b) **(i)** State the range of the thermometer in Fig. 3.1. [1]

(ii) State how you know that the scale of the thermometer in Fig. 3.1 is linear. [1]

(c) Fig. 3.2 shows a thermometer which is more sensitive than the thermometer in Fig. 3.1. Only 0 °C is marked on this new thermometer.

On Fig. 3.2, draw the temperature markings for 10 °C and 20 °C. [1]

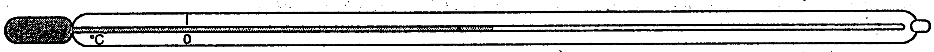


Fig. 3.2

[J07/P2/Q3]

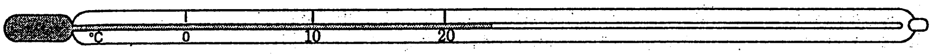
Solution

(a) A lower fixed point (0 °C) is marked on the thermometer by placing its bulb in pure melting ice and then the upper fixed point (100 °C) is marked on it by placing its bulb in steam from the boiling water at standard atmospheric pressure. The distance between these two marks is divided into 100 equal parts. Each division is then equal to 1°C.

(b) **(i)** 120 °C or −10°C to 110°C

(ii) Since the distance between each division along the scale is the same, so the scale of the thermometer is linear.

(c)



COMMENT on ANSWER

❝(c) Since the mercury level of a more sensitive thermometer shows a more rising for an increase in temperature, so the spacing between 0 to 10 °C and 10 to 20 °C will be greater on the thermometer in fig. 3.2 than the thermometer in fig. 3.1 which is less sensitive.❞

Question 2

Fig. 9.1 shows a flask, partly full of a liquid and partly full of air.

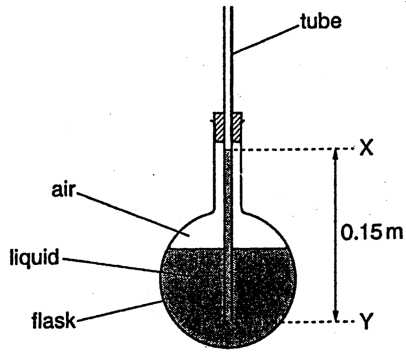


Fig. 9.1

When the flask is heated, the pressure of the air inside the flask increases and the liquid rises up the tube.

(a) Explain, using ideas about molecules, why heating the air inside the flask causes the pressure to increase. [3]

(b) A teacher uses the flask as a thermometer. He marks the liquid level at 0 °C and at 100 °C.

(i) Describe how the teacher obtains these temperatures. [2]

(ii) State two ways in which the thermometer can be made more sensitive. [2]

(iii) The thermometer has a non-linear scale.
Explain what is meant by a *non-linear* scale on a thermometer. [2]

(c) The inner cross-sectional area of the tube is 5.0×10^{-6} m^2.
The density of liquid in the tube is 1200 kg / m^3.
The distance between X and Y is 0.15 m.
The gravitational field strength g is 10 N / kg.

Calculate

(i) the mass of liquid in the tube, [2]

(ii) the weight of liquid in the tube, [1]

(iii) the pressure at the bottom of the tube caused by the liquid column between X and Y. [2]

(d) When the flask is completely full of liquid, the liquid moves up the tube a smaller distance for the same temperature rise. State why. [1]

[J13/P2/Q9]

Solution

(a) On heating, kinetic energy of air molecules increases. They then hit harder the flask walls and the liquid surface more frequently. This causes the pressure to increase.

(b) (i) The liquid level at 0 °C can be marked by placing the flask in pure melting ice and the liquid level at 100 °C is marked by placing the flask in steam above boiling water at the standard atmospheric pressure.

(ii) 1. By using a glass tube of a narrower bore.
2. By using a larger flask.

(iii) A scale is non- linear if its divisions are not equally spaced. Such a scale is produced if the thermometric liquid rises through different distances for same temperature rise due to the non-uniform expansion of the liquid.

(c) (i) Mass = density × volume

$$= \text{density} \times (\text{crossectional area} \times \text{height})$$
$$= 1200 \times (5.0 \times 10^{-5} \times 0.15)$$
$$= 0.009 = 9.0 \times 10^{-3}\ \text{kg}$$

(ii) Weight, $W = mg$

$$= 0.009 \times 10 = 0.09\ \text{N}$$

(iii) Pressure $= \rho g h$

$$= 1200 \times 10 \times 0.15 = 1800\ \text{Pa}$$

(d) The liquid moves up the tube a smaller distance because liquids expand less than gases (air).

COMMENT on ANSWER

“(b) (ii) Also, the thermometer can be made more sensitive by
— having more air and less liquid in the flask,
— using a liquid that expands more on heating.”

Question 3

All thermometers use the value of a physical property to measure temperature.

(a) (i) State what makes a physical property suitable for the measurement of temperature. [1]

(ii) State two properties that are used for the measurement of temperature. [2]

(b) When a thermometer is calibrated, two fixed points are used.

(i) One fixed point is the ice point. State what is meant by the *ice point*. [1]

(ii) Explain how the fixed points are used when calibrating a thermometer. [2]

[N15/P2/Q5]

Solution

(a) (i) The physical property changes continuously and uniformly with change in temperature.

(ii) 1. Volume of a liquid.
2. Electromotive force.

(b) (i) Ice point, also known as the lower fixed point, is the temperature of pure melting ice.

(ii) The bulb of the thermometer is immersed in pure melting ice. The mercury level is marked on the stem when it becomes steady. This mark corresponds to the ice point and is assigned a value of 0 °C

The bulb of the thermometer is then held in steam above boiling water. When the mercury level becomes steady, it is marked on the stem. This mark corresponds to the upper fixed point and is assigned a value of 100 °C. The difference between these two fixed points is then divided into 100 equal parts.

COMMENT on ANSWER

“(a) (ii) Also,
- Volume of a gas
- Voltage
- Current
- Resistance
- Pressure (of gas)
- Colour
- Quantity of radiation emitted
- Liquid crystal structure

(b) (i) Alternatively:
- It is the temperature at which water freezes.
- It is the temperature of water / ice mixture.”

Topic 10 Gas Laws And Particles Of Matter

MCQ Section

1. Some of the more energetic molecules in a liquid leave the surface, leaving the rest of the liquid slightly cooler.

What is the name given to this process?

A boiling
B condensation
C evaporation
D freezing

[J06/P1/Q15]

2. A substance consists of particles that are close together and moving past each other at random. The average speed of the particles is gradually increasing.

What best describes the substance?

A a gas being heated
B a liquid being heated
C a solid being heated
D a solid being melted

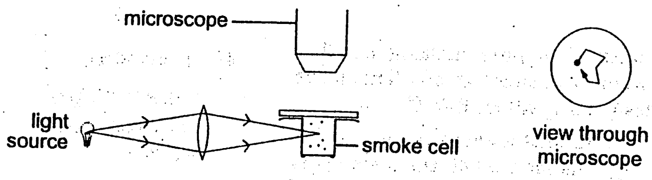
[J06/P1/Q16]

3. What is a property of both liquids and gases?

A They always fill their containers.
B They are incompressible.
C They can flow.
D They have molecules in fixed positions.

[N06/P1/Q13]

4. The diagram shows an experiment to look at the behaviour of smoke particles in air.

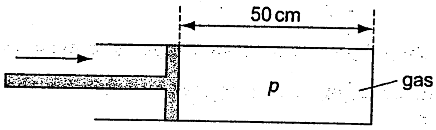


Why is each smoke particle seen to move about at random?

A Air molecules collide with smoke particles.
B Convection currents cause the air to move.
C Draughts cause the smoke particles to move.
D Smoke particles gain kinetic energy from the light.

[N06/P1/Q14]

5. A gas is trapped inside a cylinder by a movable piston. The length of the gas column is 50 cm and the pressure inside the cylinder is p.



The piston is pushed in a distance of 30cm, so that the length of the gas column is now 20 cm.

The temperature of the gas does not change.

What is the new pressure of the gas?

A 0.4 p **B** 0.6 p
C 1.5 p **D** 2.5 p

[J07/P1/Q12]

MCQ Answers

1. **C** Fact.

2. **B** In a liquid, the particles are close together and are moving past each other at random. The average speed of particles of a liquid can be increased by increasing their K.E by heating.

3. **C** Fact.

4. **A** This is an experimental demonstration of Brownian motion due to collisions by air molecules.

5. **D** $p_1 \times V_1 = p_2 \times V_2$

since $V \propto l$

$p_1 \times l_1 = p_2 \times l_2$

$p \times 50 = p_2 \times 20$

$p_2 = \frac{p \times 50}{20} = 2.5p$

MCQ Answers

6. What describes the molecular structure of a liquid?

	distance between the molecules	motion of the molecules	strength of forces between the molecules
A	close together	stationary	very strong
B	close together	random	fairly strong
C	far apart	stationary	fairly strong
D	far apart	random	weak

[J07/P1/Q14]

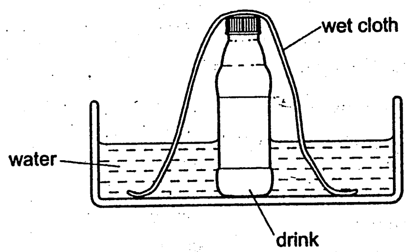
7. A liquid is heated.
Which statement is **incorrect**?
A The molecules expand.
B The molecules gain energy.
C The molecules move further apart.
D The molecules move faster.
[J07/P1/Q13]

8. Which of the following correctly compares the forces between the molecules in steam, water and ice?

	weakest forces →		strongest forces
A	ice	steam	water
B	ice	water	steam
C	steam	water	ice
D	water	steam	ice

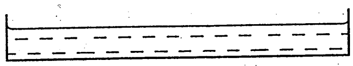
[N07/P1/Q13]

9. On a hot day, a drink in a bottle can be kept cool by standing it in a bowl of water and placing a wet cloth over it.



Why is the drink kept cool?
A Hot air cannot escape from the bottle.
B The cloth conducts heat from the bottle into the water.
C The drink cannot evaporate from the bottle.
D Water evaporating from the cloth cools the drink.
[N07/P1/Q14]

10. A student is investigating the evaporation of water.



The student can change:
the depth of the water;
the surface area of the water;
the temperature of the water.
How many of these changes, if any, would alter the rate at which evaporation occurs?
A 0 **B** 1
C 2 **D** 3
[J08/P1/Q19]

11. A fixed mass of gas at constant temperature is compressed to reduce its volume.
How do the molecules of gas now strike the walls of the container?
A less often than before with a higher velocity
B less often than before with the same velocity
C more often than before with a higher velocity
D more often than before with the same velocity.
[J09/P1/Q18]

12. According to the kinetic theory, matter is made up of very small particles in a constant state of motion.
Which row best describes the particle behaviour in the liquid state?

6. B Fact.

7. A On heating a liquid, its molecules gain energy, begin to move faster and move further apart but the molecules never expand.

8. C Fact.

9. D This is a fact that evaporation causes cooling.

10. C The rate of evaporation depends on surface area, temperature of the water and the presence of wind blowing over the surface of water. Changing the depth of the water would not affect the rate of evaporation of water.

11. D On compressing the gas, the molecules of the gas are confined in a smaller space. So they collide with the walls of the container more frequently than before but their velocity remains the same as before because the velocity or the K.E. of the molecules depends on the temperature of the gas which is kept constant.

12. B Intermolecular forces of attraction in a liquid are fairly strong but the molecules are free to move randomly at slow speed in clusters.

	forces between particles	motion of particles
A	strong	move randomly at high speed
B	strong	vibrate but are free to move position
C	strong	vibrate to and fro around a fixed position
D	weak	move randomly at high speed

[J11/P1/Q16]

13. Which row explains why a liquid has a fixed volume but does **not** have a fixed shape?

	force between molecules in the liquid	movement of molecules in the liquid
A	large	move throughout the liquid
B	large	vibrate at fixed positions
C	small	move throughout the liquid
D	small	vibrate at fixed positions

[N11/P1/Q15]

14. An airtight container holds a fixed mass of gas. Its pressure and volume are measured on four occasions when the temperature is 20°C.

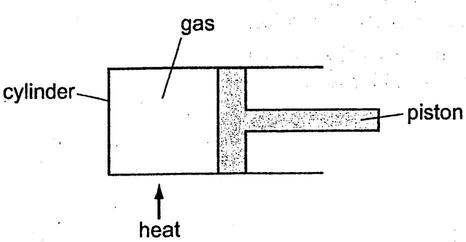
The results are shown in the table. Three sets of readings are correct.

Which set of readings is **not** correct?

	pressure/kPa	volume/cm^3
A	120	36
B	100	48
C	80	60
D	60	80

[J13/P1/Q12]

15. The diagram shows a fixed mass of gas in a cylinder fitted with a piston that can move easily.



What is the change, if any, in the pressure and volume of the gas after it is heated?

	pressure	volume
A	no change	increases
B	decreases	no change
C	decreases	increases
D	increases	decreases

[J13/P1/Q20]

16. What happens to the molecules of a gas when the gas changes into a liquid?

A They move closer and lose energy.

B They move closer and gain energy.

C They move apart and lose energy.

D They move apart and gain energy.

[J13/P1/Q21]

17. A fixed mass of gas is kept at constant pressure. Its temperature is raised.

What happens to the volume of the gas and to its molecules?

	volume	molecules
A	decreases	move more slowly
B	increases	stay the same distance apart
C	increases	move further apart
D	no change	move at the same speed

[N13/P1/Q19]

18. Air is heated in a sealed container with constant volume.

Why does the air pressure increase when the temperature increases?

A The air molecules expand.

B The air molecules bounce off each other more frequently.

C The air molecules bounce off the walls more frequently.

D The number of air molecules increases.

[N13/P1/Q20]

ThinkinG ProcesS

MCQ Answers

13. A Fact.

14. A The pressure exerted by a gas is inversely proportional to the volume of the gas i.e.

$$P \propto \frac{1}{V}$$

or PV = constant

The product of the values of P and V is constant in each case except **A**.

15. A Before heating the gas pressure inside the cylinder is equal to the external atmospheric pressure. After heating, the gas expands and the gas pressure on the piston initially increases and pushes the piston outwards. The piston stops moving when the gas pressure on the piston finally becomes equal to the external atmospheric pressure. Hence the pressure of the gas remains unchanged but the volume of the gas increases.

16. A When a gas is condensed to become a liquid, its molecules come closer to each other and they lose energy.

17. C On raising the temperature the pressure of a gas increases but in order to keep the pressure constant, the volume of the gas has to be increased. The increase in the volume will result in the molecules moving further apart.

18. C On heating, the K.E. of the air molecules increases. They then collide and bounce off the walls of the container more frequently. This results in the increase in the force per unit area and hence the pressure exerted by the air molecules on the walls of the sealed container.

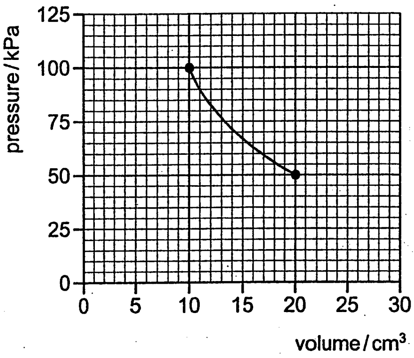
19. At a constant temperature, a solid has a fixed shape and a fixed volume.

Which row describes the shape and the volume of a liquid at constant temperature?

	shape	volume
A	fixed	fixed
B	fixed	not fixed
C	not fixed	fixed
D	not fixed	not fixed

[N14/P1/Q15]

20. The graph shows how the pressure of a fixed mass of gas varies with volume at constant temperature.



What is the volume of the gas when the pressure is 25 kPa?

A $2.5\ cm^3$

B $10\ cm^3$

C $30\ cm^3$

D $40\ cm^3$

[J15/P1/Q11]

21. Some gas is trapped in a closed container. The gas is cooled and the volume of the container is kept constant.

What happens to the gas molecules?

A They collide with the walls more often.

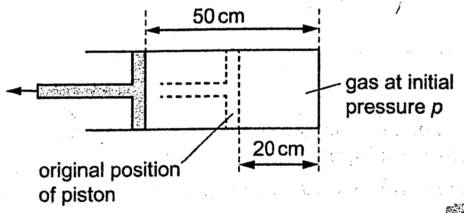
B They contract.

C They get closer together.

D They move more slowly.

[J15/P1/Q20]

22. A gas is trapped inside a cylinder by a movable piston. The length of the gas column is 20 cm and the pressure inside the cylinder is p.



The piston is pulled out a distance of 30 cm, so that the length of the gas column is now 50 cm. The temperature of the gas does not change.

What is the new pressure of the gas?

A 0.40 p **B** 0.60 p

C 1.5 p **D** 2.5 p

[N15/P1/Q12]

23. A gas is in a sealed container of constant volume. The gas is heated and the pressure of the gas on the walls of the container increases.

How do the particles of the gas cause this increase in pressure?

A They expand.

B They hit each other more frequently.

C They hit the container more frequently.

D They vibrate faster.

[N15/P1/Q16]

MCQ Answers

19. C Fact.

20. D $P_1V_1 = P_2V_2$

$100 \times 10 = 25 \times V_2$

$V_2 = \frac{100 \times 10}{25}$

$V_2 = 40\ cm^3$

21. D Some heat energy is removed from a gas trapped in a closed (sealed) container. As a result the K.E. of the gas molecules decreases and then they move more slowly than before.

22. A $P_1 \times V_1 = P_2 \times V_2$

$p \times 20 = P_2 \times 50$

$P_2 = \frac{20p}{50}$

$= 0.40p$

23. C The K.E. and speed of the molecules increases on heating the gas. They then hit the walls of container more frequently exerting more force per unit area of the walls. Therefore, the pressure of the gas on the walls increases.

Topic 10 Gas Law And Particles Of Matter

THEORY Section

Question 1

A student has an open tank for storing water outside her house. The tank is black and is in direct sunlight.

She notices that the level of water inside the tank slowly decreases as water evaporates.

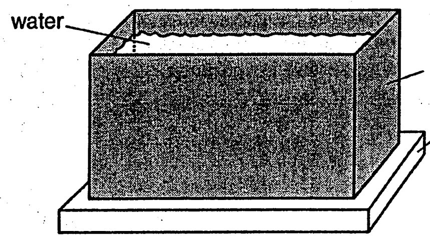


Fig. 9.1

She investigates whether some changes, shown in the table, will affect the amount of water evaporated each day.

change 1	a heater is used to increase the temperature of the water
change 2	a sheet of plastic is used to cover half the surface of the water
change 3	a fan is used to blow air over the top of the tank
change 4	the outside of the tank is painted white

Only one change is made at a time. All other factors are kept constant.

(a) State whether each change will increase, leave unchanged or decrease the amount of water evaporated each day. Explain each of your answers. [8]

(b) She notices that the water level in the tank falls by 0.005 m in 40000 s. The cross-sectional area of the tank is 3.0 m^2. The density of water is 1000 kg/m^3.

The specific latent heat of vaporisation of water is 2.2×10^6 J/kg.

Calculate

(i) the volume of water that evaporates, [1]

(ii) the mass of water that evaporates, [2]

(iii) the energy required to evaporate the water, [2]

(iv) the average rate at which energy is used to evaporate the water. [2]

[J06/P2/Q9]

Solution

(a) change 1: The amount of water evaporated increases with the increase in the temperature of the water since on heating the water, the kinetic energy of the water molecules increases and more molecules gain enough energy to escape the water surface.

change 2: This decreases the amount of water evaporated as the surface area for the escape of the water molecules have decreased so less number of molecules are able to escape.

change 3: This increases the amount of water evaporated because the escaping water molecules are swept away by the air allowing more molecules to come out of the water surface.

change 4: This decreases the amount of water evaporated because the heat or infra-red rays from the surroundings are reflected back by the white surface of the tank. This keeps the water cool and less molecules will have enough energy to escape.

(b) (i) Volume of water evaporated

= cross-sectional area of tank × change in height of water level

$= 3.0 \times 0.005 = 0.015\ \text{m}^3$

(ii) mass = density × volume

$= 1000 \times 0.015 = 15\ \text{kg}$

(iii) energy required: $Q = m \times l$

$= 15 \times (2.2 \times 10^6) = 3.3 \times 10^7\ \text{J}$

(iv) average rate $= \dfrac{\text{energy}}{\text{time}}$

$= \dfrac{3.3 \times 10^7}{40000} = 825\ \text{J/s}$

Question 2

Fig. 5.1 shows the arrangement of atoms in a solid block.

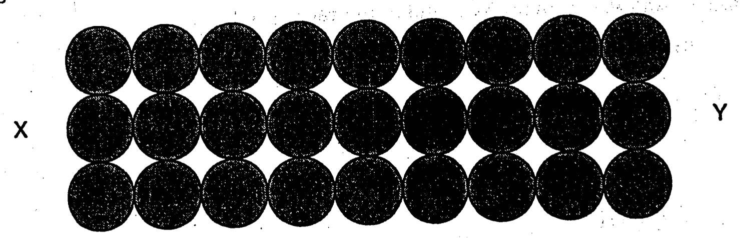


Fig. 5.1

(a) End X of the block is heated. Energy is conducted to end Y, which becomes warm.

(i) Explain how heat is conducted from X to Y by the atoms. [2]

(ii) Explain why the solid block expands when it is heated. [1]

(b) The block is heated and becomes a liquid.

Describe the changes that occur to the arrangement and the motion of the atoms. [2]

[N07/P2/Q5]

Solution

(a) (i) On heating, the atoms at the hot end X start vibrating vigorously and transfer their energy to the neighbouring atoms by colliding with them making them to vibrate more as well. This process of passing heat through the atomic vibrations from one layer to the next continues until it reaches the end Y.

(ii) The heating increases the energy of the atoms and make them to vibrate with greater amplitude covering more distance on both sides of their mean positions. This causes an increase in their spacing. Hence an expansion occurs in the solid block.

(b) The increase in the energy of atoms due to heating causes an increase in their spacing and speed. This in turn results in the breaking of their bonds providing them a greater freedom of movement in the liquid. They can now move freely and randomly in clusters throughout the liquid.

Question 3

During a marathon race, the runner shown in Fig. 3.1 is very hot.

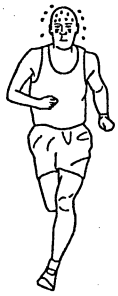


Fig. 3.1

At the end of the race, evaporation and convection cool the runner.

(a) (i) Explain how evaporation helps the runner to lose energy. Use ideas about molecules in your answer. [2]

(ii) Explain why hot air rises around the runner at the end of the race. [1]

(b) At the end of the race, the runner is given a shiny foil blanket, as shown in Fig. 3.2.
Wearing the blanket stops the runner from cooling too quickly.

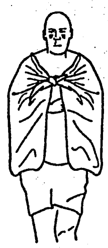


Fig. 3.2

Explain how the shiny foil blanket helps to reduce energy losses.

Use ideas about conduction, convection and radiation in your answer.

[3]

[J08/P2/Q3]

Solution

(a) (i) The liquid molecules absorb energy from the body of the runner and the high energy liquid molecules use this energy as latent heat and escape as vapours. The loss of energy from the runner's body causes cooling of his body.

(ii) The cold air comes in contact with the runner's hot body and becomes hot, expands, becomes less dense and rises up.

(b) The shiny blanket traps air which is a bad conductor of heat and reduces the heat loss by conduction. As a little heat energy travels to the outer surface of the blanket, weak convection currents are formed and this reduces the heat loss by convection. Also, the shiny surface of the blanket being a good reflector of infrared radiation from his body, reduces the heat loss through the process of radiation.

Question 4

(a) State **two** differences between the properties of liquids and gases at normal pressures. Explain these differences in molecular terms.

Difference 1 ....

Explanation 1 ....

Difference 2 ....

Explanation 2 .... [4]

(b) A nurse places a damp cloth on the forehead of a sick patient. As the water evaporates, the patient's forehead is cooled. Explain in terms of the water molecules how the cooling is produced. [3]

[N08/P2/Q5]

Solution

(a) Difference 1: Liquids have fixed volumes but gases have no fixed volume.

Explanation 1: The molecules of liquids have very small spacing between them due to strong intermolecular force of attraction between them so they can not be compressed whereas the molecules of gases are far apart due to negligible force of attraction between them so they can be easily compressed.

Difference 2: Liquids have high density but gases have low density.

Explanation 2: The number of molecules per unit volume and hence the mass per unit volume is greater in a liquid due to molecules close packing but it is much smaller in a gas due to the molecules being far apart.

(b) Water in the damp cloth absorbs heat energy from the patient's hot forehead which increases the Kinetic energy of water molecules. The high energy water molecules use their energy to overcome the intermolecular forces of attraction from the neighbouring molecules and escape. Since the patients forehead loses heat to water, so its temperature decreases and it cools down.

COMMENT on ANSWER

“ **(b)** The water absorbs heat energy from the patient's forehead and uses it as latent heat to change its state into vapours and evaporate. The evaporation causes cooling of the damp cloth as well as of the patient's forehead. ”

Question 5

Fig. 4.1 shows the arrangement of molecules in a solid and in a liquid.

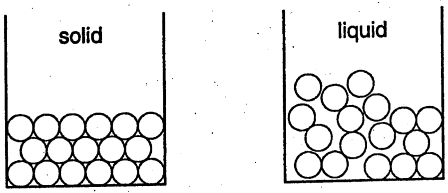


Fig. 4.1

(a) State one difference between the two arrangements. [1]

(b) By writing about the forces between molecules and the motion of molecules, explain why

(i) the molecules of a solid and of a liquid have different arrangements, [1]

(ii) the evaporation of a liquid cools the liquid, [2]

(iii) the rate of evaporation is greater when a liquid is hotter. [2]

[J09/P2/Q4]

Solution

(a) The molecules in a solid are arranged in a more regular pattern and have less spacing between them as compared to the molecules in a liquid.

(b) (i) The intermolecular forces of attraction are stronger in solids than in liquids.

(ii) During evaporation, the high energy molecules escape and low energy molecules are left in the liquid. This decreases the average K.E. of the remaining molecules in the liquid and lowers the temperature of the liquid.

(iii) At a higher temperature, more molecules of a liquid have enough energy to overcome the intermolecular forces of attraction and break the bonds to escape. So the rate of evaporation from a hotter liquid is greater.

COMMENT on ANSWER

❝ (a) *Alternatively:* The molecules in a solid vibrate about their fixed positions but the molecules in a liquid move randomly throughout the liquid. ❞

Question 6

(a) Explain, using ideas about molecules,

(i) why a balloon filled with gas expands when heated, [2]

(ii) why a balloon filled with water expands very little when heated. [1]

(b) (i) A bubble of gas rises from the bottom of a lake to the surface. The pressure at the bottom of the lake is 3.0×10^5 Pa and the pressure at the surface is 1.0×10^5 Pa. The volume of the bubble at the bottom of the lake is $2.0\ cm^3$.

Calculate the volume of the bubble at the surface. [2]

(ii) State one assumption that you have made in your calculation in (i). [1]

[J11/P2/Q3]

Solution

(a) (i) On heating the gas, its molecules have more kinetic energy and speed. So they hit the walls of the balloon more frequently and with greater force too, exerting a greater pressure on its walls. As a result, the balloon expands.

(ii) Heating produces very little increase in the kinetic energy of molecules of a liquid due to the strong intermolecular forces between them. So they hit the sides of balloon less frequently and less harder too, exerting much less pressure on the sides of balloon than gas molecules.

(b) (i)

$$P_1 \times V_1 = P_2 \times V_2$$

$$(3.0\times10^5)\times 2.0 = (1.0\times10^5)\times V_2$$

$$V_2 = \frac{(3.0\times10^5)\times 2.0}{(1.0\times10^5)} = 6.0\ \text{cm}^3$$

(ii) It is assumed that the temperature of the lake water and hence the temperature of the air in the bubble remains constant.

COMMENT on ANSWER

❝ (b) (ii) Alternatively:
No gas /air enters or leaves the bubble and the mass of this gas remains constant. ❞

Question 7

A student places a small electrical heater inside a cup of water, as shown in Fig. 11.1.

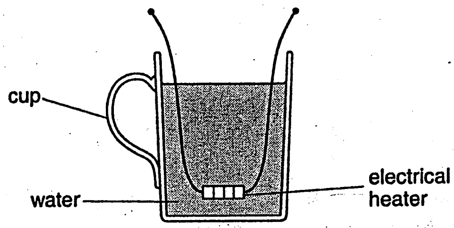


Fig. 11.1

(a) During heating, the student notices that some of the water evaporates from the cup.

(i) Describe, using ideas about molecules of water, what happens during evaporation. [2]

(ii) The student finds that the amount of evaporation increases when the temperature of the water is higher.
State and explain one other change that increases the amount of evaporation. [2]

(iii) State two differences between evaporation and boiling. [2]

(b) The student turns off the power supply and the water cools.
Describe and explain how convection in the air causes the water to cool. [2]

[J13/P2/Q11(c,d)]

Solution

(a) (i) During evaporation, the high energy molecules escape from the surface of water.

(ii) Larger surface area: An increase in the surface area enables more molecules to be at the surface to escape.

(iii) 1. Evaporation occurs at the surface of a liquid and the boiling occurs inside the liquid.

2. Evaporation occurs at any temperature and boiling occurs at a fixed temperature (i.e. at boiling point).

(b) The hot water loses heat energy to the surrounding air which comes in contact with the cup and the water surface. This air expands, becomes less dense and rises. Cold and denser air replaces the hot air and the process of convection currents continues till the water cools to the room temperature.

COMMENT on ANSWER

"(a) (iii) Also:
— Boiling is a quick process and evaporation is a slow process
— Bubbles are formed in the liquid during boiling but no bubbles are formed in evaporation.
—Temperature remains constant during boiling but temperature may change.
— Heat supplied by a heating source in boiling but in evaporation heat is supplied by the surroundings.
— Evaporation increases by draughts, higher temperature and surface area but boiling is not."

Question 8

Fig. 3.1 shows a helium cylinder being used at a funfair to inflate balloons that float in the air.

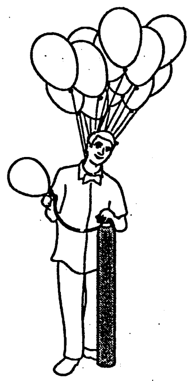


Fig. 3.1

Initially, all the helium is stored in the cylinder at a pressure of 2.0×10^7 Pa. When no more balloons can be filled, all the helium occupies a total volume of $1.8\ m^3$ and is at a pressure of 1.0×10^5 Pa. The temperature of the helium has not changed.

(a) Calculate, stating the formula used, the initial volume of the helium in the cylinder. [3]

(b) The balloon seller takes the cylinder back to the helium supplier and it is refilled. The mass of helium in the cylinder is 0.30 kg.

(i) Calculate the density of helium in the cylinder. [2]

(ii) The mass of the empty cylinder is 16 kg.
Suggest why weighing the cylinder is not an accurate method of determining the amount of helium supplied. [1]

[N14/P2/Q3]

Solution

(a) $V_1P_1 = V_2P_2$

$$V_1 = \frac{V_2P_2}{P_1}$$

$$= \frac{1.8 \times (1.0 \times 10^5)}{2.0 \times 10^7} = 0.9 \times 10^{-2}\ m^3 = 9000\ cm^3$$

COMMENT on ANSWER

"(a) $1\ m^3$
$= (100 \times 100 \times 100)\ cm^3$
$= 1 \times 10^6\ cm^3$"

(b) (i) Density $= \dfrac{\text{mass}}{\text{volume}}$

$= \dfrac{0.3}{0.9 \times 10^{-2}} = 33.33 \text{ kg/m}^3$

(ii) A cylinder full of helium gas has a very small weight as compared to the weight of the empty cylinder and so the difference in weight of the cylinder when filled or empty is not noticeable.

COMMENT on ANSWER

" **(b) (ii)** The amount of helium gas in a cylinder is usually determined by attaching a pressure guage to it. "

Question 9

A gas is trapped at atmospheric pressure in a cylinder by a piston. The piston is held in a fixed position by a movable rod. Fig. 6.1 shows the cylinder.

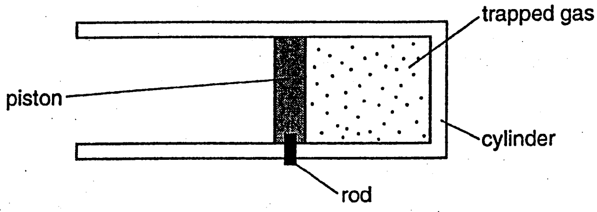


Fig. 6.1

The cylinder is heated. As the temperature of the gas increases, its pressure increases.

(a) Explain, in terms of molecules, why the pressure of the trapped gas increases. [2]

(b) The rod is pulled down and the piston is then free to move as shown in Fig. 6.2.

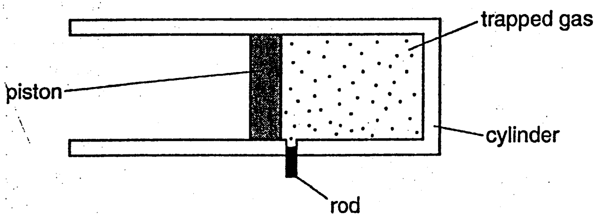


Fig. 6.2

As the piston moves, the temperature of the gas remains constant.

State and explain, in terms of molecules, what happens to the pressure of the gas. [3]

[N15/P2/Q6]

Solution

(a) On heating the gas, its molecules gain kinetic energy and start moving faster. Their collisions with the cylinder walls become more frequent and harder. As a result, the force exerted per unit area of the walls of the cylinder increases. Hence, the pressure of the gas increases.

(b) As the piston moves outward, the volume of the gas increases and the gas molecules move further apart. They then make less number of collisions per unit area per unit time with the walls. As a result, the pressure exerted by the gas on the piston and the walls of the cylinder decreases and becomes equal to the atmospheric pressure.

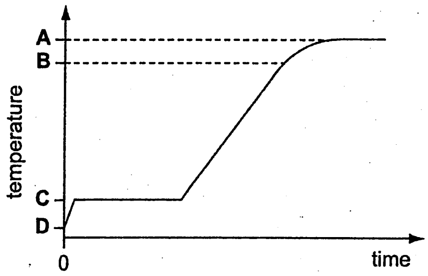
Topic 11 Change Of State

MCQ Answers

MCQ Section

1. Some ice cubes are taken from a deep-freeze and placed in a metal container. The container is heated at a constant rate and readings of temperature and time are taken. The results are recorded on a graph.

Which temperature corresponds to 0 °C?



[J06/P1/Q18]

2. The energy required to change liquid water into water vapour at the same temperature is called latent heat of vaporisation.

What does this energy do?

A increases the average separation of the water molecules

B increases the average speed of the water molecules

C raises the temperature of the air near the water

D splits the water molecules into their separate atoms

[N06/P1/Q16]

3. A 2 kW kettle containing boiling water is placed on a balance. It is left there and continues to boil for 5 minutes. The balance reading changes by 0.2 kg.

What does this information give as a value for the specific latent heat of vaporisation of water?

A 2000 J/kg

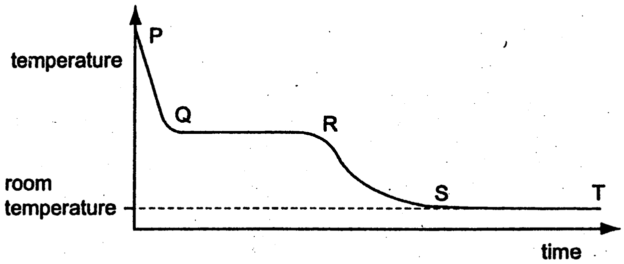
B 3000 J/kg

C 50 000 J/kg

D 3 000 000 J/kg

[N06/P1/Q17]

4. The graph shows the cooling curve of a hot substance.



In which part of the curve is latent heat released?

A PQ **B** QR

C RS **D** ST

[N07/P1/Q16]

5. Using an electric kettle, 100 g of water at 100 °C is converted into steam at 100 °C in 300 seconds.

The specific latent heat of steam is 2250 J/g.

What is the average electrical power used?

A $\dfrac{2250}{300 \times 100}$ W

B $\dfrac{100 \times 2250}{300}$ W

C $\dfrac{300 \times 2250}{100}$ W

D $100 \times 300 \times 2250$ W

[N08/P1/Q18]

6. When ice melts to become water, which force must be overcome?

A the attraction between electrons and the nucleus

B the attraction between the atoms in a molecule

C the force between molecules

D the force of gravity

[N08/P1/Q20]

1. C The horizontal sections of the graph represent a change in state which occurs at constant temperature. C represents the melting of ice at 0°C and A represents boiling at 100°C.

2. A Fact

3. D Using Pt = ml, specific latent heat of vaporisation

$l = \dfrac{Pt}{m} = \dfrac{(2000)(5 \times 60)}{0.2}$
= 3 000 000 J/kg.

Power P must be in W and time t must in seconds. The mass of water converted to steam is equal to the loss in mass recorded by the balance.

4. B The horizontal part 'QR' of the graph shows the constant temperature at which the hot substance changes its state and releases the latent heat energy.

5. B $P \times t = m \times l$

$P = \dfrac{m \times l}{t}$

$= \left(\dfrac{100 \times 2250}{300}\right)$ W

7. Which factors increase the rate of evaporation of a liquid?

	increasing its temperature	increasing its surface area	increasing its depth
A	yes	yes	yes
B	yes	yes	no
C	yes	no	yes
D	no	yes	yes

[N08/P1/Q21]

8. A substance that is originally a solid is heated strongly for some time.

At one stage, the energy given to the substance is used as latent heat of vaporisation.

At this stage, what change does the energy cause?

A It breaks the bonds holding the molecules together. Molecules escape from the liquid.

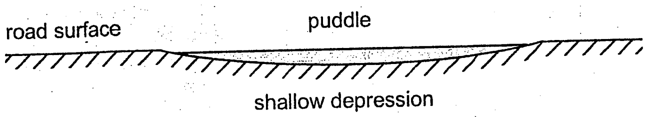
B It breaks the bonds holding the molecules together. The solid becomes liquid.

C It makes the molecules move faster but there is still a strong attraction between them.

D It makes the molecules move faster and so the temperature rises.

[J09/P1/Q16]

9. The diagram shows a cross-section through a rain-water puddle formed in a shallow depression in a road surface.



Over a period of time, the air temperature, wind speed and wind direction all remain constant.

What happens to the rate of evaporation of water from the puddle?

A It decreases, because the surface area decreases.

B It increases, because the puddle gets shallower.

C It increases, because the surface area decreases.

D It remains constant.

[N09/P1/Q18]

10. An ice-cube has a mass of 7.50 g. The ice-cube is at 0 °C.

Heat from the surroundings reaches the ice-cube at an average rate of 1.25 J/s.

How long does it take for all of the ice to melt?
(specific latent heat of fusion of ice = 333 J/g)

A 35.5 s **B** 55.5 s
C 2000 s **D** 3120 s

[J10/P1/Q14]

11. The liquid in a puddle evaporates and this causes its temperature to change.

How does the temperature of the liquid change and why?

	change	reason
A	decreases	less energetic molecules leave the liquid
B	decreases	more energetic molecules leave the liquid
C	increases	less energetic molecules leave the liquid
D	increases	more energetic molecules leave the liquid

[J10/P1/Q15]

12. A liquid evaporates rapidly. Why does this cause it to cool?

A Air molecules remove heat by contact with the liquid surface.

B Energy is lost by convection currents.

C Some of the most energetic molecules leave the liquid.

D The molecules have less room to move around.

[N10/P1/Q14]

MCQ Answers

6. C It is a fact that to convert ice into water, the intermolecular force of attraction is overcome.

7. B Since the evaporation occurs at the surface of a liquid only, so the rate of evaporation is not affected by the depth of a liquid but increase in temperature and the surface area both increase the rate of evaporation.

8. A As the solid is heated strongly, it is converted into a liquid. Note that, at this stage the heat energy is used as latent heat of vaporisation. Hence when vaporisation occurs, the molecules escape from the liquid.

9. A The rate of evaporation decreases with the decrease in the surface area.

10. C

$P \times t = m \times l$

$1.25 \times t = 7.50 \times 333$

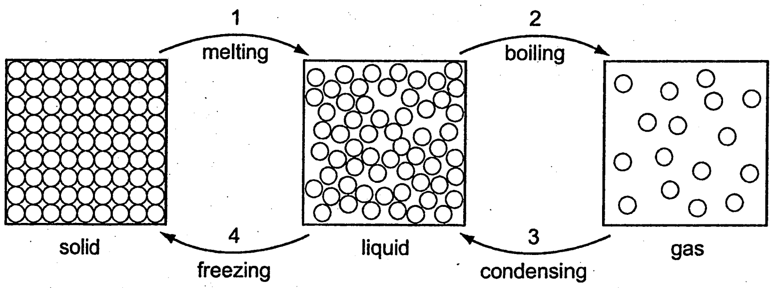
$t = \frac{7.50 \times 333}{1.25}$

$t = 1998 \approx 2000$ sec

11. B It is a fact that during evaporation, high energy liquid molecules escape and this results in the decrease in temperature of the liquid.

12. C During evaporation, the most energetic molecules leave the liquid leaving behind the low energy molecules which results in the cooling of the liquid.

13. Substances can change from one state to another as shown.



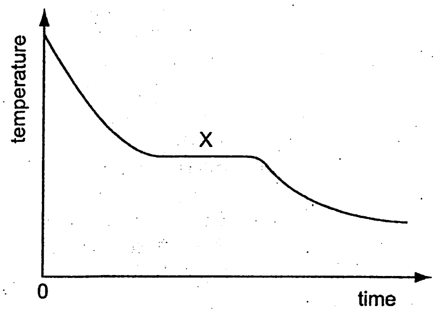
For substances to change from one state to another, there must be some energy transfer.

Which changes involve the substance taking in energy and which changes involve the substance giving out energy?

	energy taken in	energy given out
A	1 and 2	3 and 4
B	1 and 3	2 and 4
C	2 and 4	1 and 3
D	3 and 4	1 and 2

[N11/P1/Q18]

14. A hot liquid is poured into a beaker. The graph shows how its temperature changes as it cools towards room temperature.

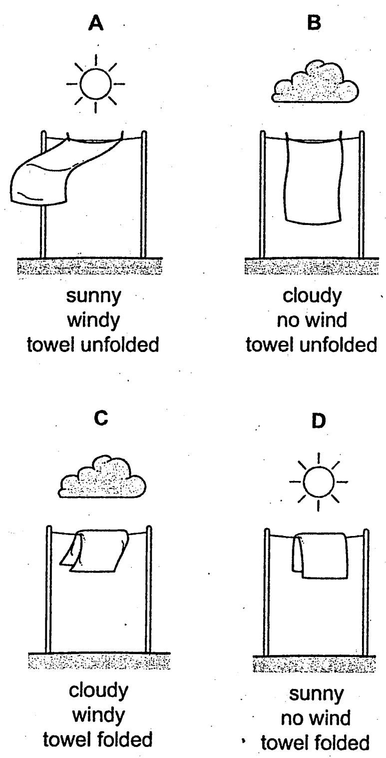


Which processes are taking place at region X?

A boiling and evaporation
B condensation only
C evaporation only
D solidification and evaporation

[N10/P1/Q15]

15. Four wet towels are hung out to dry as shown.
Which towel dries most quickly?



[J12/P1/Q16]

MCQ Answers

13. A During melting and boiling, heat is supplied to break the intermolecular forces of attraction and hence, increase the separation between molecules. While during condensing and freezing, heat is taken out to bring the molecules closer.

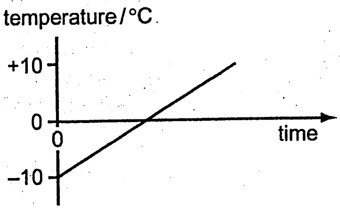
14. D The temperature of the hot liquid first falls and then becomes constant at X because its state changes from liquid to a solid. The evaporation also occurs at the same time from the liquid which is not yet solidified.

15. A The larger surface area of unfolded towel, higher temperature due to the bright sun and the wind increase the rate of evaporation and dries the towel more quickly as compared to the low temperature, humid and windless environment on a cloudy day as well as the reduced surface area of the folded towel which slow down the rate of evaporation from the towel.

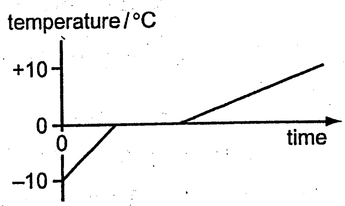
16. Ice at –10°C is heated until it is water at +10°C.

Which graph shows how the temperature changes with time?

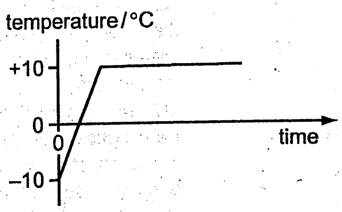
A



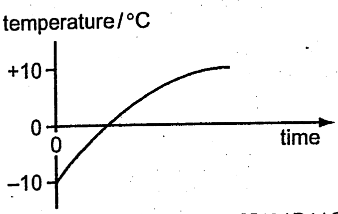
B



C



D



[J12/P1/Q19]

17. In hot weather, people use electric fans to keep cool.

Why do the fans make them feel cool?

A They change one form of energy into another.

B They cool the air in the room.

C They increase the rate of evaporation from the skin.

D They speed up the vibration of air molecules.

[N12/P1/Q16]

18. An ice cube, at a temperature of 0 °C, has a mass of 10 g. The specific latent heat of fusion of water is 3×10^5 J/kg.

How much heat energy is needed to convert the ice cube into 10 g of water at 0 °C?

A 30 J **B** 3000 J

C 3×10^4 J **D** 3×10^6 J

[N12/P1/Q19]

19. Using an electric kettle, 200 g of water at 100 °C is converted into steam at 100 °C in 300 seconds.

The specific latent heat of steam is 2250 J / g.

What is the average electrical power used?

A $\frac{2250}{300 \times 200}$ W

B $\frac{200 \times 2250}{300}$ W

C $\frac{300 \times 2250}{200}$ W

D $200 \times 300 \times 2250$ W

[J13/P1/Q19]

20. The more energetic molecules in a liquid may escape from its top surface.

What is this process called?

A boiling

B Brownian motion

C convection

D evaporation

[N13/P1/Q21]

21. Thermal energy is transferred to a solid. First it melts and then it boils to produce a gas.

Which statement about the temperature is correct?

A When melting and boiling the temperature does not change.

B When melting and boiling the temperature increases.

C When melting the temperature increases but when boiling the temperature stays the same.

D When melting the temperature stays the same but when boiling the temperature increases.

[J14/P1/Q22]

Thinking Process

MCQ Answers

16. B Since the melting point of ice is 0°C, so the ice melts and its temperature remains constant at 0°C for sometime. When all the ice has melted then the temperature of the melted ice (i.e. water) starts increasing again.

17. C Fact.

18. B $Q = ml$

$= 0.01 \times (3 \times 10^5)$

$= 3000$ J

19. B $P \times t = m\, l_v$

$\therefore \; P = \frac{m\, l_v}{t}$

$= \frac{200 \times 2250}{300}$

20. D By definition.

21. A When transitioning from a solid to a liquid or from a liquid to a gas, energy is used to break the intermolecular forces of attraction. During this time, the temperature remains constant.

22. C $E = ml$

$= 2 \times 2250$

$= 4500$

$= 4.5 \times 10^3$ J

23. D Solidification is the change of state that occurs when a liquid becomes a solid. Region X indicates that a change of state is taking place. Since the hot liquid is cooling to room temperature, therefore this change of state must be solidification. During the process of solidification, some liquid present is also exposed to the atmosphere which causes evaporation.

22. Steam at 100 °C is passed into some water in a beaker. All the steam condenses in the water.

The mass of water in the beaker rises from 120.0 g to 122.0 g.

The specific latent heat of vaporisation of water is 2250 J/g.

How much thermal energy is lost by the steam as it condenses?

A 8.9×10^{-4} J

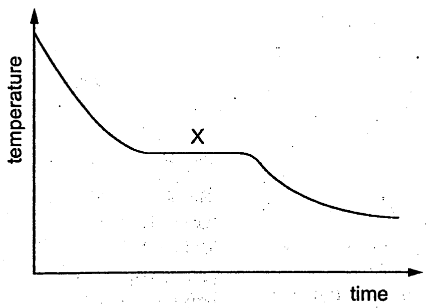
B 1.1×10^{3} J

C 4.5×10^{3} J

D 2.7×10^{5} J

[J14/P1/Q23]

23. A hot liquid is poured into a beaker. The graph shows how the temperature of the liquid changes as it cools towards room temperature.



What is occurring at region X?

A boiling and evaporation

B condensation only

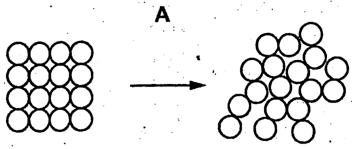
C evaporation only

D solidification and evaporation

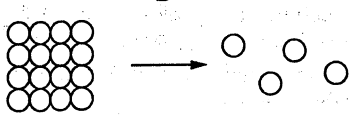
[J14/P1/Q24]

24. Which diagram represents the change in the arrangement of the molecules in a solid as the substance melts?

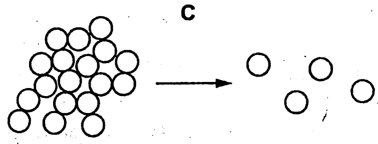
A



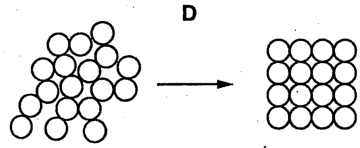
B



C



D



[J15/P1/Q19]

25. In a liquid, some energetic molecules break free from the surface even when the liquid is too cold for bubbles to form.

What is the name of this process?

A boiling **B** condensation

C convection **D** evaporation

[J15/P1/Q21]

26. A pupil adds 37 g of ice at 0 °C to 100 g of water at 30 °C. The final temperature of the water and melted ice is 0 °C. No heat is lost to, or gained from, the surroundings.

The specific heat capacity of water is 4.2 J/(g °C).

What is the specific latent heat of ice?

A 47 J/g **B** 341 J/g

C 4700 J/g **D** 12 600 J/g

[J15/P1/Q22]

27. Some of the liquid in a dish evaporates, as shown in the diagrams.

before evaporation after evaporation

Which molecules leave the liquid and which molecules in the liquid have greater average kinetic energy?

	molecules that leave have	molecules in the liquid have greater average kinetic energy
A	high energy	before evaporation
B	high energy	after evaporation
C	low energy	before evaporation
D	low energy	after evaporation

[N15/P1/Q18]

MCQ Answers

24. A The molecules in a solid are closely packed in a regular pattern but on melting the molecules are irregularly arranged with a little spacing between them.

25. D By definition.

26. B By the method of mixtures:

Heat lost by water to cool from 37°C to 0°C = Heat gained by ice to melt

$\Rightarrow \quad mc\Delta\theta = ml$

$100 \times 4.2 \times 30 = 37 \times l$

$l = 340.54 \approx 341$ J/g

27. A It is the fact that during evaporation, the high energy molecules escape from the liquid and the low energy molecules are left behind in the remaining liquid. So, the dish with less liquid contains the molecules having low average K.E. and the dish with more liquid contains molecules having greater average K.E.

Topic 11 Change Of State

THEORY Section

Question 1

A student investigates the evaporation of water. He pours 100 cm^3 of water into measuring cylinder A and 100 cm^3 of water into measuring cylinder B. Measuring cylinder A is kept at 40 °C and B is kept at 80 °C in the same part of the laboratory. Fig. 2.1 shows the two measuring cylinders after 3 days.

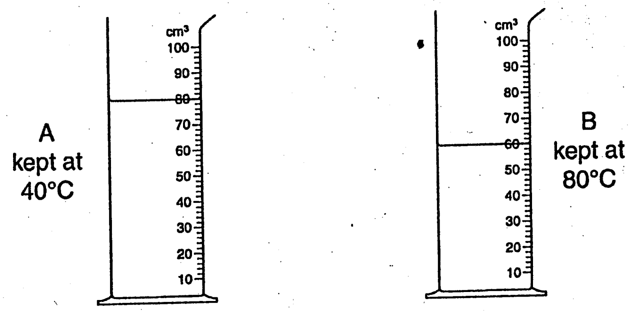


Fig. 2.1

(a) (i) Using ideas about molecules, explain why more water evaporates when the water is kept at 80 °C. [2]

(ii) Apart from an increase in temperature, state one change that causes water to evaporate faster. [1]

(b) The specific latent heat of vaporisation of water is 2300 J/g and the density of water is 1.0 g / cm^3. During the three days, the water level in B drops from the 100 cm^3 mark to the level shown in Fig. 2.1. Calculate the energy used to evaporate water from B during the three days. [2]

[J07/P2/Q2]

Solution

(a) (i) The molecules of the hotter water of 80°C possess more kinetic energy so more molecules are able to overcome the intermolecular forces of attraction and escape from the surface of the water.

(ii) The increase in the surface area of water, can also increase the rate of evaporation.

(b) volume of water evaporated = 40 cm^3

$\therefore$ mass of water evaporated = 40 g

energy required, $Q = m \times l$

$= 40 \times 2300 = 92000$ J

COMMENT on ANSWER

❝ (b) Volume of water evaporated from cylinder B = 100 – 60 = 40 cm^3

Mass of evaporated water (m) = density × volume = 1.0 × 40 = 40 g ❞

Question 2

Fig. 3.1 shows apparatus to measure the specific latent heat of fusion of water. In this question, you may ignore heat transfer to the ice from the room.

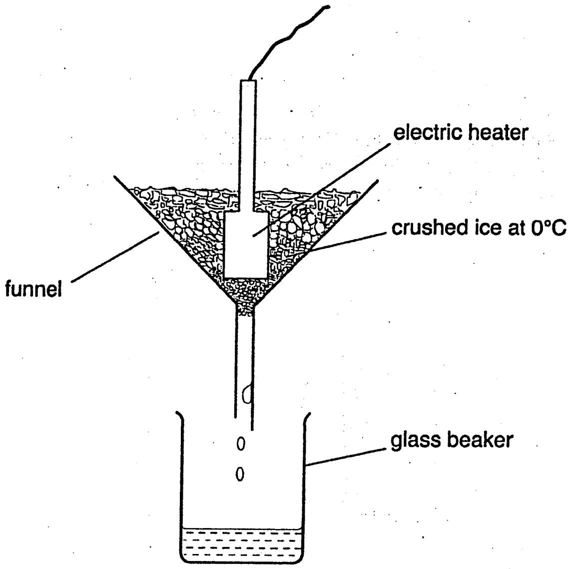


Fig. 3.1

The heater is switched on and water drips into the beaker at a constant rate. In 2.0 minutes, 31 g of water drips into the beaker. The power of the heater is 85 W.

(a) Calculate the amount of electrical energy supplied to the heater in 2.0 minutes.

energy = ... [2]

(b) Use your answer to **(a)** to calculate the specific latent heat of fusion of water.

specific latent heat = ... [2]

(c) In another experiment using the same heater, ice colder than 0 °C is used. State why less water drips into the beaker in 2.0 minutes. [1]

[J09/P2/Q3]

Solution

(a) $E = Pt$

$= 85 \times (2 \times 60)$

$= 10,200 \text{ J}$

(b) $E = ml$

$10200 = 31 \times l$

$l = 329 \text{ J/g}$

(c) Since some of the heat energy supplied by the heater is used to raise the temperature of ice to its melting point, so less heat energy is available to melt the ice.

COMMENT on ANSWER

" (a) *Note:* Don't forget to change the time in minutes into seconds.

(b) *Alternatively:* Change the value of m into kilograms.

So,

$E = ml$

$10200 = 0.031 \times l$

$l = 3.29 \times 10^5 \text{ J kg}^{-1}$ "

Question 3

A student notices puddles of water on a road, as shown in Fig. 4.1.

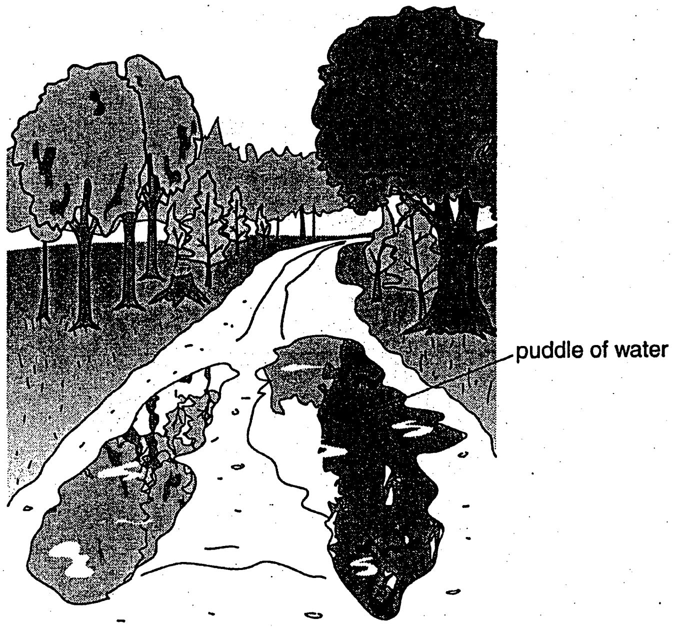


Fig. 4.1

Later in the day, he passes the puddles again and some of the water has evaporated.

(a) State two changes to the atmospheric conditions that would cause the water to evaporate faster. [2]

(b) Explain, in terms of molecules, what happens during evaporation. [2]

[J10/P2/Q4]

Solution

(a) 1. Increase in temperature.

2. Wind starts blowing.

(b) The high energy water molecules overcome the inter molecular forces of attraction and escape from the water surface leaving behind the less energy molecules which results in a fall in the temperature of the remaining water.

Question 4

A large test-tube contains wax above its melting point. It is placed in a cool room.

Fig. 4.1 shows how the temperature T of the wax changes in a time of 30 minutes.

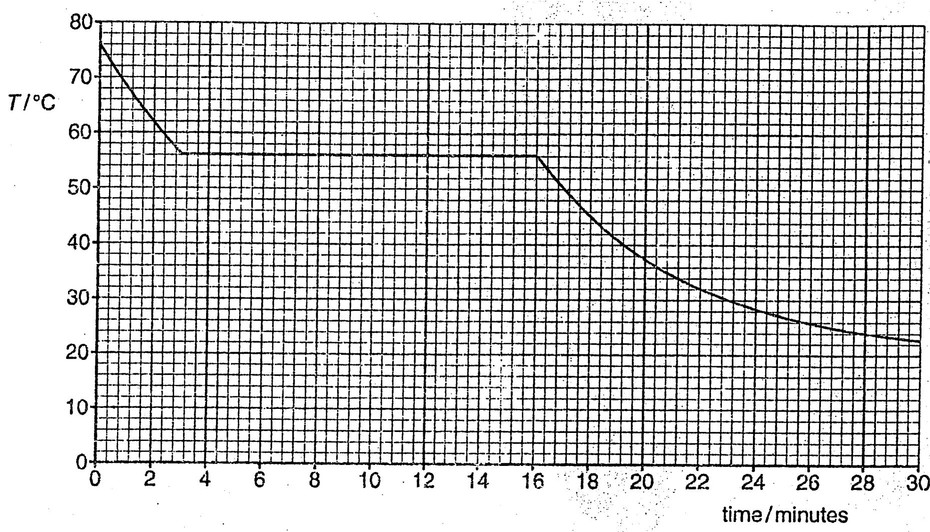


Fig. 4.1

(a) Determine the melting point of the wax. [1]

(b) The test-tube contains 110 g of wax that has a specific latent heat of fusion of 210 J / g.

Calculate the thermal energy transferred from the wax between 3 and 16 minutes. [2]

(c) (i) State what happens to the wax between 3 and 16 minutes. [1]

(ii) Between 3 and 16 minutes, the temperature of the wax is above room temperature and energy is lost to the room.

Explain, in terms of molecules, why the temperature of the wax remains constant. [2]

[N13/P2/Q4]

Solution

(a) melting point = 56° C

(b) $Q = ml$

$= 110 \times 210$

$= 23100$ J

(c) (i) The wax solidifies.

(ii) During solidification, the wax loses the latent heat energy. So, its molecules potential energy decreases but their kinetic energy remains constant. Hence the temperature of the wax remains constant.

COMMENT on **ANSWER**

" **(c)** **(ii)** During the change of state, the molecules lose their P.E. and come closer to each other to strengthen their bonds but their K.E. remains constant, so the temperature of the wax remains constant. "

Question 5

A test-tube contains solid wax. The melting point of the wax is 58 °C.

The test-tube is partially immersed in a beaker of boiling water and the wax melts. A thermometer is placed in the liquid wax.

At time $t = 0$, the thermometer reads 90 °C and the test-tube is immediately removed from the water. The test-tube then cools to room temperature of 23°C.

(a) The temperature of the wax changes as it cools to room temperature. On the axes of Fig. 5.1, sketch a graph to show how the temperature changes with time t. Mark on the temperature axis 90 °C, 58 °C and 23 °C. [3]

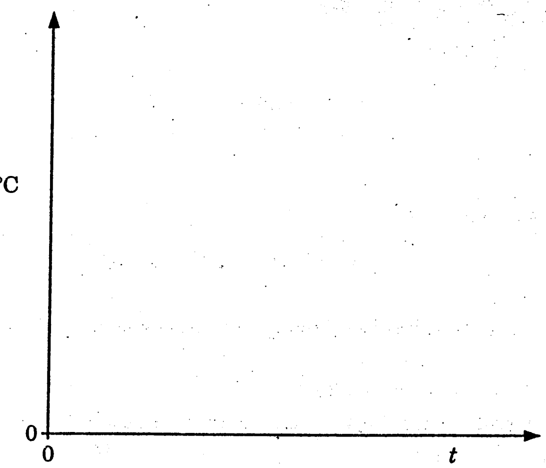


Fig. 5.1

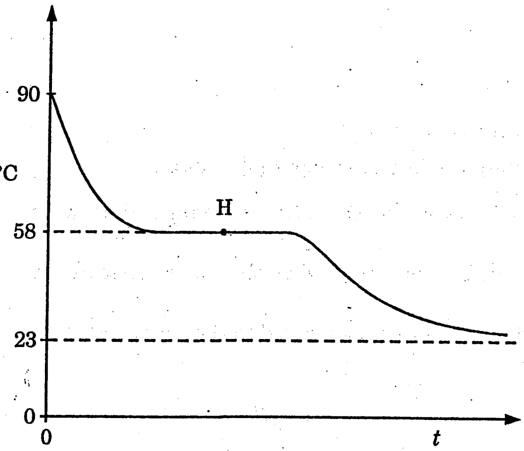
(b) On the completed graph of Fig. 5.1, mark a point H, where half of the wax is solid and half is liquid. [1]

(c) The specific latent heat of fusion of the wax is 220 J/g and the mass of the wax is 45 g. Calculate the thermal energy released by the wax as it solidifies. [2]

[N14/P2/Q5]

Solution

(a) & (b)



(c) Thermal energy, $E = ml$

$= 45 \times 220 = 9900$ J.

COMMENT on ANSWER

❝ (a) When a substance changes from one state to another, it always does so at a constant temperature. Therefore at the melting point, there is a constant horizontal line till all of the liquid has converted back into a solid.

Question 6

Aeroplanes fly at high altitudes where the temperature is well below 0 °C. Ice that forms on an aeroplane can fall to earth and strike the ground.

Fig. 9.1 shows a block of ice falling from an aeroplane as it approaches an airport.

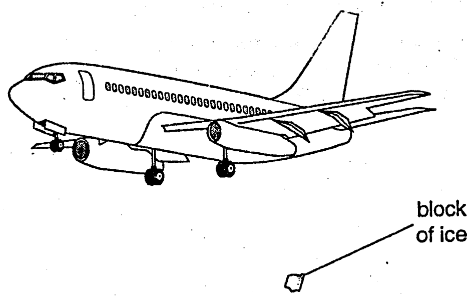


Fig. 9.1 (not to scale)

The mass of the falling block of ice is 1.2 kg and the gravitational field strength g is 10 N / kg.

(a) The block strikes the ground and it stops moving. This impact causes some of the ice to melt.

(i) The specific latent heat of fusion of ice is 330 J / g.

Calculate the maximum possible mass of ice that melts as a result of the impact. [2]

(ii) In practice, the mass of ice that melts on impact is less than the value calculated in **(c)(i)**.

Suggest two reasons for this. [2]

(b) As the solid ice melts, it changes into liquid water.

Describe, in terms of molecules, how ice differs from liquid water. [3]

[N15 / P2 / Q9(c,d)]

Solution

(a) (i) $E = m \times l$

$960 = m \times 330$

$m = 2.91$ g.

(ii) 1. The temperature of ice is below 0 °C

2. Some of the heat energy is lost to the ground and air.

(b) 1. The inter atomic forces between ice molecules are larger than water molecules.

2. The molecules in ice are in regular lattice while the water molecules are placed randomly.

3. The ice molecules are further apart as compared to the water molecules.

COMMENT on ANSWER

❝**(c)** (ii) *Alternative reasons:*

Some of the energy of the falling ice block is used in work done to compress the ground.

(d) Also,

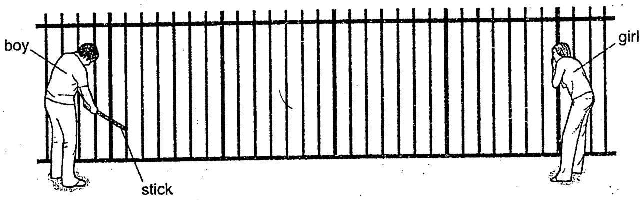
- Ice molecules are fixed in positions while the water molecules move around randomly.
- Ice molecules vibrate but water molecules do not vibrate. ❞

MCQ Answers

Topic 12 Longitudinal Waves

MCQ Section

1. A boy strikes a rigid metal fence with a stick to create a sound along the fence. A girl listens with her ear against the fence. One second after the fence is struck, the girl hears a sound through the air.

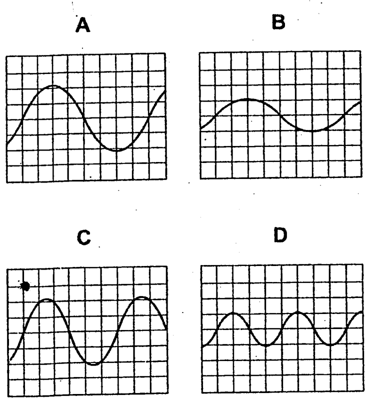


How long will it take for the sound to reach the girl through the fence?

A 0 second
B less than 1 second
C 1 second
D more than 1 second

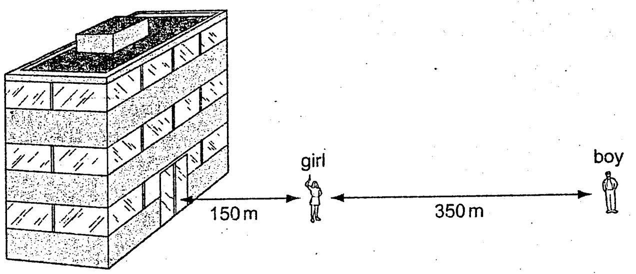
[J06/P1/Q26]

2. The diagrams show oscilloscope traces of sounds picked up by microphones. The oscilloscope controls are set in the same position for all the traces.
Which trace shows the sound that is both loud and low-pitched?



[N06/P1/Q23]

3. A girl, standing 150 m in front of a tall building, fires a shot using a starting pistol. A boy, standing 350 m from the girl, hears two bangs 1s apart.

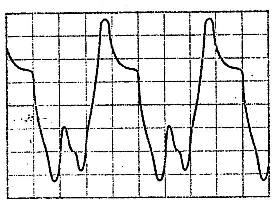


From this information, what is the speed of sound in air?

A 300 m/s **B** 350 m/s
C 500 m/s **D** 650 m/s

[J07/P1/Q23]

4. Waveforms are shown on a cathode-ray oscilloscope for a flute and for a guitar, each playing the same note. The oscilloscope settings are the same for both waveforms.



1. B The speed of sound in metals is greater than the speed of sound in air. So if the sound takes 1 second to travel through air from the boy to the girl then it will take less than a second to cover the same distance.

2. A The display on an oscilloscope is a voltage-time graph. A louder sound has a greater amplitude and a lower-pitch sound has a lower frequency or higher period.

3. A The time difference between the two sounds is 1 second.

i.e. $t_2 - t_1 = 1$

$\frac{d_2}{v} - \frac{d_1}{v} = 1$

$\frac{1}{v}(d_2 - d_1) = 1$

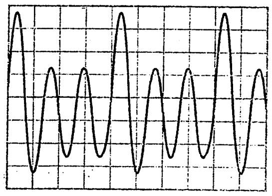
$d_2 - d_1 = v$

$650 - 350 = v$

$v = 300$ m/s

4. C The both waveforms have the same amplitude, frequency and the wavelength but they have a different quality because the shape of the waveforms is different.

guitar



What is the difference between the two sounds?

A the amplitude
B the frequency
C the quality (timbre)
D the wavelength

[J08/P1/Q26] & [N11/P1/Q25]

5. An ultrasonic tape-measure is used to find the distance to a wall. It sends out an ultrasonic pulse and times how long it takes for the reflected pulse to return from the wall.

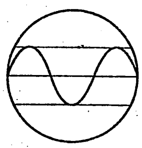
The ultrasound has a frequency, a wavelength and a speed.

Which pair of values is needed to find the distance to the wall?

A frequency and wavelength
B frequency and time taken for the pulse to return
C speed and time taken for the pulse to return
D wavelength and time taken for the pulse to return

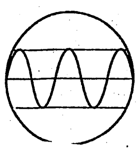
[J09/P1/Q23]

6. The diagram shows the trace produced on a cathode-ray oscilloscope (c.r.o.) by a sound.

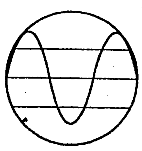


Which trace is produced when both the loudness and the pitch of the sound are increased?

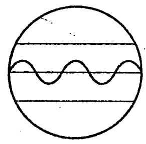
A



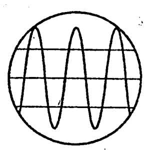
B



C



D



[N09/P1/Q23]

7. A flash of lightning and the corresponding sound of the thunder are detected 6 s apart. A student calculates that the lightning struck about 1800 m away.

On which assumption is the calculation based?

A Light reaches us almost instantaneously, but sound travels at 300 m/s.
B Light travels 300 m/s faster than sound.
C Light travels 300 times faster than sound.
D The sound of the thunder was emitted 6 s after the flash.

[J10/P1/Q20]

8. During a thunderstorm, there is an interval of 1.70 s between an observer seeing the lightning and hearing the thunder. The speed of sound is 340 m/s.

What is the distance between the observer and the storm?

A 100 m **B** 200 m
C 578 m **D** 1160 m

[N10/P1/Q21]

9. Sound travels at different speeds in air, water and steel.

For these materials, which row is correct?

	sound travels slowest in	sound travels fastest in
A	air	steel
B	air	water
C	steel	air
D	water	air

[J11/P1/Q26]

T h i n k i n G P r o c e s S

MCQ Answers

5. C Since, distance = speed × time. Hence, the values of the speed and the time taken are needed in order to find the value of the distance.

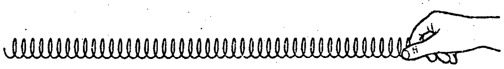
6. D The display D shows the increase in the loudness due to its increased amplitude as well as an increase in its pitch due to the increase in its frequency i.e. the number of waves.

7. A Fact.

8. C Distance
= speed × time
= 340 × 1.70 = 578 m

9. A Fact.

10. A student uses a spring to demonstrate waves. He moves the spring with his hand.



spring placed on bench

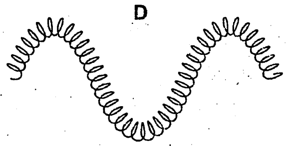
Which diagram demonstrates the type of wave produced by a source of sound?

A

B

C

D



[N11/P1/Q24]

11. Which of the following travels as a longitudinal wave?

A a radio wave in air
B a sound wave in a solid
C a wave on a rope shaken from side to side
D an infra-red wave in space

[J13/P1/Q24]

12. What is a possible frequency of an ultrasound wave?

A 0.1 kHz **B** 3 kHz
C 10 kHz **D** 30 kHz

[J13/P1/Q27]

13. A guitar string is made to vibrate.

What makes the pitch of the note rise?

A a decrease in the amplitude of vibration
B a decrease in the frequency of vibration
C an increase in the amplitude of vibration
D an increase in the frequency of vibration

[J13/P1/Q28]

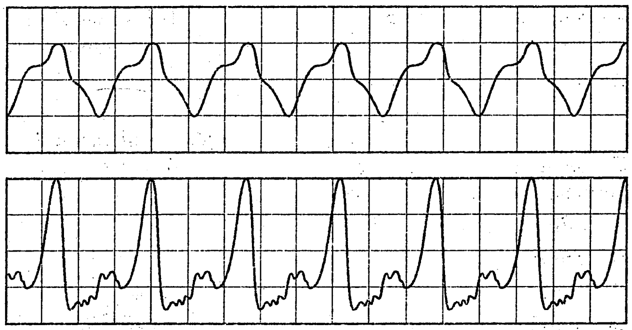
14. Two campers are woken up in the middle of the night by a thunderstorm. Their tent is lit up by a flash of lightning and they hear the thunderclap 5.0 s later. The speed of sound is 340 m/s.

How far away from the tent is the lightning?

A 68 m
B 850 m
C 1700 m
D 3400 m

[N13/P1/Q25]

15. The sounds produced by two musical instruments are directed towards a microphone connected to an oscilloscope (c.r.o.). The waveforms produced on the screen are shown.



The waveforms show that the sounds produced have a different property. What is the property?

A frequency
B speed
C timbre (quality)
D wavelength

[N13/P1/Q26]

16. Which frequency is in the ultrasound range?

A 35 Hz
B 350 Hz
C 3500 Hz
D 35 000 Hz

[J14/P1/Q28]

Thinking Process

MCQ Answers

10. B Sound is a longitudinal wave which comprises of compressions and rarefactions. When it passes through a medium, the particles of the medium vibrate parallel to the direction of motion of wave.

11. B It is a fact that sound waves travel as longitudinal waves in a solid in which vibrations are parallel to the direction of motion of the wave.

12. D Fact.

13. D Since the pitch is directly proportional to the frequency of vibration, Hence an increase in the frequency of vibration increases the pitch.

14. C Distance
$= \text{speed} \times \text{time}$
$= 340 \times 5.0$
$= 1700$ m

15. C Two sounds produced by two different musical instruments, having same frequency and amplitude but of wave forms of different shapes are said to differ in quality i.e. timbre.
This difference in quality or timbre distinguish the tone of one instrument from that of the other.

17. In an experiment to determine the speed of sound in air, a student stands 200 m away from a cliff and claps two pieces of wood together.

His class-mates standing next to him start stopwatches when the two pieces of wood meet and stop the stopwatches when they hear the echo.

Their times are:

1.44 s 1.70 s 1.58 s 1.76 s

Which value for the speed of sound do they obtain?

A 62 m/s **B** 123 m/s

C 247 m/s **D** 340 m/s

[J14/P1/Q29]

18. A student stands at a distance d from the base of a tall cliff.

He claps together two pieces of wood and measures the time that elapses before he hears the echo. He conducts the experiment five times and obtains these results.

0.72 s 0.80 s 0.71 s 0.81 s 0.71 s

The speed of sound is 320 m/s.

What is the distance d?

A 120 m **B** 240 m

C 480 m **D** 600 m

[N14/P1/Q18]

19. Ultrasound has many uses.
For what are ultrasound waves used?

A killing cancerous cells

B pre-natal scanning

C sunbeds

D telephones

[N14/P1/Q19]

20. In which situation do sound waves **not** travel?

A from a satellite in space to Earth

B from a ship to a submarine

C from an explosion underground to the surface

D through a balloon filled with helium gas

[J15/P1/Q29]

21. Two sound waves X and Y are compared.

X has the greater frequency.

Y has the greater amplitude.

How do the loudness and pitch of sound wave Y compare to those of X?

A Y is louder and higher pitch.

B Y is louder and lower pitch.

C Y is quieter and higher pitch.

D Y is quieter and lower pitch.

[J15/P1/Q30]

22. An echo sounder produces ultrasound of frequency 24 kHz. The ultrasound travels in water at a speed of 1.5 km / s.

What is the wavelength in water of ultrasound of this frequency?

A 0.063 m **B** 16 m

C 36 m **D** 63 m

[N15/P1/Q21]

23. A loudspeaker produces a sound wave of frequency 50 Hz. The amplitude of the sound wave is increased.

What is heard?

A a louder sound of a higher pitch

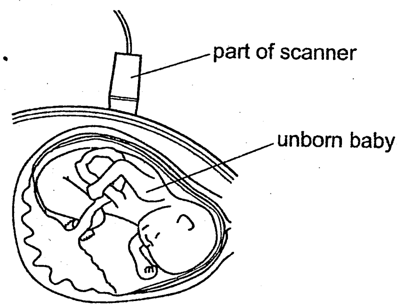
B a louder sound of the same pitch

C a sound of higher pitch but the same loudness

D a sound of the same pitch and loudness as before.

[N15/P1/Q25]

24. An ultrasound scanner produces an image of an unborn baby.



How does the scanner form an image?

A from ultrasound absorbed by the baby

B from ultrasound emitted by the baby

C from ultrasound reflected by the baby

D from ultrasound refracted by the baby

[N15/P1/Q26]

Thinking Process

MCQ Answers

16. D Ultrasound refers to sound waves above the audible range of sound i.e. 20000 Hz.

17. C Mean time

$= \frac{1.44 + 1.70 + 1.58 + 1.76}{4}$

$= 1.62$ s

Speed of sound

$= \frac{2(200)}{1.62} = 246.9$ m/s

18. A Average time

$= \frac{0.72+0.8+0.71+0.81+0.71}{5}$

$= 0.75$ seconds.

$\text{speed} = \frac{2 \times d}{\text{time}}$

$d = \frac{1}{2}(\text{speed} \times \text{time})$

$= \frac{1}{2}(320 \times 0.75)$

$= 120$ m

19. B Ultrasound waves are used in ultrasound scanning, fetal imaging and pre-natal scanning.

20. A Sound waves need a medium to travel from one place to another, so they cannot travel from a satellite to earth due to the absence of any medium in the space.

21. B As "Y" has a greater amplitude and a lower frequency, so it is louder and of a lower pitch because,
loudness $\propto$ amplitude
and pitch $\propto$ frequency.

22. A Frequency,
$f = 24$ kHz $= 24000$ Hz.
Speed, $v = 1.5$ km/s
$= 1500$ m/s
Thus, $v = f \times \lambda$
$1500 = 24000 \times \lambda$
$\lambda = 0.063$ m

25. The sound from the siren of a ship is reflected by a cliff. An echo is heard by a sailor on the deck of the ship, 4.0 s after the siren is sounded. The speed of sound in air is 320 m / s.

How far from the cliff is the ship?

A 80 m **B** 160 m

C 640 m **D** 1280 m

[N15/P1/Q27]

MCQ Answers

23. B If the amplitude of a sound wave is increased, a louder sound of the same pitch is produced because

loudness ∝ amplitude

The pitch of the sound is not affected by the change in the amplitude because it depends on the frequency as,

pitch ∝ frequency

24. C Ultrasound pulses are sent into the mother's body by means of a transmitter. Some of this ultrasound is reflected from the surface of the baby and received by a detector. These waves are then processed by a computer according to their time-intervals and an image is formed on the screen.

25. C $v = \frac{2d}{t}$

$2d = v \times t$

$d = \frac{320 \times 4.0}{2}$

$d = 640$ m

Topic 12 Longitudinal Wave

THEORY Section

Question 1

Fig. 6.1 shows the cone of a loudspeaker.

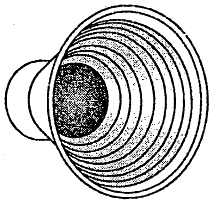


Fig. 6.1

(a) Sound is being produced. Describe in detail the behaviour of the cone and the air near to it. [2]

(b) The lowest frequency that a human can hear is 20 Hz.

(i) State the highest frequency that a human with normal hearing can hear. [1]

(ii) Calculate the longest wavelength of sound that a human can hear. The speed of sound in air is 340 m/s. [2]

[N07/P2/Q6]

Solution

(a) The cone vibrates forward and backwards and in turn makes the air molecules to vibrate also. This produces compressions and rarefactions in the air near to it.

(b) (i) 20,0000 Hz

(ii) $\lambda = \frac{v}{f} = \frac{340}{20} = 17$ m

COMMENT on ANSWER

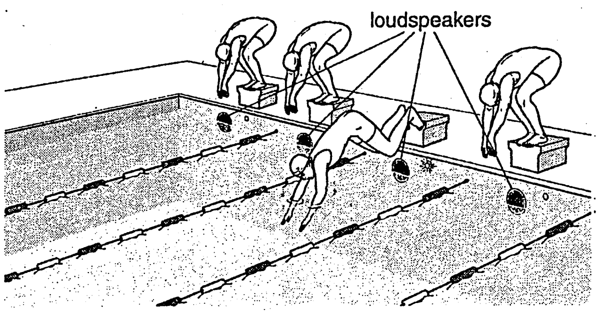
" (a) The cone vibrates and makes the molecules of nearby air to vibrate longitudenally which sets up longitudinal waves in the air near to the cone.

(b) (i) The audible frequency range for a healthy young person is from 20 Hz to 20,000 Hz.

(ii) Since $\lambda \propto \frac{1}{f}$ so, the sound of longest wavelength has a lowest frequency. "

Question 2

Fig. 9.1 shows one swimmer in a race starting before the signal.



The swimmer is called back by a loud, low-pitched sound from a loudspeaker positioned just at water level. The speed of sound in air is 330 m/s.

(a) (i) Describe how the loudspeaker causes sound to travel through the air. [3]

(ii) Explain, in terms of wave properties, what is meant by *loud* and *low-pitched*. [3]

(iii) The swimmer is 0.57 m from the loudspeaker when he hears the sound. Calculate the time taken for the sound to reach him through the air. [2]

(iv) Explain how the time taken differs when sound travels the same distance through air and through water. [2]

(b) The loudspeaker produces sound of frequency 0.20 kHz.

(i) Calculate the wavelength of this sound. [3]

(ii) Draw a diagram to show what is meant by the term *wavelength* when applied to a **longitudinal** wave such as sound. [2]

[N08/P2/Q9]

Solution

(a) (i) When an alternating current passes through the coil of loudspeaker, the coil and the paper cone attached to it oscillate forward and backwards. The forward and backward motion of the paper cone then sets the air molecules in front of it into motion. This sets up sound waves in the air consisting of compressions and rarefactions. Which then travels in the air away from the loud speaker as longitudinal waves.

(ii) The loudness of a sound depends on the amplitude of the wave that produces it. So a loud sound means a sound of large wave amplitude. The pitch of a sound is related to the frequency of the wave. The higher the frequency, the higher the pitch. So a low-pitched sound means a sound of low frequency.

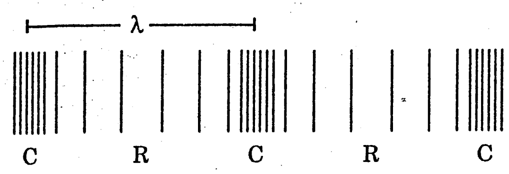
(iii) $\text{Speed} = \dfrac{\text{distance}}{\text{time}} \quad \Rightarrow \quad 330 = \dfrac{0.57}{t} \quad \Rightarrow \quad t = 1.7 \times 10^{-3}$ sec.

(iv) As $\text{time} \propto \dfrac{1}{\text{speed}}$ and the speed of sound in water (i.e. 1500 m/s) is greater than its speed in air (i.e. 330 m/s). So, the time taken by the sound to travel the same distance in water will be less than the time taken by it in air.

(b) (i) $v = f \times \lambda$

$$\lambda = \frac{v}{f} = \frac{330}{200} = 1.65 \text{ m.}$$

(ii)



Key:
C = Compression
R = Rarefaction

COMMENT on ANSWER

" **(b) (i)** Change the value of the frequency into Hz.

(ii) The wavelength of a longitudinal wave is the distance between the centres of two consecutive compressions of the wave. "

Question 3

Fig. 6.1 shows how ultrasound is used to produce an image of the heart.

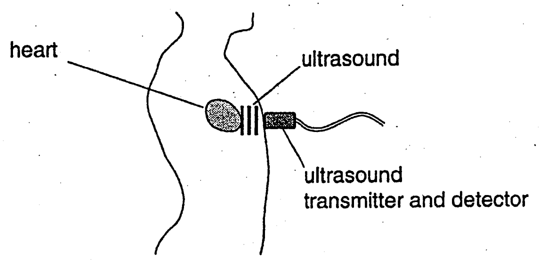


Fig. 6.1

(a) Define *ultrasound*. [1]

(b) The ultrasound has a wavelength of 1.2×10^{-3} m. The speed of the ultrasound in the human body is 1500 m/s.

Calculate the frequency of the ultrasound.

frequency = ... [2]

(c) Ultrasound is a longitudinal wave.
Describe how particles in the body move as the ultrasound passes.

You may draw a diagram if you wish. [2]

(d) There are small bubbles of gas in the body.

Explain why these bubbles expand and contract as the ultrasound passes. [1]

[J09/P2/Q6]

Solution

(a) A sound of frequency above 20 K Hz is called the ultrasound.

(b) $v = f \times \lambda$

$1500 = f \times 1.2 \times 10^{-3}$

$f = 1250,000 \text{ Hz.} = 1.25 \times 10^{6} \text{ Hz.}$

(c) The particles in the body oscillate forward and backward, parallel to the direction of motion of the ultrasound wave.

(d) The pressure increases and decreases alternatively along the path of the ultrasound in the body, which causes the gas bubbles in the body to expand and contract.

COMMENT on ANSWER

❝ **(a)** *Alternatively:*
A sound of too high a frequency to be heard is known as the ultrasound.
OR
A sound of frequency higher than the human audible range is called the ultrasound.

(d) When ultrasound passes through a body, compressions and rarefactions are produced along the path of the wave. This in turn increases and decreases the pressure along the path of the wave and causes the gas bubbles to expand and contract. ❞

Question 4

Fig. 5.1 is a full-scale diagram that represents a sound wave of frequency 5.1 kHz in air.

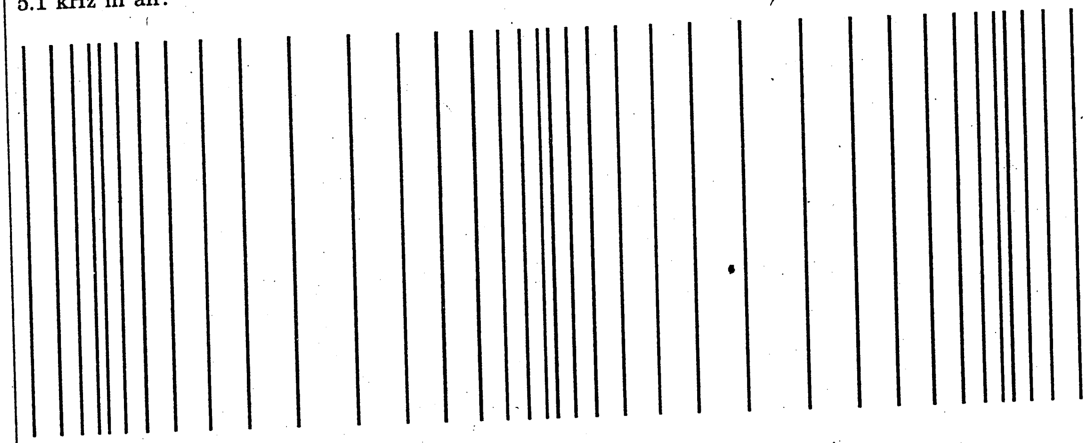


Fig. 5.1

(a) (i) On Fig. 5.1, mark the position of one compression with the letter C and of one rarefaction with the letter R. [2]

(ii) Using the full-scale diagram, measure the wavelength of this sound wave. [1]

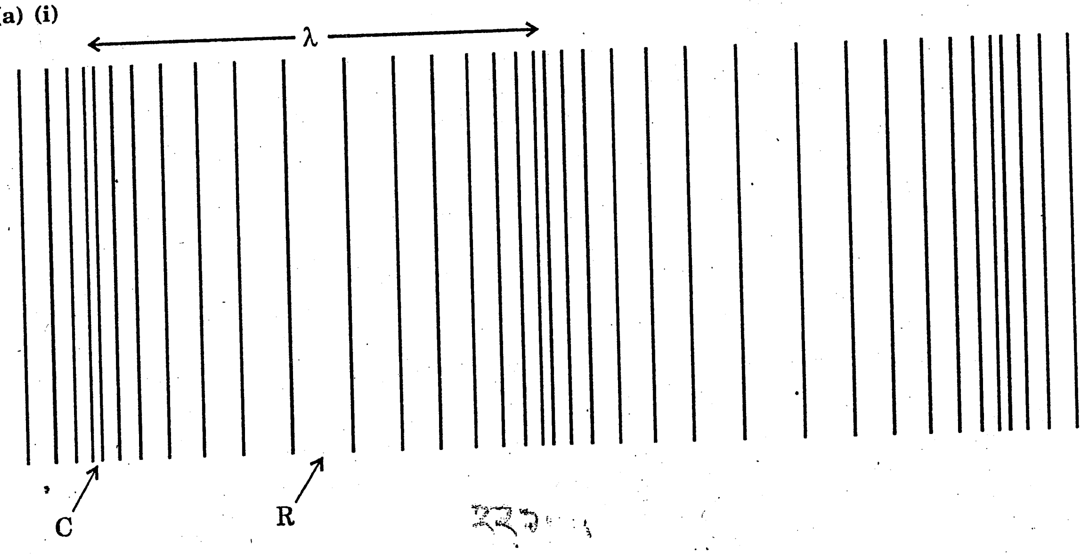
(iii) Calculate the speed of sound in air. [3]

(b) A sound wave is longitudinal. Describe how a longitudinal wave differs from a transverse wave. [2]

[N09/P2/Q5]

Solution

(a) (i)



(ii) wavelength = 6.4 cm

(iii) Wavelength of the wave = 6.4 cm = 0.064 m

frequency of the wave = 5.1 kHz = 5100 Hz

Speed = frequency × wavelength

$= 5100 \times 0.064 = 326.4 \approx 326$ m/s

(b) A longitudinal wave consists of a compression and a rarefaction and it causes the particles of a medium to vibrate parallel to its direction of motion.

A transverse wave consists of a crest and a trough. It causes the particles of a medium to vibrate perpendicular to its direction of motion.

Question 5

(a) Describe a method for measuring the speed of sound in air. In your account, state clearly
- how the sound is made,
- what measurements are taken,
- how the result is calculated,
- one precaution to produce an accurate result. [5]

(b) Ultrasound is used in quality control to detect cracks in metal.

Pulses of ultrasound are sent into the metal from a transmitter. A detector is placed next to the transmitter on the front surface of the metal.

Fig. 10.1 shows the oscilloscope trace of the ultrasound pulses produced if the metal contains no cracks.

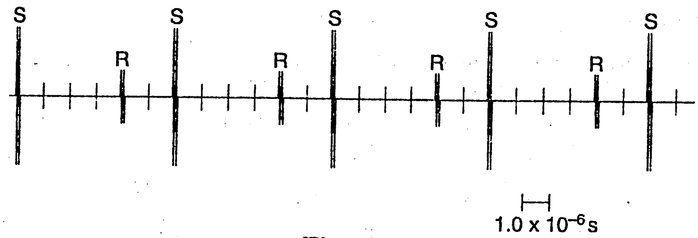


Fig. 10.1

One division along the x-axis represents 1.0×10^{-6} s.

Pulses labelled S are the pulses initially sent out from the transmitter. Each pulse labelled R is the reflection from the back surface of the metal of the previous pulse S.

(i) State what is meant by *ultrasound*. [2]

(ii) Use Fig. 10.1 to calculate the number of pulses sent out by the source in one second. [2]

(iii) Suggest two reasons why the amplitude of R is less than the amplitude of S. [2]

(iv) Some time later, the piece of metal is tested again. It now has a small crack half-way between the front surface and the back surface.

On Fig. 10.1, draw the position and size of the pulses produced by this crack.

Label each of these pulses C. [2]

(v) A second beam of ultrasound has a frequency of 8.0×10^6 Hz and a speed of 4000 m/s in the metal.

Calculate the wavelength of this ultrasound in the metal. [2]

[J10/P2/Q10]

Solution

(a) Two observers A and B are positioned approximately 1000 m apart in an open field. The exact distance between them is measured with a tape measure and recorded as '*d*'. Then the observer A fires a starting pistol and the observer B, on seeing the flash or the puff of smoke, starts the stop watch and then stops it later when he hears the sound. The time interval registered by the stopwatch is recorded as '*t*'.

The value of the speed of sound is then calculated as follows:

$$v = \frac{\text{distance travelled by sound}}{\text{time taken}} = \frac{d}{t}$$

The observers A and B then exchange their positions and repeat the experiment. An average of the result is found which will cancel the effect of wind on the speed of sound in air.

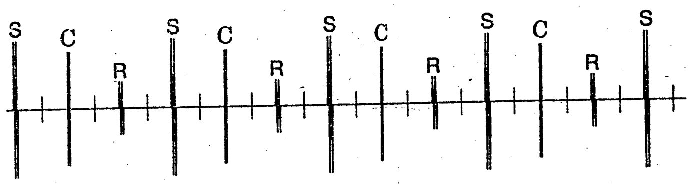
(b) (i) It is the sound of frequency above 20 KHz and which is inaudible to humans.

(ii) $f = \dfrac{1}{T}$

$$= \frac{1}{6.0 \times 10^{-6}} = 1.7 \times 10^{5}$$

(iii) 1. Some energy is absorbed in the metal.

2. Not all the sound is reflected back from the back surface but some passes out of the back of the metal.

(iv) 

(v) $\lambda = \dfrac{v}{f}$

$$= \frac{4000}{8.0 \times 10^{6}} = 5.0 \times 10^{-4}\ \text{m}$$

Question 6

A physics textbook states that sound is a longitudinal pressure wave with a frequency within the audible range.

(a) Explain what is meant by a *longitudinal wave*. [2]

(b) (i) State the approximate range of audible frequencies.

highest frequency: ....

lowest frequency: .... [2]

(ii) The speed of sound in air is 330 m / s. Using your answer in (i), calculate the shortest wavelength in air of sound in the audible range. [2]

[N13/P2/Q5]

Solution

(a) It is a wave that consists of compressions and rarefactions and which travels in a direction parallel to the direction of vibrations.

(b) (i) highest frequency: 20 kHz.

lowest frequency: 20 Hz.

(ii) Wavelength, $\lambda = \frac{v}{f}$

$= \frac{330}{20000}$

$= 0.0165 \approx 0.017 \text{ m}$

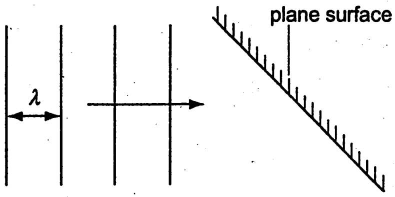
COMMENT on ANSWER

❝ **(b) (ii)** As $\lambda \propto \frac{1}{f}$ hence, to find the value of the shortest wavelength of sound in air, the highest frequency is used. ❞

Topic 13 Transverse Waves

MCQ Section

1. In an experiment using a ripple tank, plane wavefronts arrive at a plane surface.

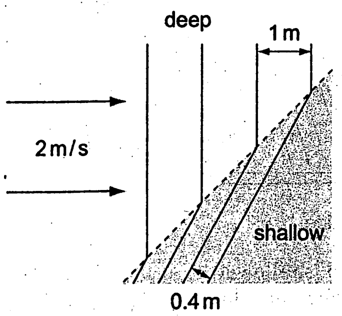


Which of the following correctly describes the waves after they are reflected from the surface?

	speed of waves	wavelength λ
A	faster	shorter
B	slower	longer
C	slower	shorter
D	the same	the same

[J06/P1/Q21]

2. Waves pass from deep water to shallow water and refraction occurs.



What is the speed of the waves in the shallow water?

A 0.2 m/s **B** 0.8 m/s
C 2.0 m/s **D** 5.0 m/s

[J06/P1/Q22]

3. What is meant by the term *wavefront*?

A the distance between successive peaks of a wave

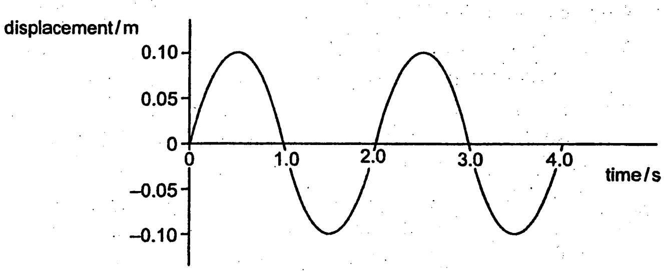
B the distance between the trough and the peak of a wave

C a line joining points along the peak of a wave

D a line joining the trough and the peak of a wave

[N06/P1/Q19]

4. The diagram shows how displacement varies with time as a wave passes a fixed point.

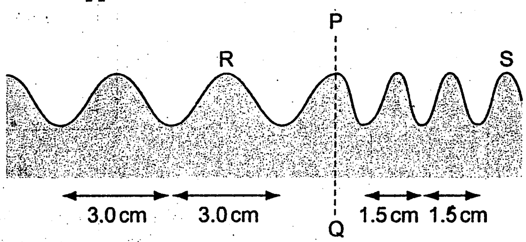


What is the frequency of this wave?

A 0.25 Hz **C** 1.0 Hz
B 0.50 Hz **D** 2.0 Hz

[N06/P1/Q20]

5. The diagram shows a water wave in a ripple tank.



The wave has a speed of 12 cm/s at R.

The wave crosses a boundary PQ where the distance between crests changes from 3.0 cm to 1.5 cm.

What is the speed of the wave at S?

A 3.0 cm/s **B** 6.0 cm/s
C 12 cm/s **D** 24 cm/s

[J07/P1/Q19]

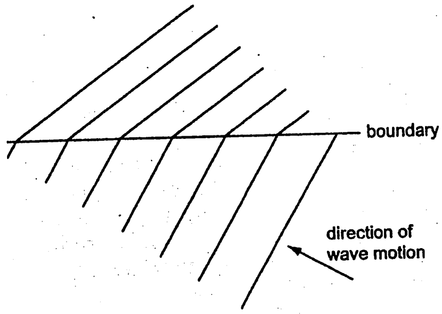
MCQ Answers

1. **D** The speed and the wavelength of a wave change when the medium changes. As the medium remains the same during the reflection so the speed and the wavelength of the waves remain unchanged.

2. **B** Using the wave equation $V = f \times \lambda$. The frequency of the wave in deep water is $f = \frac{V}{\lambda} = \frac{2}{1} = 2$ Hz. As the frequency remains constant when the wave passes into the shallow water so the speed in shallow water $= f \times \lambda$ $= 2 \times 0.4 = 0.8$ m/s

3. **C** Fact.

6. The diagram shows the refraction of water waves as they cross a boundary in a ripple tank.



What causes this refraction?

A a change in frequency due to a change in depth

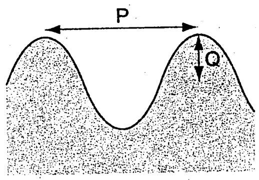
B a change in frequency due to a change in wavelength

C a change in speed due to a change in depth

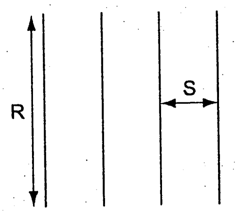
D a change in speed due to a change in frequency

[N07/P1/Q19]

7. The diagrams show different views of a water wave in a ripple tank.



cross-section of wave



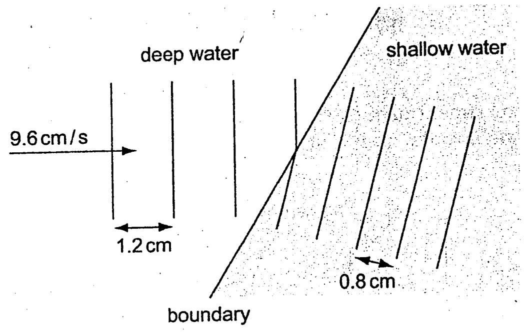
crests seen from above

Which letters represent a wavelength and a wavefront?

	wavelength	wavefront
A	P	R
B	P	S
C	Q	R
D	Q	S

[J08/P1/Q20]

8. A ripple tank is used to demonstrate refraction of plane water waves.



Waves in deep water have a wavelength of 1.2 cm and a speed of 9.6 cm/s. The wavelength of the waves in shallow water is 0.8 cm.

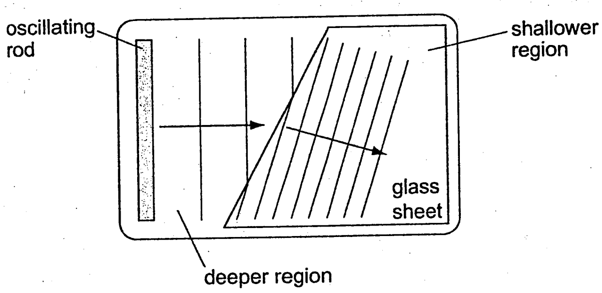
What is the speed of the waves in the shallow water?

A 6.4 cm/s **B** 8.0 cm/s

C 9.6 cm/s **D** 14.4 cm/s

[J08/P1/Q21]

9. The diagram shows the refraction of water waves in a ripple tank. The water is shallower above the glass sheet.



When crossing into the shallower region, what is the effect on the frequency and on the speed of the waves.

	wave frequency	wave speed
A	changes	changes
B	changes	unchanged
C	unchanged	changes
D	unchanged	unchanged

[N08/P1/Q22]

4. B Using the time-axis, the period T of the wave = 2.0 s by inspection. Frequency f of the wave $= \frac{1}{T} = \frac{1}{2.0} = 0.50$ Hz.

5. B The frequency of the wave at R is:

$f = \frac{V}{\lambda} = \frac{12}{3} = 4$Hz

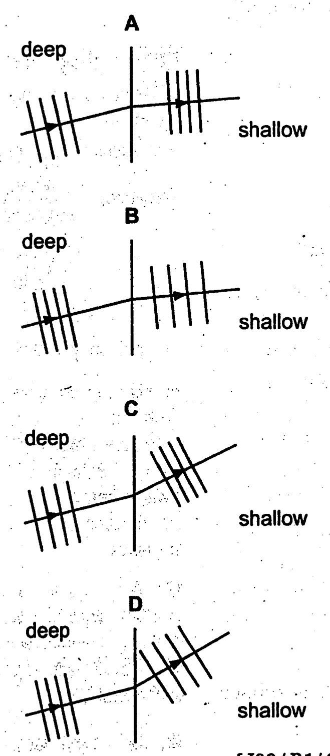
Since the frequency of a wave remains constant so the speed of the wave after crossing the boundary is:

$v = f \times \lambda$

$= 4 \times 1.5 = 6$ cm/s

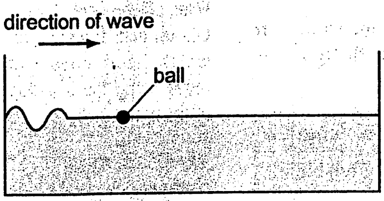
Note that the distance between the consecutive crests is equal to the wavelength of the wave.

10. Which diagram correctly represents water waves travelling from deep water to shallow water?

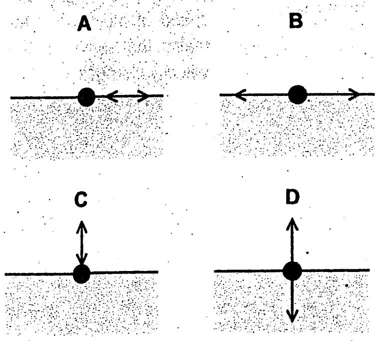


[J09/P1/Q19]

11. The diagram shows a ball floating in a tank of water.

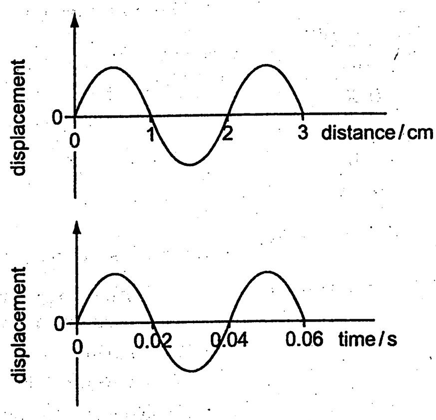


Which diagram shows the movement of the ball as the wave passes?



[N09/P1/Q19]

12. The displacement-distance and displacement-time graphs are for a water wave in a ripple tank.



What is the speed of the water wave?

A 0.02 cm/s **B** 0.08 cm/s
C 25 cm/s **D** 50 cm/s

[J11/P1/Q22]

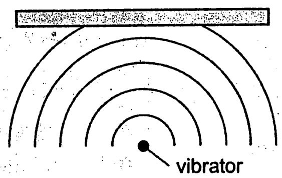
13. A wave has a frequency of 2 Hz. How many waves are produced in one minute?

A 2×60 **B** $\frac{60}{2}$

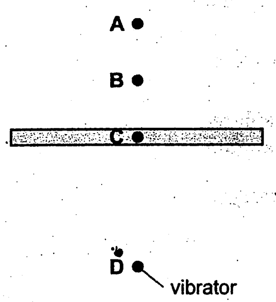
C 2 **D** $\frac{2}{60}$

[J12/P1/Q21]

14. In a ripple tank, a vibrator produces circular wavefronts which hit a flat surface.



The reflected wavefronts are also parts of circles. Where is the centre of these circles?



[N12/P1/Q21]

MCQ Answers

6. C The water waves travel from deep water to shallow water. The water waves refract due to the decrease in their speed as they enter the shallow water.

7. A By definition.

8. A The frequency of the wave in deep water, $f = \frac{v}{\lambda} = \frac{9.6}{1.2} = 8.0$ Hz

Since, the frequency of the wave remains constant, so the speed of the wave in shallow water $= f \times \lambda$ $= 8.0 \times 0.8 = 6.4$ cm/s.

9. C The speed of water waves decreases as they move from a deep water into a shallow water but their frequency remains constant.

10. A The water waves refract towards the normal as they pass from deep water to shallow water and their wavelength also decreases.

11. D Considering the ball as one of the particles of water, the transverse wave makes the particles of the medium (water) vibrate perpendicular to the direction of motion of the wave.

12. D The speed of a wave is given by: $v = f \times \lambda$

where $\lambda = 2$ cm and

$f = \frac{1}{T} = \frac{1}{0.04} = 25$ Hz

Hence $v = 25 \times 2$
$= 50$ cm/s.

13. A By definition,

No. of waves in 1 sec = frequency

No. of waves in 1 sec = 2

No. of waves in 60 sec $= 2 \times 60$

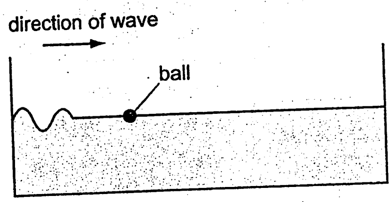
14. A Fact.

15. A wave has a frequency of 10 kHz.
Which pair of values of its speed and wavelength is possible?

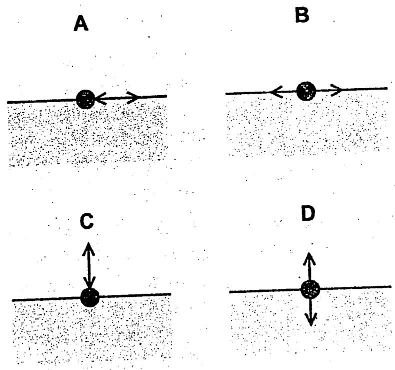
	speed m/s	wavelength m
A	330	0.33
B	330	33
C	3.0×10^8	30
D	3.0×10^8	3.0×10^4

[J13/P1/Q23]

16. The diagram shows a ball floating in a tank of water.



Which diagram shows the movement of the ball as the wave passes?



[N13/P1/Q22]

17. What is the frequency of a wave?

A The number of waves passing a fixed point per second.

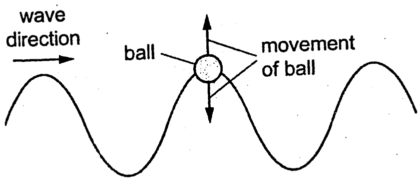
B The number of peaks added to the number of troughs passing a fixed point per second.

C The time taken for one wave to pass a fixed point.

D The time taken for the displacement to change from maximum to minimum.

[J14/P1/Q25]

18. A ball floating in a ripple tank begins to move vertically up and down as a wave passes beneath it.
The ball does not move horizontally.



Which statement is correct?

A Both energy and water are transferred in the wave direction.

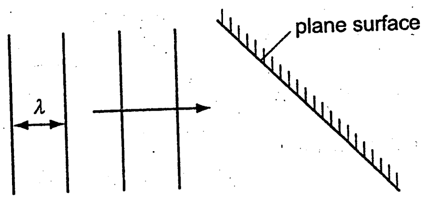
B Energy is not transferred in the wave direction but water is.

C Energy is transferred in the wave direction but water is not.

D Neither energy nor water is transferred in the wave direction.

[J15/P1/Q24]

19. In an experiment using a ripple tank, plane wavefronts arrive at a plane surface.



Which row correctly describes the waves after they are reflected from the surface?

	speed of waves	Wavelength λ
A	larger	shorter
B	smaller	shorter
C	the same	longer
D	the same	the same

[N15/P1/Q23]

MCQ Answers

15. D Using the wave equation,
speed = frequency × wavelength

$$\text{frequency} = \frac{\text{speed}}{\text{wavelength}} = \frac{3.0\times10^8}{3.0\times10^4} = 10^4\text{ Hz}$$

or frequency = 10 kHz

16. D In a transverse wave on the surface of water, the vibration of the particles of the medium is always perpendicular to the direction of motion of the wave.

17. A By definition, The frequency of a wave is the number of waves that travel past a point per second.

18. C It is a fact that in a transverse wave motion, the energy is transferred in the direction of the wave motion. The particles of water only oscillate up and down but the water itself does not move along the direction of the wave motion.

19. D Nothing changes during reflection except the direction of motion of the reflected waves. This means that speed of the waves remains the same but the velocity changes.

Topic 13 Transverse Waves

THEORY Section

Question 1

Fig. 4.1 shows circular wavefronts produced at the centre of a circular ripple tank.

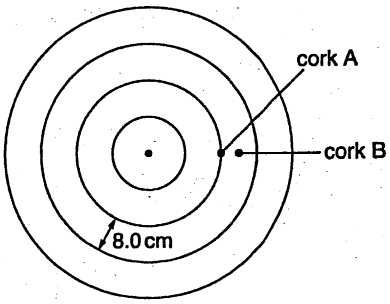


Fig. 4.1

Two corks, A and B, float on the water in the ripple tank. They move up and down on the surface of the water as the wave passes. The wavelength of the wave is 8.0 cm.

Fig. 4.2 shows how the displacement of A varies with time.

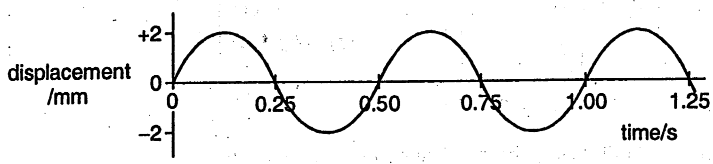


Fig. 4.2

(a) State the amplitude of the vibrations of A as the wave passes. [1]

(b) The horizontal distance between A and B is half the wavelength of the wave.
On Fig. 4.2, sketch a graph to show how the displacement of B varies with time. [2]

(c) **(i)** Use Fig. 4.2 to determine the frequency of the wave. [2]

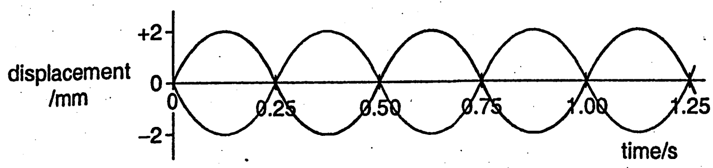
(ii) The distance between the centre of the ripple tank and its edge is 40 cm. Determine the time taken by a wavefront to travel from the centre of the tank to the edge. [2]

[J11/P2/Q4]

Solution

(a) amplitude = 2.0 mm

(b)



(c) (i) Frequency, $f = \frac{1}{T} = \frac{1}{0.50} = 2.0$ Hz

(ii) $v = f \times \lambda = 2.0 \times 8.0 = 16$ cm/s

time $= \frac{d}{v} = \frac{40}{16} = 2.5$ seconds.

Question 2

Fig. 6.1 shows a wave on the surface of water. The wave is travelling to the right.

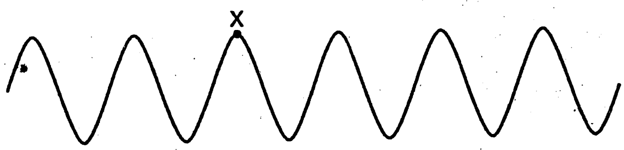


Fig. 6.1 (not to scale)

(a) Describe what is meant by *wave motion*. [2]

(b) On Fig. 6.1, draw an arrow to show the direction of the movement of a water molecule at X. [1]

(c) The frequency of the water wave is 2.0 Hz and the wavelength is 2.5 cm.

(i) Calculate the speed of the wave. [2]

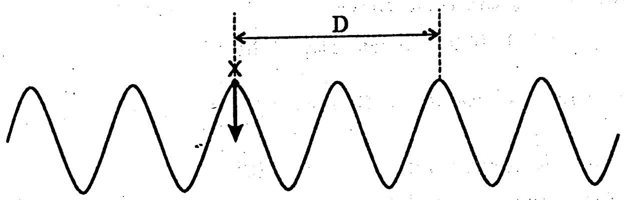
(ii) On Fig. 6.1, mark a distance which shows how far a wavefront at X moves in 1.0 s. Label this distance *D*. [1]

[J12/P2/Q6]

Solution

(a) A wave motion is a vibration or oscillation which carries energy from one point to another without any net movement of the medium.

(b)



(c) (i) $v = f \times \lambda$
$= 2.0 \times 2.5 = 5.0$

$\therefore$ speed of the wave = 5.0 cm/s.

(ii) See figure above.

Question 3

Fig. 4.1 shows part of a long rope used by a student to show a transverse wave.

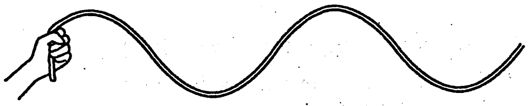


Fig. 4.1

(a) On Fig. 4.1,

(i) mark the direction of movement of the student's hand, [1]

(ii) mark and label the wavelength λ of the wave, [1]

(iii) mark and label the amplitude A of the wave. [1]

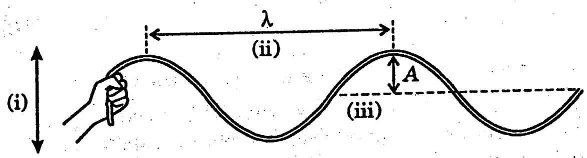
(b) Describe how the frequency of the wave is found using a stopwatch. [2]

(c) Using the same rope, the student produces a wave of a longer wavelength than that shown in Fig. 4.1.
State how the student does this. [1]

[J14/P2/Q4]

Solution

(a) (i),(ii) & (iii)



(b) Start a stopwatch and record the number of waves passing through a fixed point for a given time period. The frequency can be found by dividing the total number of waves by the total time taken. Repeat the process several times and take the average to calculate a value for the frequency of the wave.

(c) The student moves his hand with a slower speed.

COMMENT on ANSWER

" (b) Frequency $= \dfrac{1}{\text{Time period}}$

Time period $= \dfrac{\text{length of time interval}}{\text{no. of oscillations}}$ "

Question 4

Fig. 9.1 shows the wavefronts of a water wave in deep water in a ripple tank.

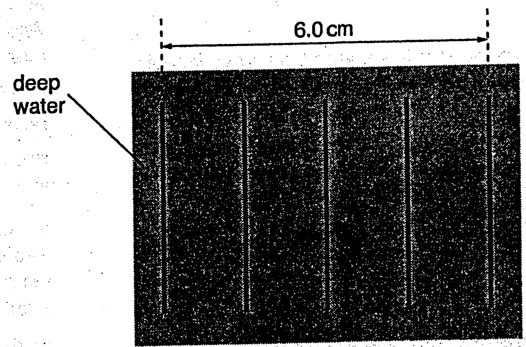


Fig. 9.1

The frequency of the wave in deep water is 5.0 Hz.

(a) Explain what is meant by the *frequency* of a wave. [2]

(b) (i) Determine the wavelength of the wave in deep water. [1]

(ii) Calculate the speed of the wave in deep water. [2]

(c) The wave passes from deep water into shallow water. The speed of the wave is less in shallower water.

(i) State and explain how this affects the wavelength of the wave. [2]

(ii) The wave in deep water shown in Fig. 9.2 travels towards the right and enters the shallow water at an angle. The wave refracts.

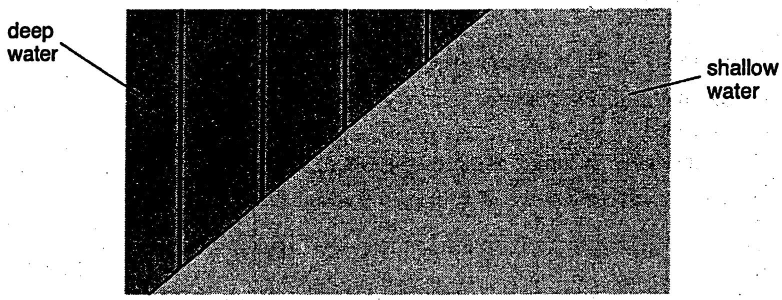


Fig. 9.2

On Fig. 9.2, draw the wavefronts in the shallow water. [3]

(d) Sound is also a wave.

(i) Describe one difference between a sound wave and a water wave. [2]

(ii) The speed of sound in carbon dioxide gas is less than the speed of sound in air. Using this information, or otherwise, describe an experiment to show the refraction of sound waves. You may include a diagram of your apparatus. [3]

[J15/P2/Q9]

Solution

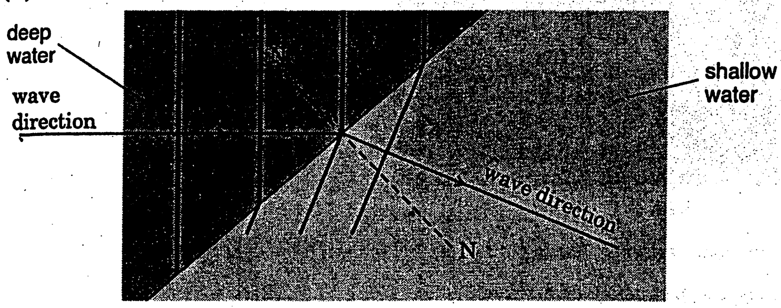
(a) The number of waves that pass a point in one second is called the frequency of the wave.

(b) (i) $\lambda = \frac{6.0}{4} = 1.5$ cm

(ii) $V = f \times \lambda = 5.0 \times 1.5 = 7.5$ cm/s

(c) (i) As the speed of the wave decreases in the shallow water. The wave travels a shorter distance in the time for one wave. As a result the wavelength of the wave decreases.

(ii)



COMMENT on ANSWER

❝ **(c)** (i) As the frequency of the wave remains the same in both sections of water, so the same number of waves travel at a faster speed in deep water and then enter into the shallow water and travel at a slower speed. As a result, they get closer to each other and the wavelength of the wave decreases.

Alternative answer:

As $v = f \times \lambda$.
Where f remain constant.

Hence $v \propto \lambda$.

i.e. when v decreases, the value of λ also decreases.

(ii) When drawing the refracted waves in the shallow water, make sure that,

— Wavefronts are with smaller wavelength,

— Smaller angle to the surface and slanted down. ❞

(d) (i) A second wave is a longitudinal wave in which the particles vibrate forwards and backwards parallel to the direction of wave motion.

Whereas a waterwave is a transverse wave in which the particles of the medium vibrate up and down, perpendicular to the direction of the wave motion.

(ii)

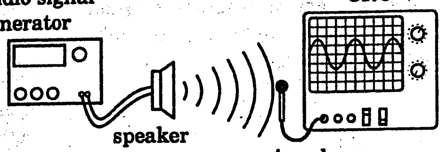


Fig (i)

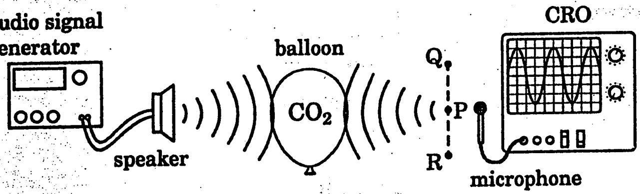


Fig (ii)

A sound signal is displayed on the screen of a CRO and its amplitude is noted down (Fig i). The sound signal is then passed through a balloon filled with CO_2 (Fig ii). The amplitude of the wave on the CRO screen is found to have increased. This is because CO_2 is denser than air. The sound waves refract towards the normal when moving into the balloon and away from the normal when moving out. Consequently, the balloon acts as a convex lens and converge the sound waves at a point P. The microphone records a wave of a larger amplitude on the screen when placed at P than the points Q and R.

COMMENT on ANSWER

"(d) (i) *Alternative answer:*

The sound waves consist of compressions and rarefactions, their particles vibrate forwards and backwards along the direction of motion of the wave and the speed of sound is about 300m/s.

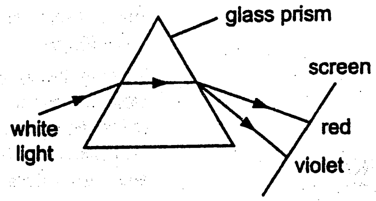
Whereas, the water waves consist of crests and troughs and the particles vibrate up and down and the speed of the waves is much slower than the sound."

Topic 14 Dispersion Of Light

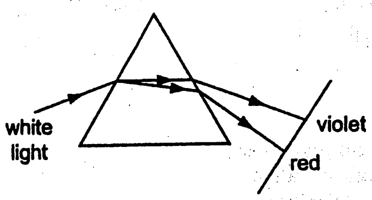
MCQ Section

1. Which diagram correctly shows the dispersion of white light by a glass prism?

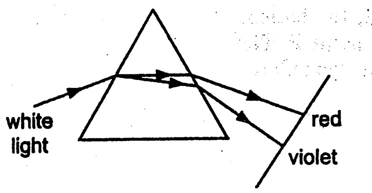
A



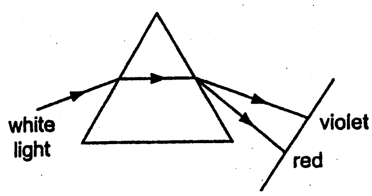
B



C

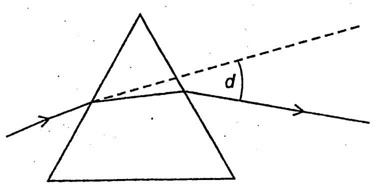


D



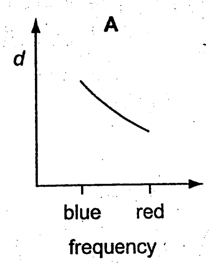
[J04/P1/Q23]

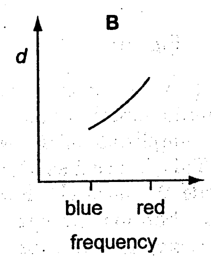
2. Light rays are deviated by a prism.

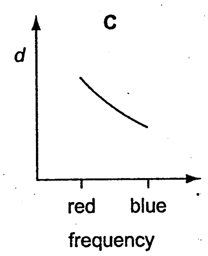


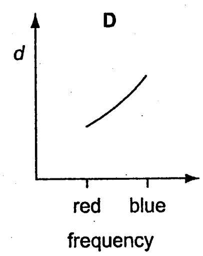
The deviation angle d is measured for light rays of different frequency, including blue light and red light.

Which graph is correct?









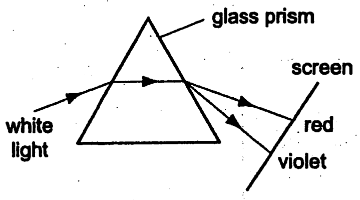
[J06/P1/Q24]

1. C The dispersed light rays always bend (refract) towards the thicker part (base) of the prism. Red is deviated least from its original path whereas violet is deviated the most.

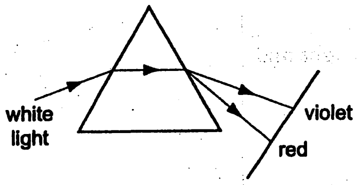
2. D A glass prism causes dispersion of the component colours of white light as it passes through it. The blue colour refracts more than the red colour. So the angle of deviation of the blue colour is greater than that of the red colour.
Also, the frequency of the blue colour is greater than that of the red colour.

3. Which diagram correctly shows the dispersion of white light by a glass prism?

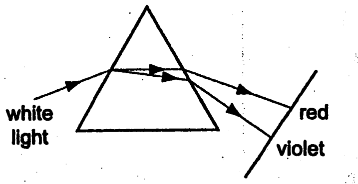
A



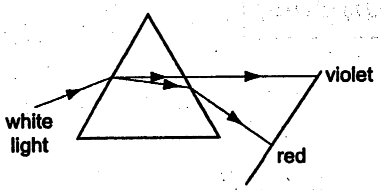
B



C



D



[N07/P1/Q21]

4. When white light is dispersed by a prism, compared with blue light, the **red** light is

A slowed down less and refracted less.

B slowed down less and refracted more.

C slowed down more and refracted less.

D slowed down more and refracted more.

[J09/P1/Q22]

5. Which statement about red light and blue light is correct?

A Red light has a higher frequency than blue light.

B Red light has a longer wavelength than blue light.

C Red light has the same speed in glass as blue light.

D Red light is refracted by a glass prism more than blue light.

[N12/P1/Q25]

6. Which statement about red light and blue light is correct?

A Red light has a higher frequency than blue light.

B Red light has a longer wavelength than blue light.

C Red light has the same speed in glass as blue light.

D Red light is refracted by a glass prism more than blue light.

[N15/P1/Q24]

MCQ Answers

3. C Fact.

4. A It is a fact that the speed of the red light is least affected by the denser medium of glass as compared to the light of other colours. So it quickly moves out of the prism and its direction too is less affected i.e. it is less refracted.

5. B It is a fact that the red light has a longer wavelength than the blue light.

6. B It is a fact that red light has a longer wavelength than the blue light.

Topic 14 Dispersion Of Light

THEORY Section

Question 1

Visible light, radio waves, X-rays, gamma rays and microwaves are some of the components of the electromagnetic spectrum.

(a) State two other components of the electromagnetic spectrum. [1]

(b) White light is a mixture of different colours.

Fig. 5.1 shows a ray of white light entering a glass prism.

The white light separates into a number of colours. Only the blue light and the red light are shown.

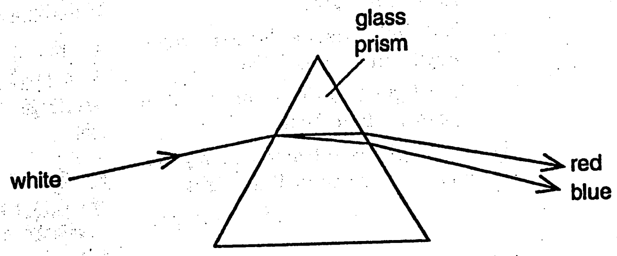


Fig. 5.1

Explain why the blue light and the red light separate as shown.

Use the term *refractive index* in your answer. [3]

[J14/P2/Q5]

Solution

(a) 1. Ultra violet

2. Infra red

(b) The blue and red light have different refractive indexes. This causes them to travel with different speeds in the glass. Therefore, blue light bends more than the red light causing them to separate.

Topic 15 *Lenses*

MCQ Section

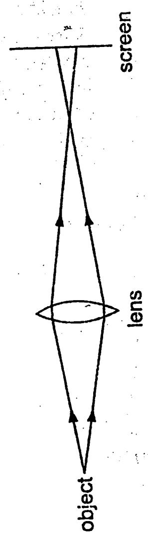
1. The human eye has a converging lens system that produces an image at the back of the eye.

If the eye views a distant object, which type of image is produced?

A real, erect, same size
B real, inverted, diminished
C virtual, erect, diminished
D virtual, inverted, magnified

[N06/P1/Q22]

2. A lens forms a blurred image of an object on a screen.



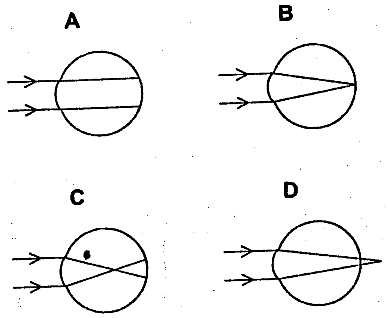
How can the image be focussed on the screen?

A by moving the object away from the lens and screen
B by moving the screen away from the lens and object
C by using a brighter object at the same position
D by using a lens of longer focal length at the same position

[J06/P1/Q23]

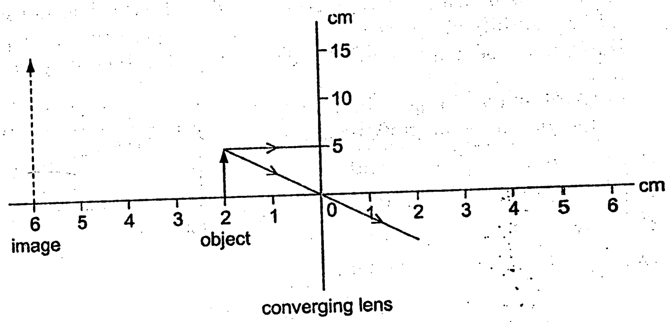
3. A man is short-sighted.

Which ray diagram shows what happens when he looks at a distant object?



[J08/P1/Q24]

4. An object 5.0 cm high is placed 2.0 cm from a converging (convex) lens which is being used as a magnifying glass. The image produced is 6.0 cm from the lens and is 15 cm high.



What is the focal length of the lens?

A 2.0 cm **B** 3.0 cm
C 4.0 cm **D** 6.0 cm

[J08/P1/Q23]

5. In a short-sighted eye, rays from distant objects are not focused on the retina.

Where are these rays focused and what type of lens is needed to correct the problem?

	where focused	lens needed
A	behind the retina	converging lens
B	behind the retina	diverging lens
C	in front of the retina	converging lens
D	in front of the retina	diverging lens

[N08/P1/Q25]

MCQ Answers

1. B For the eye to capture the image, the image must be real. All real images produced by a converging lens are inverted.

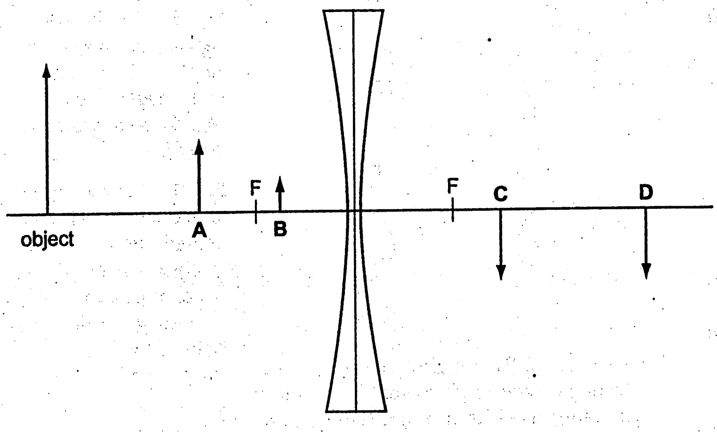
2. D For the image to be clear and well focused, it must be formed on the screen. By using a lens of longer focal length, the rays will be focused further away from the lens and may reach the screen.

3. C Fact.

4. B Completing the ray diagram for the virtual image formed behind the object, it is seen that the ray of light from the top of the object and parallel to the principal axis passes through the 3 cm mark. So the focal length of the lens is 3 cm.

5. D Fact.

6. An object is placed in front of a diverging lens as shown on the scale diagram.
The principal focus F is marked on each side of the lens.
What is the position of the image formed by the lens?



[N09/P1/Q22]

7. Convex lenses are used in cameras and as magnifying glasses.
Which types of image are formed?

	type of image in camera	type of image in magnifying glass
A	real	real
B	real	virtual
C	virtual	real
D	virtual	virtual

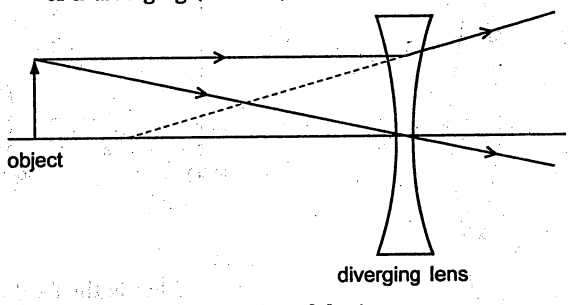
[J10/P1/Q18]

8. An object is viewed through a concave (diverging) lens.
What is the correct description of the image formed?

A real, inverted, magnified
B real, upright, diminished
C virtual, inverted, magnified
D virtual, upright, diminished

[N10/P1/Q24]

9. The ray diagram shows two rays from a point on an object placed in front of a diverging (concave) lens.

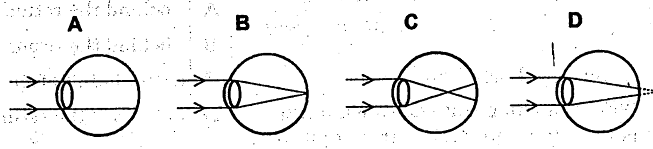


What are the properties of the image produced?

A real and larger than the object
B real and smaller than the object
C virtual and larger than the object
D virtual and smaller than the object

[J11/P1/Q24]

10. A man is short-sighted.
Which ray diagram shows what happens in his eye when he looks at a distant object?



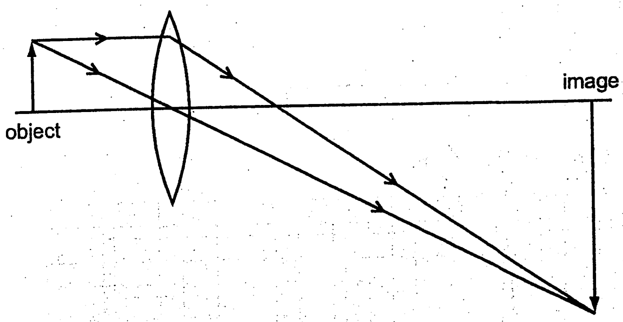
[J12/P1/Q24]

Thinking Process

MCQ Answers

[redacted]

11. A lens is used to produce a magnified image, as shown in the scale diagram.

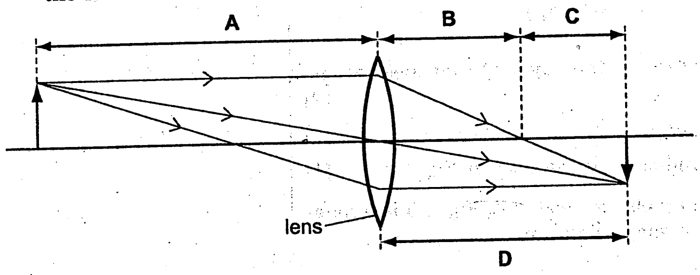


What is the linear magnification of the object?

A 0.33 B 3.0
C 4.0 D 6.0

[N12/P1/Q24]

12. Which length is the focal length of the lens?



[J13/P1/Q26]

13. An image is formed by a thin converging lens when it is used as a magnifying glass.

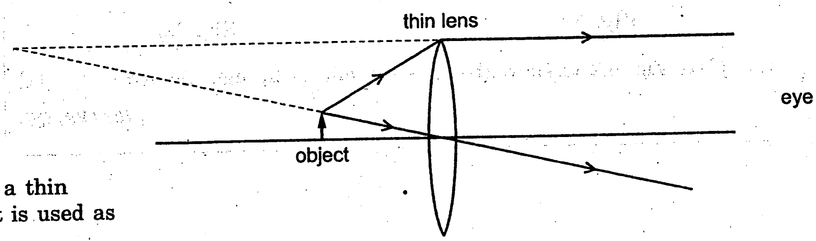
What is the correct description of the image?

A real and erect
B real and inverted
C virtual and erect
D virtual and inverted

[J15/P1/Q27]

14. An object is viewed through a converging lens.

The diagram shows the paths of two rays from the top of the object to an eye.



How does the image compare with the object?

A It is larger and inverted.
B It is larger and upright.
C It is smaller and inverted.
D It is smaller and upright.

[N15/P1/Q22]

MCQ Answers

10. C A short-sighted person cannot see a distant object clearly. This is because the parallel rays of light coming from a distant object meet at a point in the eye before reaching the retina and form a blurred image.

11. B

Linear magnification

$= \dfrac{\text{image length}}{\text{object length}}$

$= \dfrac{39\text{ mm}}{13\text{ mm}} = 3.0$

12. B By definition

13. C It is a fact that in order to use a converging lens as a magnifying glass, the object is placed within its focal length on one side of the lens and a virtual and an erect image is produced on the same side of the lens behind the object.

14. B A virtual, large and upright image is formed behind the object on the same side of the lens. It is formed where the backward extended rays of light (dotted lines) intersect each other.

Topic 15 Lenses

THEORY Section

Question 1

Fig. 5.1 is drawn full scale. The focal length of the lens is 3.0 cm.

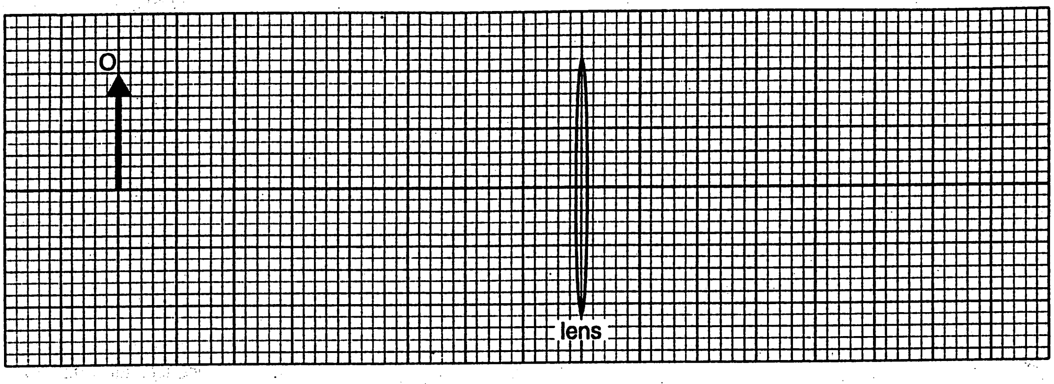


Fig. 5.1

(a) On Fig. 5.1, draw two rays from the top of the object O that meet at the image. [2]

(b) (i) Define the term *linear magnification*. [1]

(ii) Determine the magnification produced by the lens in Fig. 5.1. [1]

(c) Fig. 5.2 shows a normal eye viewing an object close to it. Fig. 5.3 is a long-sighted eye viewing an object at the same distance.

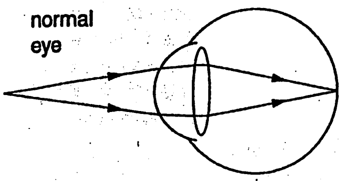


Fig. 5.2

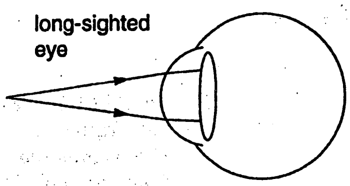


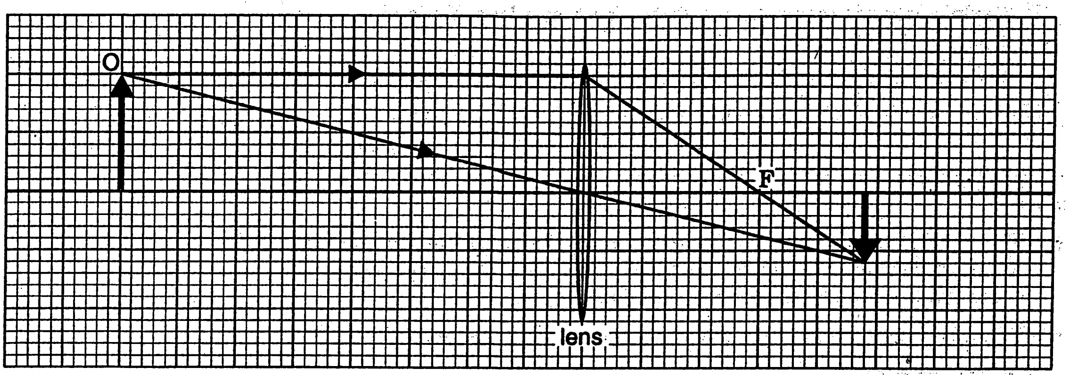
Fig. 5.3

Complete Fig. 5.3 to show the rays travelling through the eye. [1]

[J07/P2/Q5]

Solution

(a)



(b) (i) The linear magnification is the ratio of the image height to the object height, i.e.

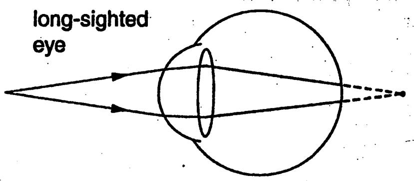
$$\text{linear magnification (m)} = \frac{\text{image height}}{\text{object height}}$$

(ii) $\text{linear magnification} = \frac{1.2 \text{ cm}}{2.0 \text{ cm}} = 0.6$

COMMENT on ANSWER

" (b) (ii) Also linear magnification = $\frac{\text{Image distance}}{\text{object distance}} = \frac{4.8 \text{ cm}}{8 \text{ cm}}$ $= 0.6$ (no units). "

(c)



Question 2

(a) Fig. 11.1 shows a ray of light passing through the edge of a converging lens.

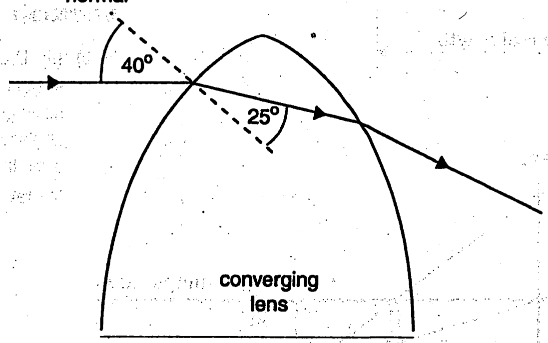


Fig. 11.1

(i) Describe what happens to the direction of the ray of light as it enters and leaves the lens. [2]

(ii) State what happens to the speed, frequency and wavelength of the light as it enters the lens. [3]

(iii) Calculate the refractive index of the glass used in the lens. [3]

(b) The focal length of the lens is 20 cm. An object is placed 50 cm from the lens and an image is formed on a screen.

(i) Explain what is meant by the *focal length* of a lens. You may draw a diagram if you wish. [2]

(ii) Draw a ray diagram to scale to show the formation of the image. [3]

(iii) The image is real. State **two** other properties of the image. [2]

[N07/P2/Q11]

Solution

(a) (i) The ray of light refracts and bends towards the normal as it enters into the denser medium of the lens and it refracts again and bends away from the normal as it moves into the rarer medium.

(ii) When the light enters into the denser medium of the lens, its

speed: decreases

wavelength: decreases

frequency: unchanged

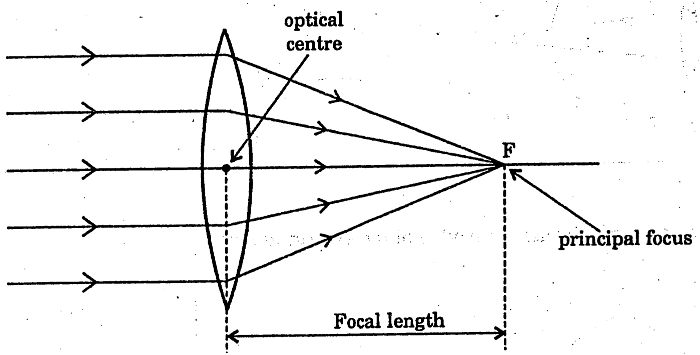
(iii) Refractive index $= \dfrac{\sin \hat{i}}{\sin \hat{r}}$

$$= \frac{\sin 40^\circ}{\sin 25^\circ} = 1.521 \approx 1.5$$

COMMENT on ANSWER

" (a) (iii) Note that missing of the sign of degree (°) on the values of the angles $\hat{i}$ and $\hat{r}$ is penalised. "

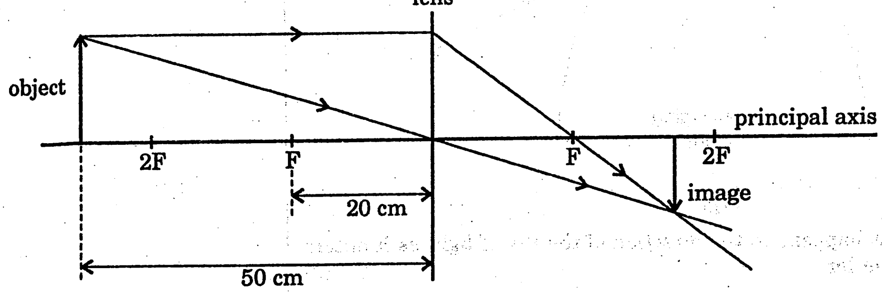
(b) (i) The focal length of a lens is the distance between the optical centre of the lens and the principal focus (F) as shown below:



COMMENT on ANSWER

" (b) (ii) Draw thin and straight lines and do not forget to put arrowheads on them to show the direction of the rays of light. "

(ii)



scale used: 10 cm = 1 cm

(iii) The image is inverted and diminished.

Question 3

(a) Fig. 10.1 represents a simple camera.

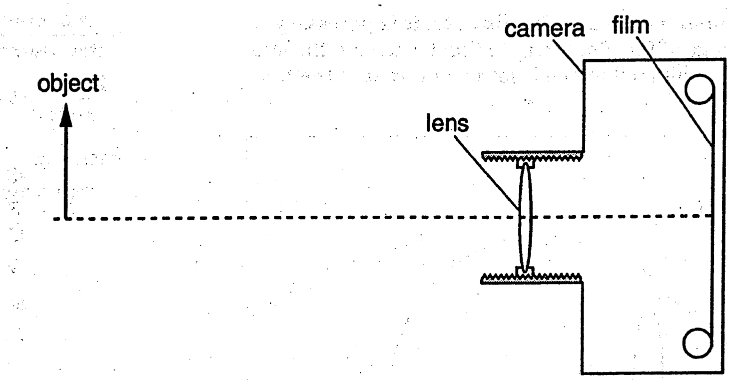


Fig. 10.1 (to scale)

(i) State the type of lens used in this simple camera. [1]

(ii) Draw two rays from the top of the object to show how the image is formed on the film.
Mark and label the image on the film. [3]

(iii) Define the term *linear magnification*. [1]

(iv) Fig. 10.1 is drawn to scale. Determine the linear magnification of the object shown in Fig. 10.1. [1]

(v) Apart from its size, state one other property of the image formed by the lens. [1]

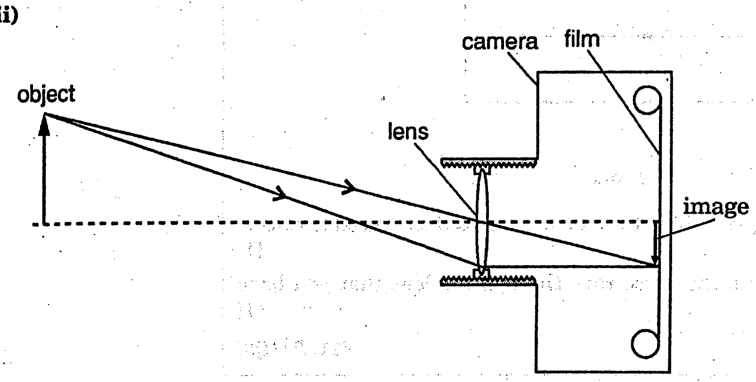
(vi) Explain why, when taking photographs of other objects, it may be necessary to move the lens towards the film. [3]

[J10/P2/Q10(b)]

Solution

(a) (i) Convex lens

(ii)



(iii) The linear magnification of an image is defined as the ratio of the length of the image to the length of the object, i.e.

$$\text{Linear magnification} = \frac{\text{length of image}}{\text{length of object}}$$

COMMENT on ANSWER

" **(b) (iii)** *Alternatively:*
Linear magnification
$= \dfrac{\text{image distance}}{\text{object distance}}$ "

(iv) Linear magnification = $\frac{\text{image height}}{\text{object height}} = \frac{6.4\text{ mm}}{16\text{ mm}} = 0.4$

(v) The image is inverted.

(vi) When taking photograph of an object at a far distance, it is necessary to focus a clear and sharp image of the object on the film by moving the lens towards the film otherwise a blurred image is formed in front of the film.

COMMENT on ANSWER

" (b) (iv) *Alternatively:*

Linear magnification $= \frac{\text{image distance}}{\text{object distance}} = \frac{24.7\text{ mm}}{63.0\text{ mm}} = 0.4$

(v) *Alternatively:*

The image is real."

Question 4

Fig. 8.1 shows a short-sighted eye.

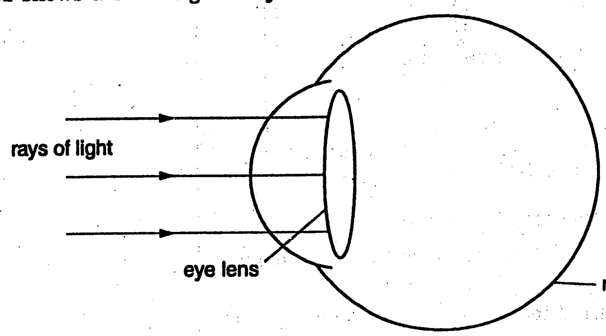


Fig. 8.1

Rays of light from a distant star are parallel as they reach the lens of the eye. Refraction of light as it enters the eye has been ignored in Fig. 8.1.

(a) (i) On Fig. 8.1, continue the rays to show their paths inside the short-sighted eye until they strike the retina. [2]

(ii) Explain how your diagram shows that the image of the star seen by the observer is blurred. [1]

(b) Fig. 8.2 shows three parallel rays of light.

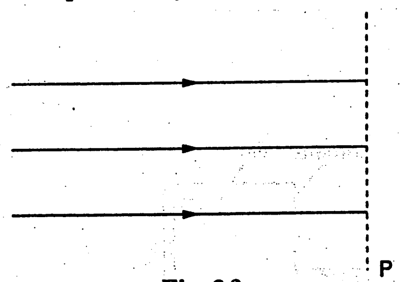


Fig. 8.2

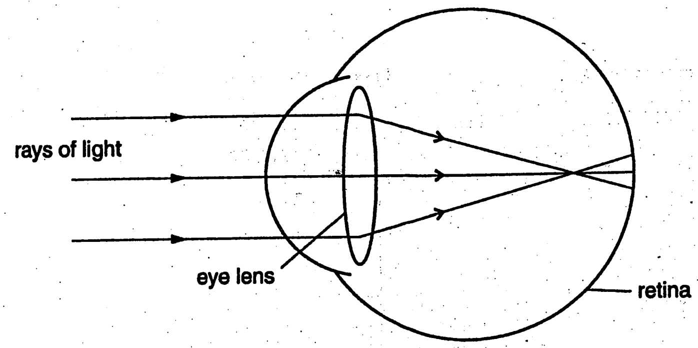
(i) On the line P in Fig. 8.2, draw the shape of a lens that is used to correct short sight. [1]

(ii) On Fig. 8.2, continue the three rays through the lens that you have drawn. [1]

[N11/P2/Q8]

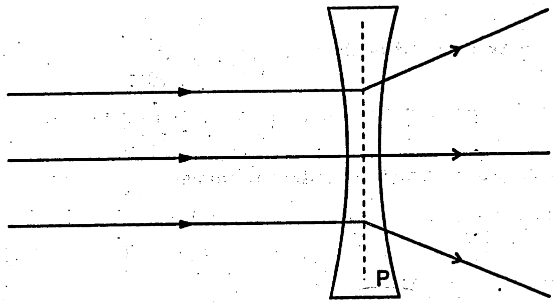
Solution

(a) (i)



(ii) The image seen by the observer is blurred because the rays of light coming from the distant star do not meet at a point on the retina.

(b) (i) & (ii)



COMMENT on ANSWER

" (a) (i) Note that

— Central ray emerges out from lens undeviated.

— Two outer rays and central ray converge before retina and carry on to strike the retina.

(b) (ii) All rays diverge except central ray which emerges out undeviated. "

Question 5

(a) A beam of parallel light strikes a converging lens of focal length 2.8 cm. The width of the beam before it reaches the lens is 1.0 cm. The width changes on the other side of the lens.

State a distance from the lens where the width of the beam is

(i) less than 1.0 cm,

(ii) more than 1.0 cm. [1]

(b) An object is placed 3.0 cm from a converging lens of focal length of 2.8 cm. Fig. 6.1 is an incomplete, full-scale ray diagram for this arrangement.

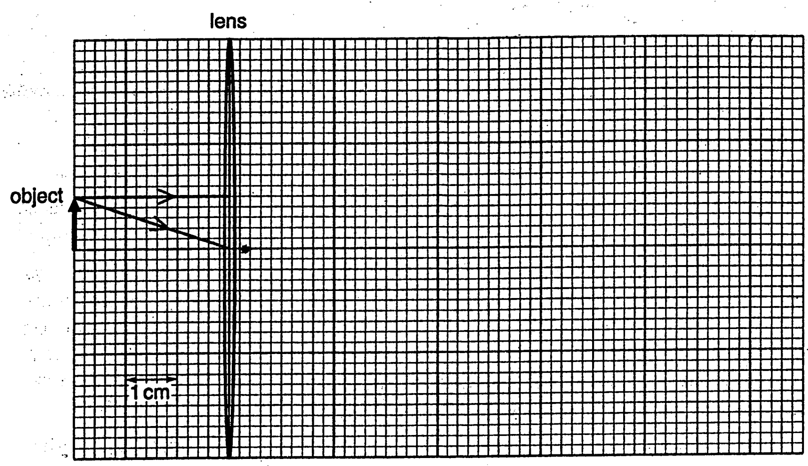


Fig. 6.1 (full scale)

(i) On Fig. 6.1, draw the paths of the two rays after they pass through the lens. [2]

(ii) Explain how your ray diagram shows that the image is more than 11 cm from the lens. [1]

(iii) Underline **three** of the following words which describe the image.

diminished inverted magnified real upright virtual [1]

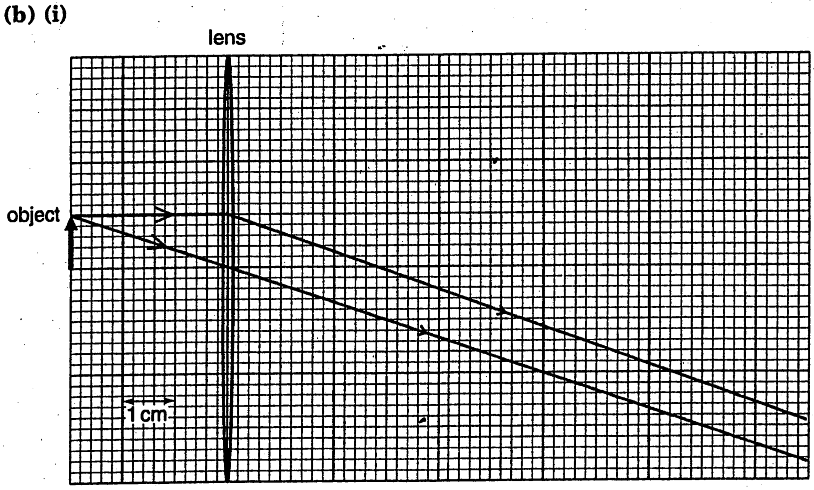
[J14/P2/Q6]

Solution

(a) (i) less than 1.0 cm: 2.0 cm

(ii) more than 1.0 cm: 6.0 cm

(b) (i)



(ii) The lines drawn do not meet till a distance of more than 11 cm from the lens. Therefore the image produced will be more than 11 cm from the lens.

(iii) <u>inverted</u> <u>magnified</u> <u>real</u>

COMMENT on ANSWER

❝ (a) (i) Any value between 0 and two times the focal length of the lens is correct.

(ii) Any length greater than two times the focal length of the lens is correct. ❞

Topic 16 Refraction

MCQ Section

1. What happens to light as it passes from glass into air?

A Its frequency decreases because its speed decreases.

B Its frequency increases because its speed increases.

C Its wavelength decreases because its speed decreases.

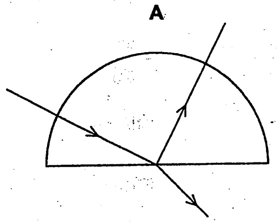
D Its wavelength increases because its speed increases.

[J07/P1/Q21]

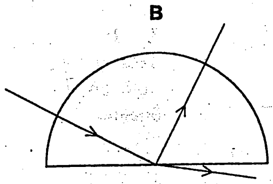
2. A ray of red light enters a semi-circular glass block normal to the curved surface.

Which diagram correctly shows the partial reflection and refraction of the ray?

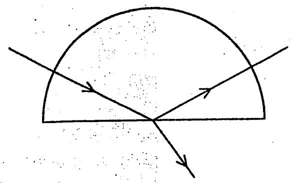
A



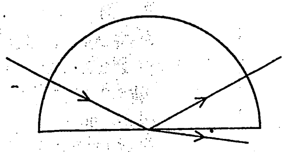
B



C



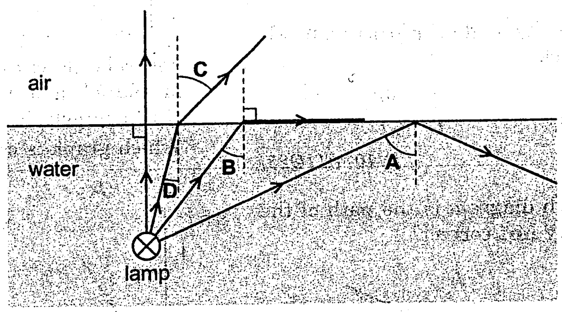
D



[J08/P1/Q22]

3. The diagram shows four rays of light from a lamp below the surface of some water.

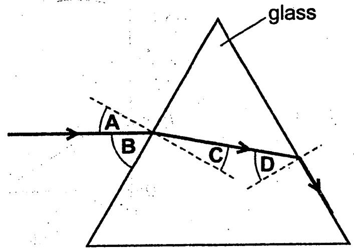
What is the critical angle for light in water?



[J09/P1/Q21]

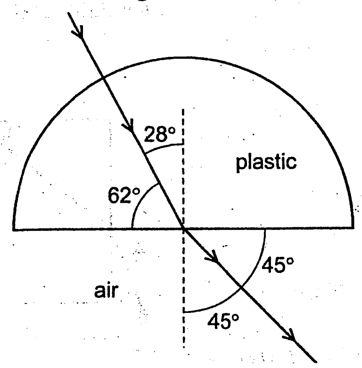
4. The diagram shows the passage of a ray of light through a triangular glass block.

What is the critical angle of light in glass?



[N09/P1/Q21]

5. A semi-circular block is made from a plastic. A ray of light passes through it at the angles shown.



1. D The refractive index is lower in air (1.0) than in the glass (1.5). So the speed of light increases in air. Since the wavelength is directly proportional to the speed so the wavelength of light also increases as its speed increases on entering into the air.

2. D During the partial reflection, the angle of incidence must be equal to the angle of reflection for the rays of light inside the semi-circular glass block and during the partial refraction of the ray when it passes from the glass into the air, it must bend away from the normal. Both of these properties are shown correctly in the diagram D only.

3. B By definition, it is the angle of incidence in the denser medium for which the angle of refraction in the rarer medium is 90°.

To two decimal places, what is the refractive index of the plastic?

A 1.25 **B** 1.41
C 1.51 **D** 1.61

[J10/P1/Q23]

6. A ray of light strikes the surface of a glass block at an angle of incidence of 45°.

The refractive index of the glass is 1.5.

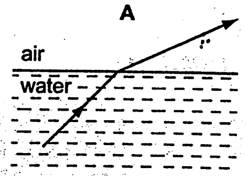
What is the angle of refraction inside the block?

A 28° **B** 30°
C 45° **D** 67°

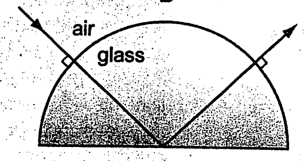
[N10/P1/Q23]

7. In which diagram is the path of the light ray **not** correct?

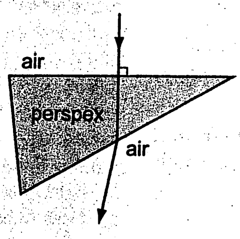
A



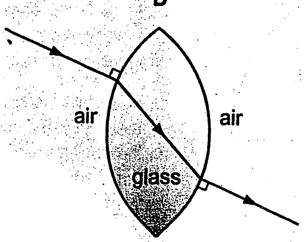
B



C

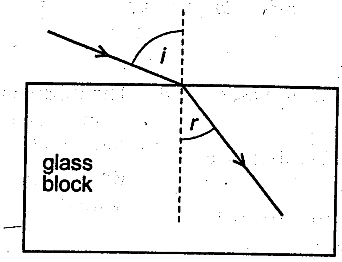


D



[J11/P1/Q21]

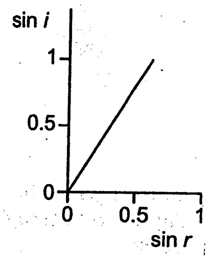
8. A ray of light enters a glass block at an angle of incidence i, producing an angle of refraction r in the glass.



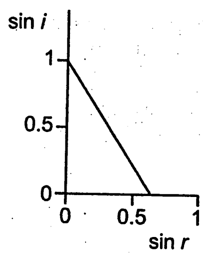
Several different values of i and r are measured, and a graph is drawn of $\sin i$ against $\sin r$.

Which graph is correct?

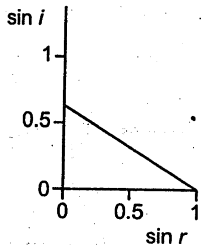
A



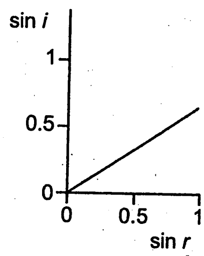
B



C



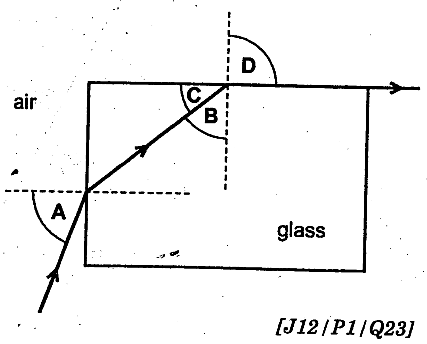
D



[N11/P1/Q20]

9. Light travels through a glass block as shown.

Which angle is the critical angle for light in the glass?



[J12/P1/Q23]

Thinking Process

MCQ Answers

4. D When light travels from an optically denser medium (e.g. glass) to an optically less denser medium (e.g. air) and the angle of refraction is 90° (i.e. refracted ray travels on the boundary), the corresponding angle of incidence in the denser medium is called the critical angle.

5. C For a ray of light moving from denser to rarer medium,

$n = \frac{\sin \hat{r}}{\sin \hat{i}}$

$= \frac{\sin 45°}{\sin 28°} = 1.51$

6. A Refractive Index

$= \frac{\sin \hat{i}}{\sin \hat{r}}$

$\sin \hat{r} = \frac{\sin \hat{i}}{\text{refractive index}}$

$\sin \hat{r} = \frac{\sin 45°}{1.5}$

$\hat{r} = 28°$

7. D A ray of light passing perpendicularly from one medium into another does not bend but the diagram D shows the bending of light which is not correct.

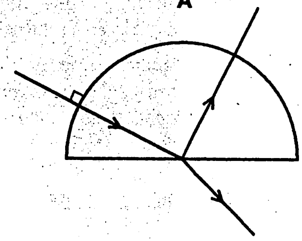
8. A The gradient of the graph between $\sin i$ and $\sin r$ passing through the origin gives the refractive index of glass. As the refractive index of glass is greater than 1, monly graph A satisfies this condition.

9. B By definition, the angle B is the critical angle in the denser medium (glass) for which the angle of refraction (D) in the rarer medium (air) is 90°.

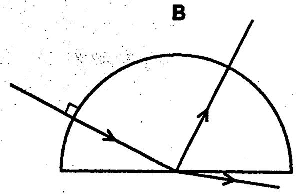
10. A ray of red light enters a semi-circular glass block normal to the curved surface.

Which diagram shows the partial reflection and refraction of the ray?

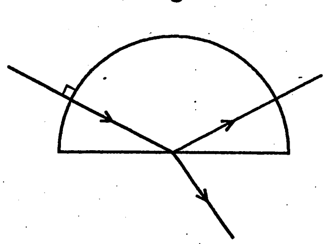
A



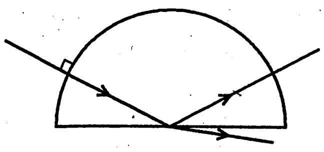
B



C

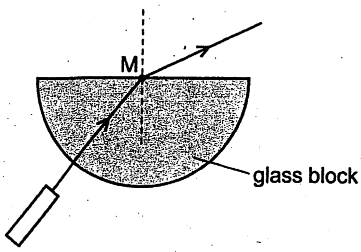


D



[N12/P1/Q23]

11. A ray of red light from a laser passes into a semi-circular glass block.



What is shown at M?

A dispersion
B rarefaction
C reflection
D refraction

[N13/P1/Q23]

12. A ray of light strikes the surface of a glass block at an angle of incidence of 45°.

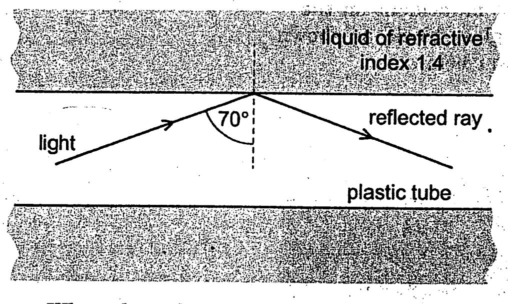
The refractive index of the glass is 1.8.

What is the angle of refraction inside the block?

A 23° **B** 25°
C 45° **D** 81°

[N13/P1/Q24]

13. A plastic tube is immersed in a liquid of refractive index 1.4. Light travelling in the plastic tube strikes the inside surface at an angle of incidence of 70°. The light undergoes total internal reflection.



What describes the values of the critical angle in the plastic and the refractive index of the plastic?

	critical angle in plastic	refractive index of plastic
A	greater than 70°	greater than 1.4
B	greater than 70°	less than 1.4
C	less than 70°	greater than 1.4
D	less than 70°	less than 1.4

[N14/P1/Q16]

Thinking Process

MCQ Answers

10. D The ray of light must not bend because it is passing perpendicularly from air into glass. During partial reflection at the straight edge of the glass block it must obey the law. Also during partial refraction at the straight edge, the ray must bend away from the normal as it is passing from a denser to a less denser medium. All these conditions are correctly shown in diagram D.

11. D Fact.

12. A Refractive index $= \frac{\sin i}{\sin r}$

$1.8 = \frac{\sin 45°}{\sin r}$

$\sin r = \frac{\sin 45°}{1.8}$

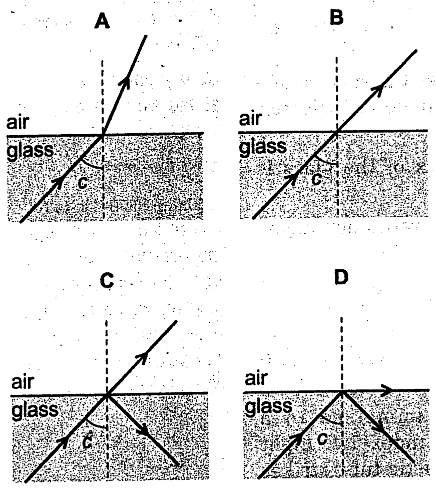
$\sin r = 0.3928$

$r = 23°$

13. C For total internal reflection to occur, the angle of incidence should be greater than the critical angle, and the refractive index of the inner layer must be greater than the refractive index of the outer layer.

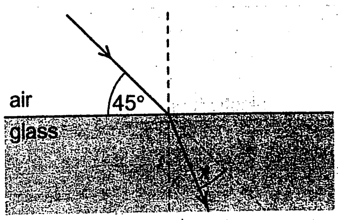
14. A ray of light in glass is incident on the surface at an angle c. The angle c is the critical angle.

Which diagram shows what happens to the light?



[J15/P1/Q25]

15. A ray of light is incident on the surface of a glass block, as shown in the diagram below.



The refractive index of the glass is 1.5.

The light ray changes direction when entering the glass.

What is the angle x through which the ray moves?

A 30° **B** 28°

C 17° **D** 15°

[J15/P1/Q26]

Thinking Process

MCQ Answers

14. D A ray of light incident at the critical angle in a denser medium is partially reflected ($\hat{i} = \hat{r}$) and partially refracted at right angle in the less denser medium.

15. C $n = \dfrac{\sin \hat{i}}{\sin \hat{r}}$

$1.5 = \dfrac{\sin 45°}{\sin \hat{r}}$

$\hat{r} = 28°$

So, angle $x = 45° - 28°$
$= 17°$

Topic 16 Refraction

THEORY Section

Question 1

Fig. 4.1 and Fig. 4.2 show rays of light passing through the same semi-circular block of plastic.

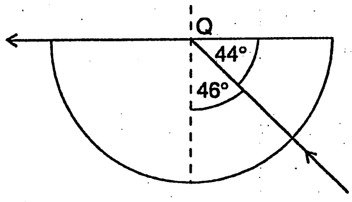


Fig. 4.1

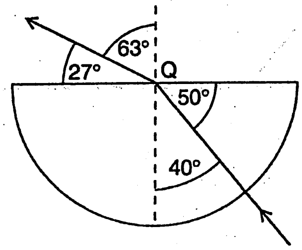


Fig. 4.2

Q is the centre of the straight side of the block.

(a) State the value of the critical angle in the plastic.

critical angle = ... [1]

(b) Explain what is meant by the *critical angle*. [2]

(c) Calculate the refractive index of the plastic. State the formula that you use.

refractive index = ... [3]

(d) Some light reflects back into the plastic at Q.
On Fig. 4.1, draw the reflected ray at Q. [1]

[J06/P2/Q4]

Solution

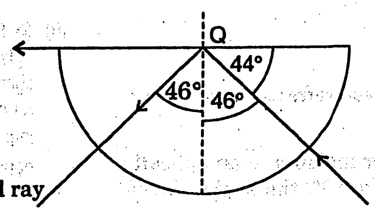
(a) critical angle = 46°

(b) It is the angle of incidence made by the ray in the denser medium for which the angle of refraction is 90°.

(c) Formula for refractive index, $n = \frac{1}{\sin C}$

refractive index of plastic $= \frac{1}{\sin 46^\circ} = \frac{1}{0.7193} = 1.39$

(d)



COMMENT on ANSWER

“ (b) Alternatively, the critical angle is the value of the angle of incidence for which the refracted ray travels along the surface of the denser medium.

(c) Also,

$$n = \frac{\sin i}{\sin r}$$

$$= \frac{\sin 63^\circ}{\sin 40^\circ} = 1.386$$

$$n \approx 1.39$$ ”

Question 2

(a) Fig 4.1 shows a ray of light travelling from air into glass. The incident ray makes an angle of 50° with the boundary. Some of the light is reflected at the glass surface but most passes into the glass and is refracted. The refracted ray makes an angle of 65° with the boundary.

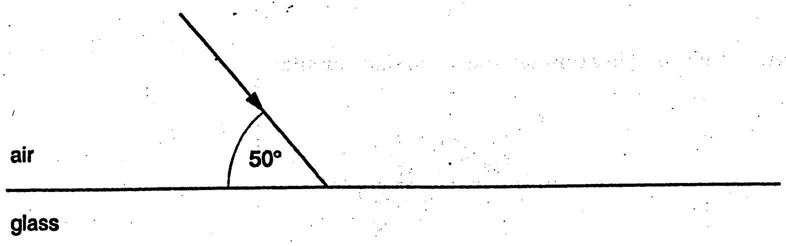


Fig. 4.1

(i) Complete Fig. 4.1 to show the reflected and refracted rays. [1]

(ii) Calculate a value for the refractive index of the glass. State clearly the formula that you use. [3]

(b) In the arrangement shown in Fig. 4.1, it is not possible for total internal reflection to occur, whatever the angle of incidence.

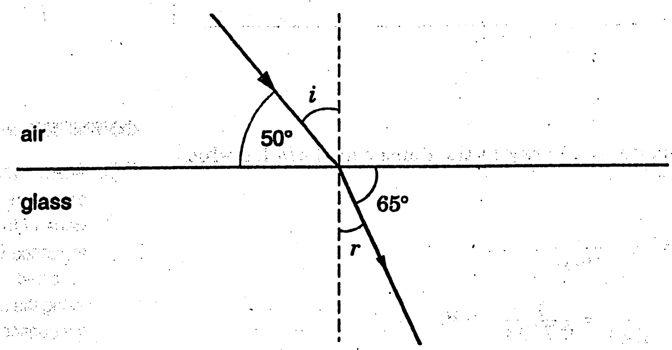
(i) Explain why total internal reflection cannot occur. [1]

(ii) Define *critical angle*. [2]

[N06/P2/Q4]

Solution

(a) (i)



(ii) Refractive index = $\dfrac{\sin i}{\sin r} = \dfrac{\sin 40°}{\sin 25°} = 1.5$

(b) (i) The light is travelling from medium with a lower refractive index to a medium with a higher refractive index.

(ii) When light is travelling from an optically denser medium to an optically less dense medium and the angle of refraction is 90°, the angle of incidence is known as critical angle.

COMMENT on ANSWER

❝ (a) Note that the angle of incidence = (90° – 50°) = 40° and the angle of refraction is (90° – 65°) = 25°.

(b) (i) Since the refractive index of air is 1.0, light is traveling from an optically less dense medium to an optically denser medium. ❞

Question 3

Fig. 4.1 shows part of an optical fibre.

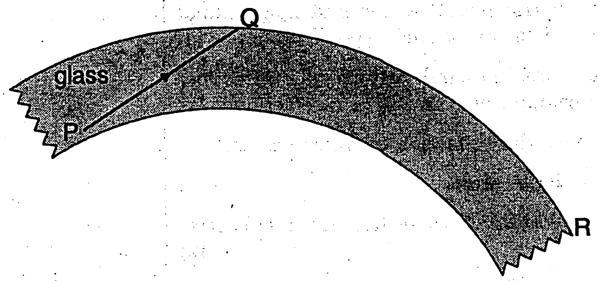


Fig. 4.1

The ray PQ undergoes total internal reflection in the optical fibre.

(a) On Fig. 4.1, continue the path of ray PQ until it reaches end R. [1]

(b) Explain what is meant by *total internal reflection*. [1]

(c) Optical fibres are cheaper and lighter than copper wires. State one other advantage of using optical fibres rather than copper wires for telephone communications. [1]

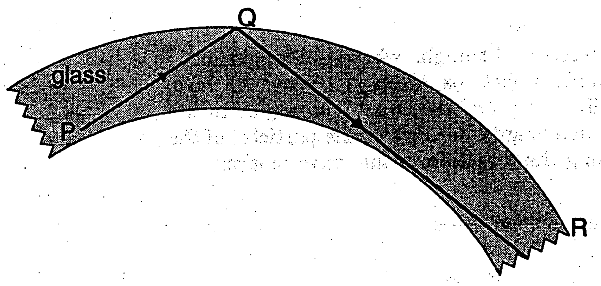
(d) The light in the optical fibre is travelling at a speed of 2.1×10^8 m/s and has a wavelength of 6.4×10^{-7} m.

Calculate the frequency of the light. [2]

[J07/P2/Q4]

Solution

(a)



(b) If a ray of light passes from a more dense medium to a less dense medium and its angle of incidence is greater than the critical angle then the whole of the ray is reflected back into the denser medium and none escapes into the less dense medium.

(c) A less power loss occurs in optical fibres than copper wires so a signal of better quality is received using optical fibres.

(d) $\text{frequency} = \dfrac{\text{speed}}{\text{wavelength}} = \dfrac{v}{\lambda} = \dfrac{2.1\times10^8}{6.4\times10^{-7}} = 3.3\times10^{14}$ Hz

COMMENT on ANSWER

❝ (c) The other advantages of optical fibres are:

- ability to handle more telephone calls
- more and faster data/sec transfer
- less energy loss
- less attenuation
- need repeaters at a greater distance
- less noise/ interference in the signal received
- harder to tap a telephone call
- greater band width. ❞

Question 4

(a) Water waves are transverse waves. Sound is a longitudinal wave.

(i) Describe the difference between transverse waves and longitudinal waves. In your account, draw a diagram of each type of wave. [4]

(ii) Sound contains regions of compression and regions of rarefaction. Describe what is meant by a compression and by a rarefaction. [2]

(b) A ripple tank is used to demonstrate the reflection of water waves.

(i) Draw a labelled diagram of a ripple tank. [2]

(ii) Draw a diagram showing the reflection of waves from a plane barrier in a ripple tank. [2]

(c) Fig. 10.1 shows a water wave passing a floating log. The log is stationary.

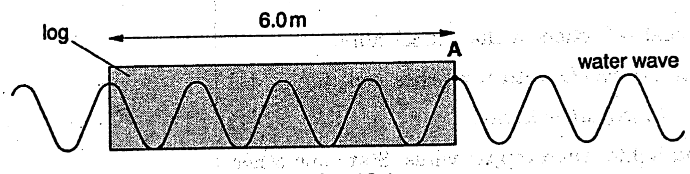


Fig. 10.1

The log is 6.0 m long and 5 complete waves take 10 seconds to pass point A.

Determine

(i) the wavelength of the water waves, [1]

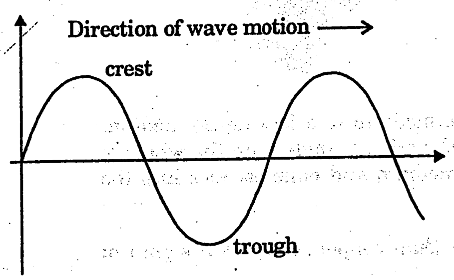
(ii) the frequency of the water waves, [2]

(iii) the speed of the water waves. [2]

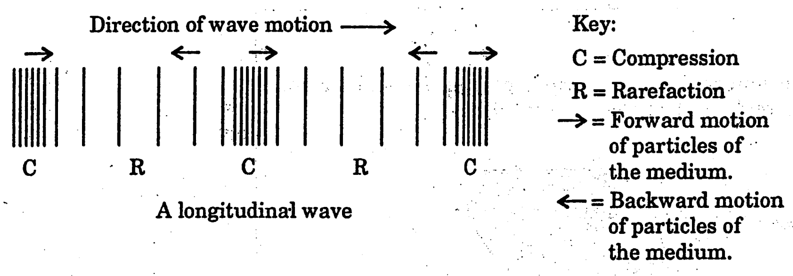
[J08/P2/Q10]

Solution

(a) (i) A transverse wave comprises crests and troughs whereas a longitudinal wave consists of compressions and rarefactions. Also, in a transverse wave, the particles of the medium vibrate up and down at right angles to the direction of the wave, whereas in a longitudinal wave, the particles of the medium vibrate to and fro along the direction of the wave motion.

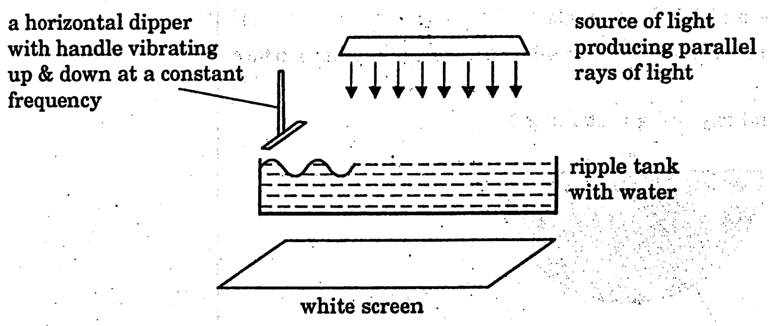


A transverse wave

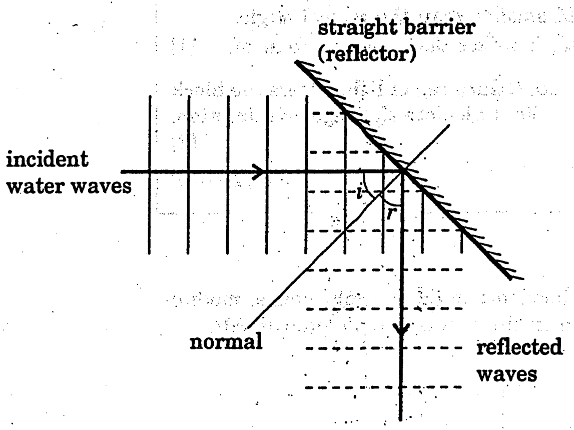


(ii) A compression in a sound wave is the region in which the molecules of the medium are closer together and a rarefaction is the region in which the molecules of the medium are further apart.

(b) (i)



(ii)



(c) (i) $\lambda = \frac{6}{4} = 1.5$ m

(ii) $f = \frac{5}{10} = 0.5$ Hz

(iii) $v = f\lambda$

$= 0.5 \times 1.5 = 0.75$ m/s

Question 5

Fig. 5.1 shows a ray of light entering a semi-circular glass block and striking the glass surface at M, the mid-point of the straight face.

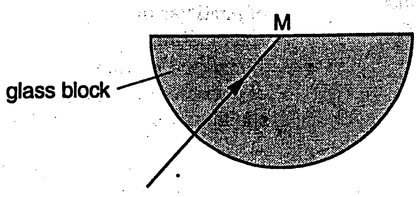


Fig. 5.1

(a) The ray of light strikes the glass surface at M with an angle of incidence *C* equal to the critical angle of light in glass.

(i) State what is meant by *critical angle*. [1]

(ii) On Fig. 5.1, mark and label the angle *C*. [1]

(iii) On Fig. 5.1, continue the ray of light after it strikes the glass surface at M. [1]

(b) Fig. 5.2 shows a second ray of light striking M.

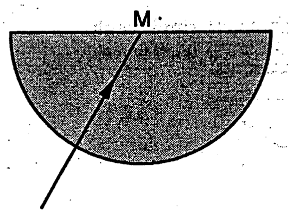


Fig. 5.2

This ray has an angle of incidence at M smaller than the critical angle.
On Fig. 5.2, continue this ray of light after it strikes the glass surface at M. [1]

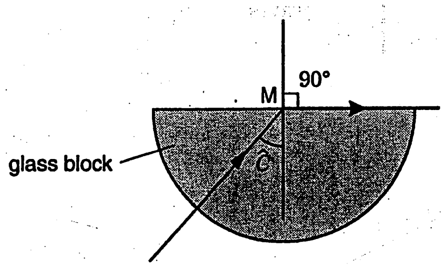
(c) The refractive index of this glass is 1.5. A third ray of light enters the block from air with an angle of incidence of 50°. Calculate the angle of refraction. [2]

[J10/P2/Q5]

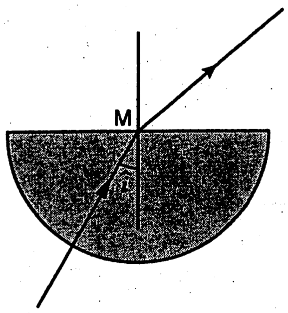
Solution

(a) (i) The critical angle is the angle of incidence in the optically denser medium for which the angle of refraction in the less dense medium is 90°.

(ii) & (iii)



(b)



(c) Refractive index $= \dfrac{\sin \hat{i}}{\sin \hat{r}}$

$$1.5 = \frac{\sin 50}{\sin \hat{r}}$$

$$\hat{r} = 31°$$

COMMENT on ANSWER

"(c) For a ray of light passing from air-to-glass, the refractive index is given as

$${}_a n_g = \frac{\sin \hat{i}}{\sin \hat{r}}$$

And for a ray of light passing from glass-to-air, the refractive index is given as

$${}_g n_a = \frac{\sin \hat{r}}{\sin \hat{i}}."$$

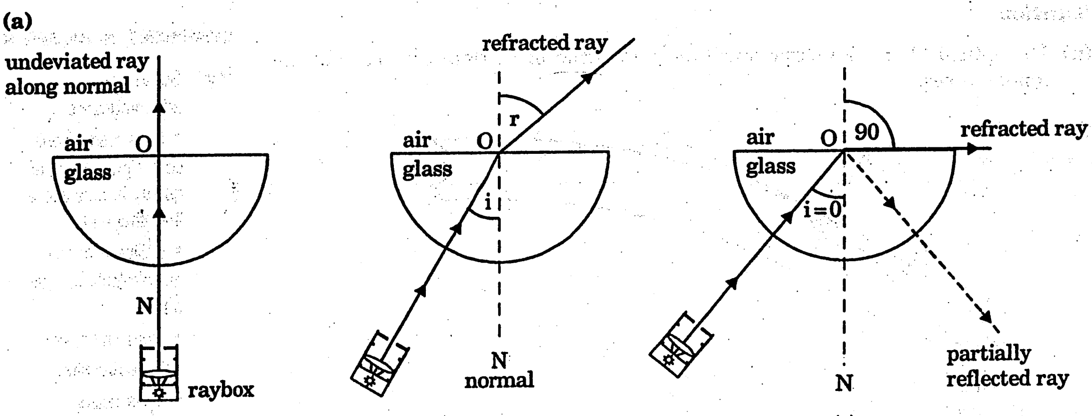
Question 6

(a) Describe an experiment to measure the critical angle for light in glass or perspex. Your answer should include a labelled diagram. **[5]**

[J10/P2/Q10(a)]

Solution

(a)



Place a semicircular glass block on a sheet of paper and draw the outline of the block. Draw a normal ON at the midpoint O of the straight side.
Direct a narrow ray of light towards O along the normal using a ray box (Fig. a).
Move the ray box to the left of the normal, round the circular side of the block.
As a result the angle of incidence (i) as well as its corresponding angle of refraction (r) increases (Fig. b).
Continue moving the ray box to the left of the normal until the critical condition occurs when the refracted ray is seen lying flat on the boundary making $\hat{r} = 90°$ (Fig. c). Mark this position of the ray box.
Remove the glass block and draw the incident and refracted rays.
Measure the angle of incidence. It equals the critical angle.

Question 7

Optical fibres are used to transmit telephone signals. Fig. 5.1 shows a ray of light that strikes the inside surface of an optical fibre at P.

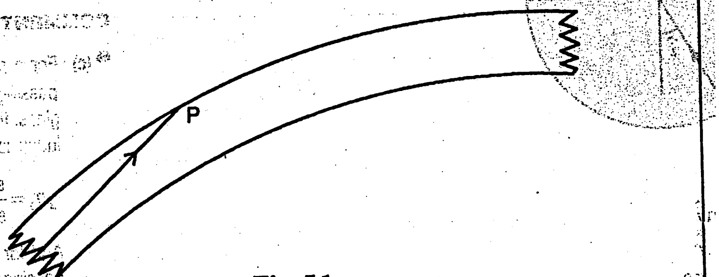


Fig. 5.1

(a) State one advantage of using optical fibres to transmit telephone signals. [1]

(b) (i) On Fig. 5.1, draw a normal at P and mark the angle of incidence with the letter *i*. [1]

(ii) State and explain what happens to the ray at P. Use the term *critical angle* in your answer. [2]

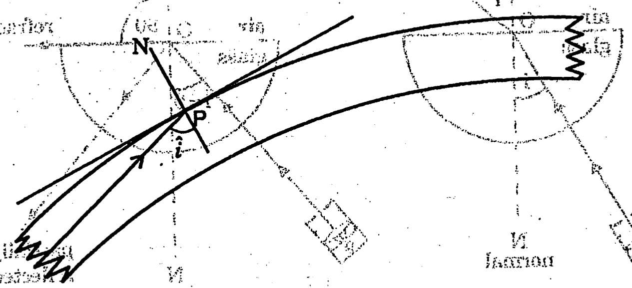
(c) The optical fibre is made of glass of refractive index 1.5.
At the start of the optical fibre, the ray enters the glass from air.
The angle of incidence in the air is 60°.
Calculate the angle of refraction in the glass. [2]

[J12/P2/Q5]

Solution

(a) The optical fibers can carry much more information or data per second than copper wires.

(b) (i)



(ii) As the angle of incidence at P is greater than the critical angle, so the ray of light under-goes total internal reflection.

(c) $n = \dfrac{\sin\hat{i}}{\sin\hat{r}} \Rightarrow \sin\hat{r} = \dfrac{\sin\hat{i}}{n}$

$\sin\hat{r} = \dfrac{\sin 60°}{1.5}$

$\hat{r} = 35.3$

$\therefore$ angle of refraction $= 35°$

COMMENT on ANSWER

“(a) Some other advantages are:

- Less loss of energy so a signal of better quality is received at the other end.
- Ability to handle more telephone calls at a time.
- More and faster data/sec transfer.
- Less noise/ interference in the signals received.”

Question 8

A student traces the path of a ray of blue light as it enters and as it leaves a glass prism. Fig. 10.1 shows the trace obtained by the student.

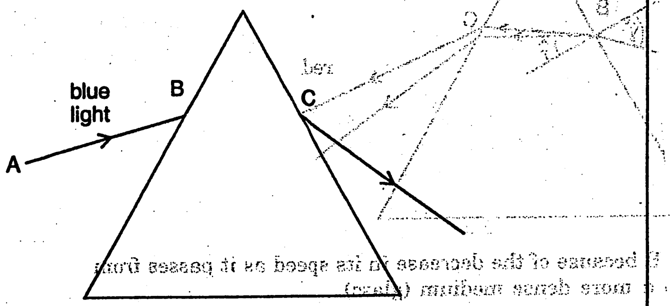


Fig. 10.1

(a) **On Fig. 10.1, draw and label, at the point B, the normal, the angle of incidence *i* and the angle of refraction *r*.** **[3]**

(b) **State, in terms of the properties of light waves, why the light refracts at B.** **[1]**

(c) **The angle of incidence for the ray of blue light at B is 45°. The refractive index of the glass is 1.5. Calculate the angle of refraction at B.** **[3]**

(d) **The student performs another experiment with a ray of red light along the line AB.**

On Fig. 10.1, show the path taken by this ray of light as it passes through and leaves the prism. **[2]**

(e) **The student performs another experiment with a semicircular glass block and a ray of white light. Fig. 10.2 shows the path taken by this ray of light as it enters the glass at P until it hits the straight edge at Q.**

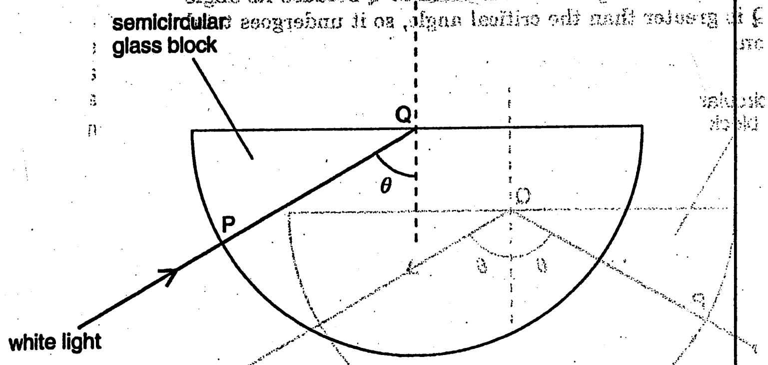


Fig. 10.2

The student finds that there is no change in direction as the ray enters the glass at P and that no light passes out of the glass at Q.

(i) **Explain why the ray does not change direction at P.** **[1]**

(ii) **Explain why no light passes out of the glass at Q.** **[2]**

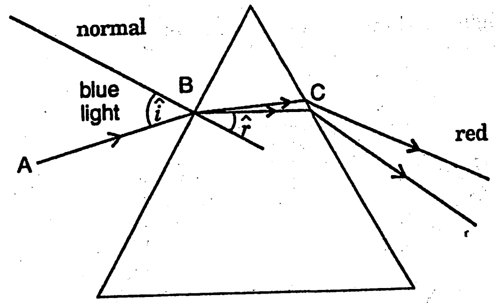
(iii) **On Fig. 10.2, draw the complete path followed by this ray.** **[1]**

(iv) **The student directs the ray of white light into the glass along different paths, so that the angle θ is slowly reduced.**
Describe what happens to the ray at Q. **[2]**

[J13/P2/Q10]

Solution

(a)



(b) The light refracts at B because of the decrease in its speed as it passes from a less dense (air) to a more dense medium (glass).

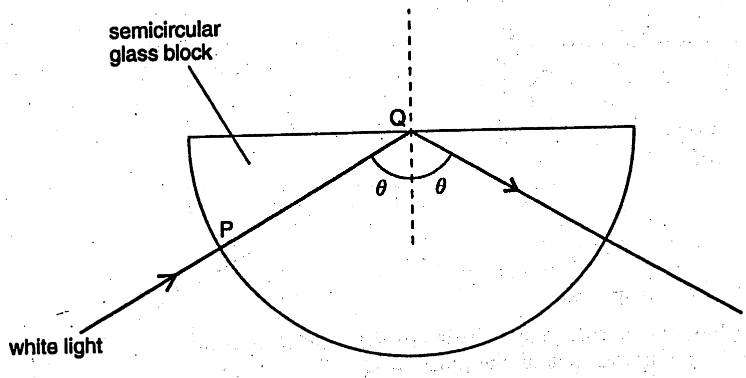
(c)
$$n = \frac{\sin \hat{i}}{\sin \hat{r}}$$
$$\sin \hat{r} = \frac{\sin \hat{i}}{n}$$
$$= \frac{\sin 45°}{1.5}$$
$$\hat{r} = 28.13°$$
$\therefore$ angle of refraction $\approx 28°$

(d) Refer to figure in (a).

(e) **(i)** The ray of light does not change direction at P because it enters the glass block perpendicularly (i.e. at $\hat{i} = 0°$)

(ii) The ray of light does not emerge out of the block at Q because its angle of incidence at Q is greater than the critical angle, so it undergoes total internal reflection.

(iii)



(iv) The light now leaves the block at Q showing partial refraction but a partial reflection also occurs. The refracted ray at Q also shows dispersion and a spectrum is formed in the air.

COMMENT on ANSWER

“(d) The refractive index of glass is smaller for red light than the refractive index of glass for blue light. So, the red light bends (refracts) less than the blue light.

(e) (i) If a ray of light enters a glass block perpendicularly, its angle of incidence is equal to zero. So its angle of refraction is also zero and it does not show bending.”

Question 9

(a) State the speed of light in air. [1]

(b) Fig. 10.1 shows a ray of blue light passing from air into a glass block and refracting at the surface.

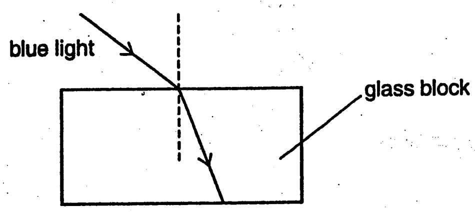


Fig. 10.1 (not to scale)

(i) As the light enters the glass, state what happens to

1. the speed of the light, [1]
2. the frequency of the light, [1]
3. the wavelength of the light. [1]

(ii) On Fig. 10.1, mark and label the angle of incidence *i* and the angle of refraction *r*. [2]

(c) The refractive index of glass for blue light is 1.5.

(i) A ray of blue light strikes the surface of a glass block at an angle of incidence of 89°.

Calculate the angle of refraction of the light in the block. [3]

(ii) Explain why the angle of refraction of blue light in glass is always less than 45°. [2]

(d) Blue light, travelling in air, strikes the side of a different glass block and continues in the same direction as it enters the glass block. Fig. 10.2 shows the ray of light and the shape of the glass block. The critical angle for this glass is 42°.

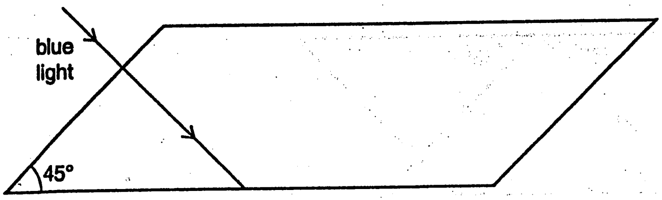


Fig. 10.2

(i) Explain why the light continues in the same direction as it enters the glass block. [2]

(ii) On Fig. 10.2, complete the path of the light until it leaves the glass. [2]

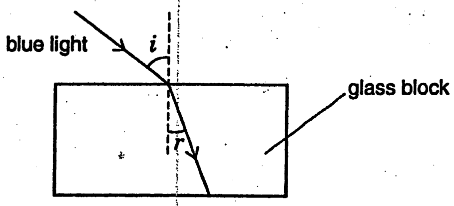
[N14/P2/Q10]

Solution

(a) speed of light in air = 3×10^8 m/s

(b) (i) 1. Decreases
2. No change
3. Decreases

(ii)



(c) (i) Refractive index $= \dfrac{\sin i}{\sin r}$

$$1.5 = \frac{\sin 89°}{\sin r}$$

$$\sin r = \frac{\sin 89°}{1.5} = 0.6666$$

$$r = 41.8°$$

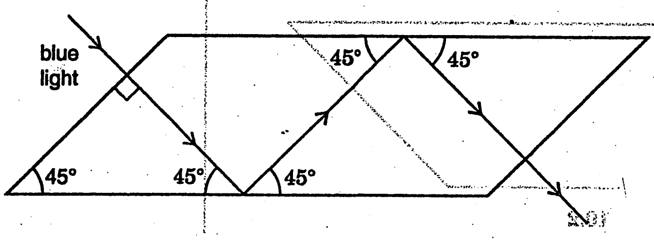
(ii) If angle of refraction is 45°, then,

$$1.5 = \frac{\sin i}{\sin 45°} \quad \Rightarrow \quad \sin i = 1.5 \times \sin 45° \Rightarrow \sin i = 1.06$$

$\sin i$ cannot be greater than 1. Thus the angle of refraction is always less than 45°.

(d) (i) The ray of blue light enters perpendicularly to the surface of the glass block and is therefore not refracted.

(ii)



Question 10

Light enters a parallel-sided glass block at A. The angle between the side of the block and the ray of light in air is 35°.

The light then strikes the edge of the block at B. Fig. 7.1 shows the ray of light and the glass block.

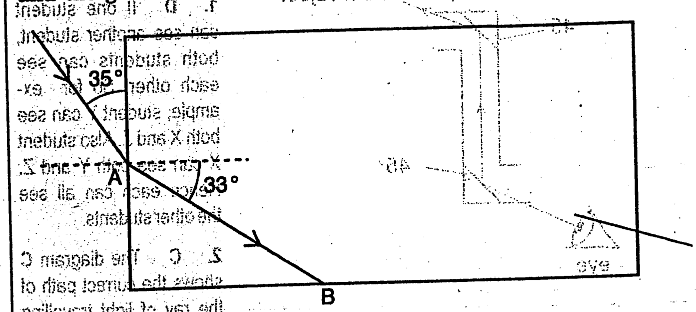


Fig. 7.1

The angle of refraction in the glass at A is 33°.

(a) Calculate the refractive index for light in the glass. [2]

(b) The light undergoes total internal reflection at B.

(i) State one condition necessary for total internal reflection to occur. [1]

(ii) On Fig. 7.1, continue the ray to show the path of the light after total internal reflection at B and until it leaves the block. [1]

[N15/P2/Q7]

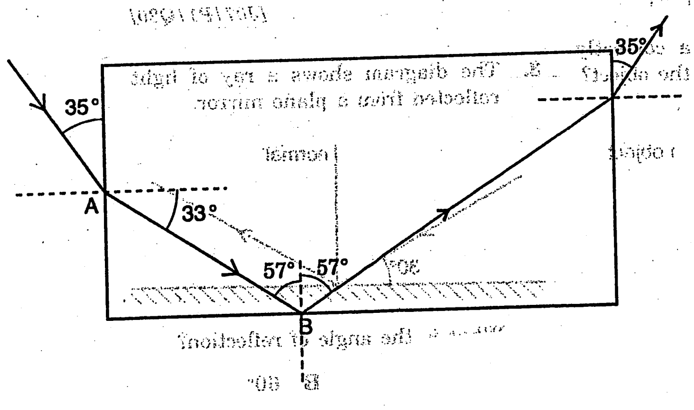
Solution

(a) Refractive index, $n = \dfrac{\sin \hat{i}}{\sin \hat{r}}$

$= \dfrac{\sin 55°}{\sin 33°} = 1.5$

(b) (i) The angle of incidence of the ray of light in the denser medium must be greater than the critical angle for the medium.

(ii)



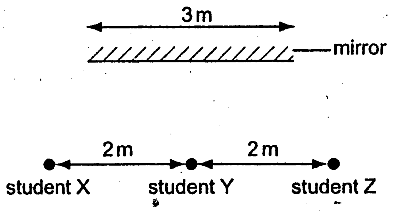
COMMENT on ANSWER

"(b) (i) Alternatively, The ray of light must be travelling from denser to rarer medium."

Topic 17 Reflection

MCQ Section

1. Three students stand 2 m apart in front of a plane mirror that is 3 m long.



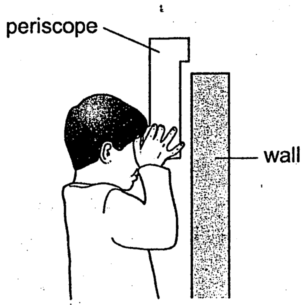
Student Y is standing opposite the mid-point of the mirror.

How many students can see the images of the other two?

A 0 **C** 2
B 1 **D** 3

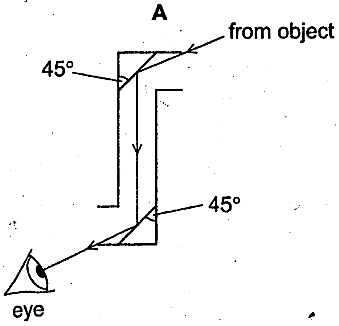
[N06/P1/Q21]

2. The diagram shows a child using a periscope to look at an object on the other side of a wall.

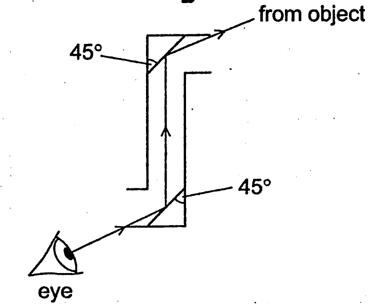


Which diagram shows a correctly drawn ray of light from the object?

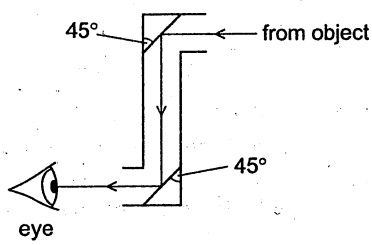
A



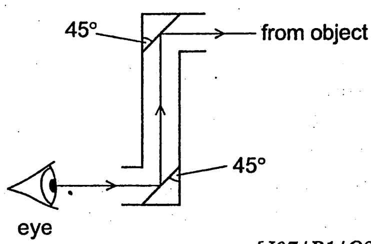
B



C

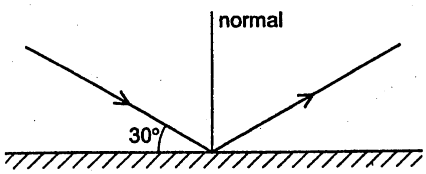


D



[J07/P1/Q20]

3. The diagram shows a ray of light reflected from a plane mirror.



What is the angle of reflection?

A 30° **B** 60°
C 90° **D** 120°

[N07/P1/Q20]

MCQ Answers

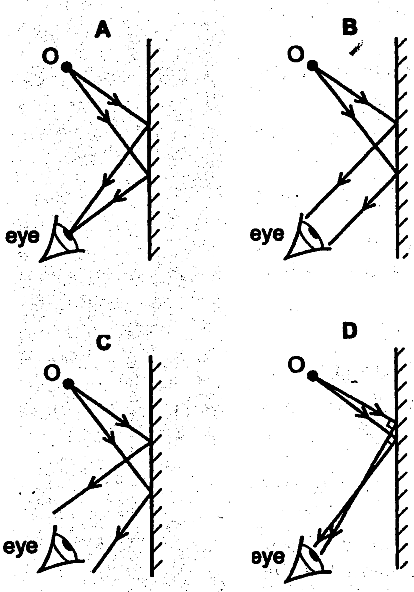
1. D If one student can see another student, both students can see each other. So for example, student Y can see both X and Z. Also student X can see both Y and Z. Hence each can all see the other students.

2. C The diagram C shows the correct path of the ray of light travelling from the object into the eye.

3. B Since the angle of incidence of the ray of light is 60°. So the angle of reflection is also 60° according to the laws of reflection.

4. An eye views an object O by reflection in a plane mirror.

Which is the correct ray diagram?



[N08/P1/Q23]

5. Which characteristics describe an image formed by a plane mirror?

A real and inverted

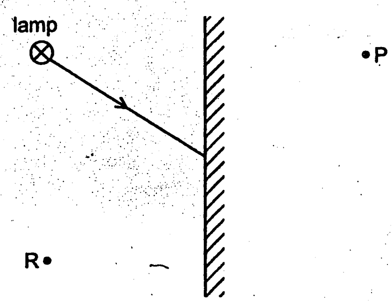
B virtual and upright

C real and larger than the object

D virtual and smaller than the object

[J09/P1/Q20]

6. The diagram shows a ray of light from one point on a lamp striking a plane mirror.



The image of the point on the lamp formed by the mirror is

A at P and is real.

B at P and is virtual.

C at R and is real.

D at R and is virtual.

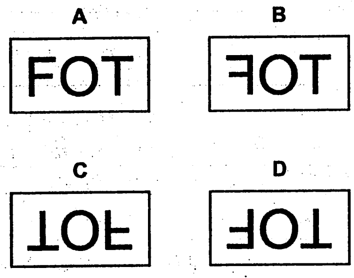
[N09/P1/Q20]

7. A student holds a sheet of paper with letters on it facing a plane mirror.

The letters on the paper are shown.

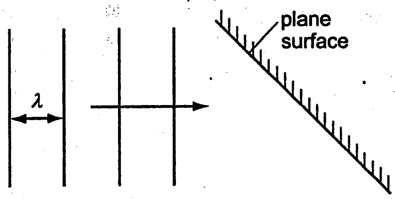
TOF

What does the student see in the mirror?



[J10/P1/Q22]

8. In an experiment using a ripple tank, plane wavefronts arrive at a plane surface.

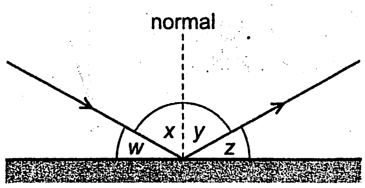


Which row correctly describes the waves after they are reflected from the surface?

	speed of waves	wavelength λ
A	faster	shorter
B	slower	shorter
C	the same	longer
D	the same	the same

[N10/P1/Q25]

9. A ray of light strikes a plane mirror and is reflected.



T h i n k i n G P r o c e s S

MCQ Answers

4. C Two rays of light from the object 'O' are incident on the mirror and then are reflected towards the eye. According to the law of reflection, the angle of incidence must be equal to the angle of reflection for the both rays. Which is true only for the diagram in option C.

Also, if the reflected rays of light in diagram 'C' are extended behind the mirror, they meet at the correct position where the image of the object should be formed.

5. B Fact.

6. B The image is formed at P, which is virtual by definition and obeys the rules, that is:

- object distance = image distance
- the line joining the object and image is perpendicular to the reflecting surface.

7. B The option B shows the laterally inverted image in a plane mirror.

8. D In reflection only the velocity changes due to the change in direction of the reflected waves. The wave length and the speed of the waves remain the same.

9. C It is a fact that in reflection the angle of incidence is equal to the angle of reflection i.e. $\hat{i} = \hat{r}$.

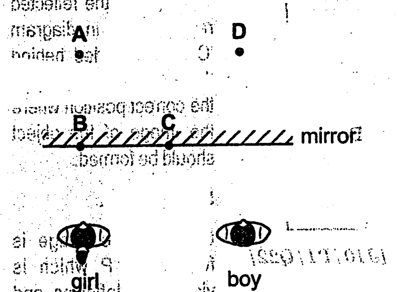
Which pair of angles **must** be equal in value?

A w and x
B w and y
C x and y
D x and z

[J11/P1/Q23]

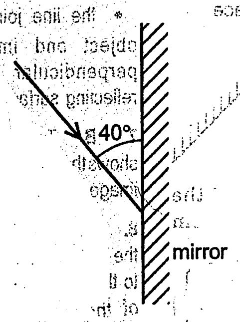
10. A boy stands beside a girl in front of a large plane mirror. They are both the same distance from the mirror, as shown.

Where does the boy see the girl's image?



[N11/P1/Q21]

11. The diagram shows a ray of light directed at a plane mirror.



What are the angle of incidence and the angle of reflection?

	angle of incidence	angle of reflection
A	40°	40°
B	40°	50°
C	50°	40°
D	50°	50°

[J12/P1/Q22]

12. An object is placed in front of a plane mirror. The image produced is

A real and smaller than the object.
B real and the same size as the object.
C virtual and smaller than the object.
D virtual and the same size as the object.

[N12/P1/Q22]

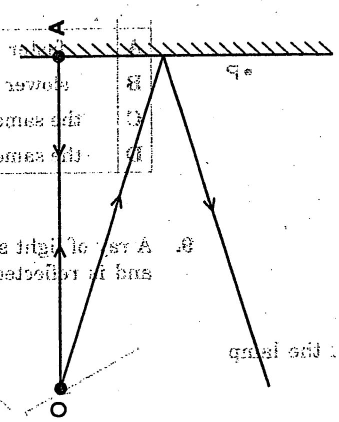
13. Which characteristics describe an image formed by a vertical plane mirror?

A real and inverted
B virtual and not inverted
C real and larger than the object
D virtual and smaller than the object

[J13/P1/Q25]

14. The diagram shows two divergent rays of light from an object O being reflected from a plane mirror.

At which position is the image formed?

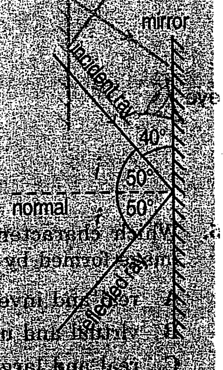


[J14/P1/Q26]

MCQ Answers

10. A The plane mirror forms an image such that object distance is equal to image distance. Also the line joining the object and the image is perpendicular to the reflecting surface.

11. D The angle of incidence is the angle between the incident ray and the normal to the mirror surface. Similarly, the angle of reflection is the angle between the reflected ray and the normal to the mirror surface.



12. D The image produced in a plane mirror is always virtual and it is of the same size as that of the object.

13. B The image of an object formed in a plane mirror is always a virtual and an upright image.

14. B The line joining the object and the image must be perpendicular to the reflecting surface and object distance = image distance.

Topic 17 Reflection

THEORY Section

Question 1

Fig. 5.1 shows a man looking at his reflection in a rectangular plane mirror.

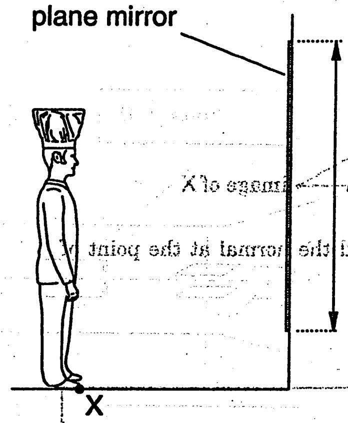


Fig. 5.1

The vertical side of the mirror has length *h*.

(a) (i) On Fig. 5.1, draw a ray of light from point X that is reflected by the mirror to the man's eye. **[1]**

(ii) On Fig. 5.1, mark the angle of incidence of your ray at the mirror.

Label this angle *i*. **[1]**

(iii) Define the *angle of incidence*. **[1]**

(b) On Fig. 5.1, draw a ray of light from the top of the man's hat that is reflected by the mirror to his eye.

Use your rays to determine the smallest value of *h* that allows the man to see all of the image in the mirror, from the top of his hat to his toes.

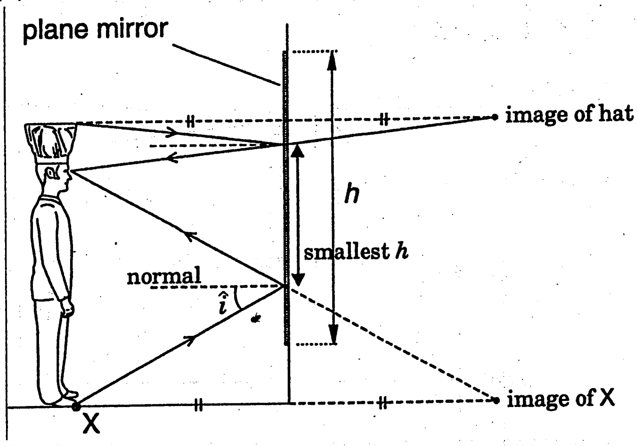
On the diagram, 1 cm represents 0.5 m.

***h* = ... [2]**

[J09/P2/Q5]

Solution

(a) (i), (ii)



(iii) It is the angle between the incident ray and the normal at the point of contact at the mirror.

(b) Smallest value of h = 2 cm = $2 \times 0.5 = 1.0$ m.

Question 2

Fig. 4.1 shows an old coin displayed in a museum.

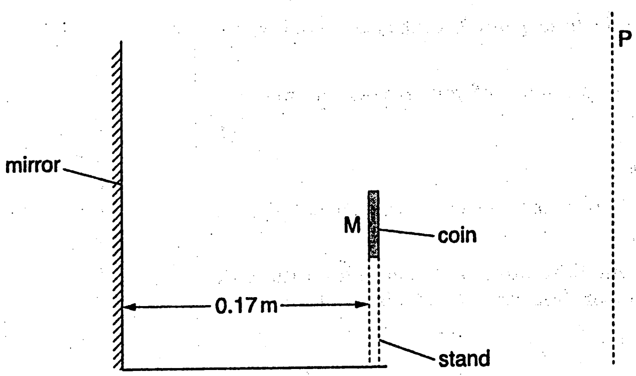


Fig. 4.1

The coin is vertical and is supported by a transparent stand. A vertical mirror 0.17 m behind the coin ensures that the back of the coin can be seen by a visitor looking from the line P.

M is a point on the back of the coin.

(a) On Fig. 4.1,

(i) draw **two** rays of light from M to show how its image is produced, [2]

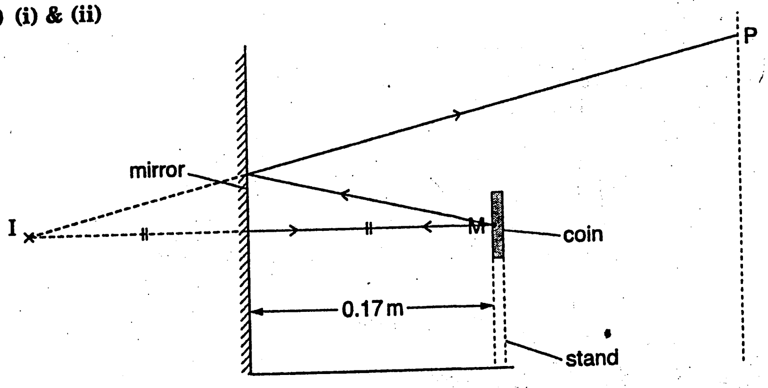
(ii) label the image I. [1]

(b) State the distance from point M on the coin to its image. [1]

[N09/P2/Q4]

Solution

(a) (i) & (ii)



(b) distance = 0.34 m

Question 3

Fig. 9.1 shows a very large plane mirror, inclined at 45° to the horizontal, beneath a pattern on the high ceiling of a hall.

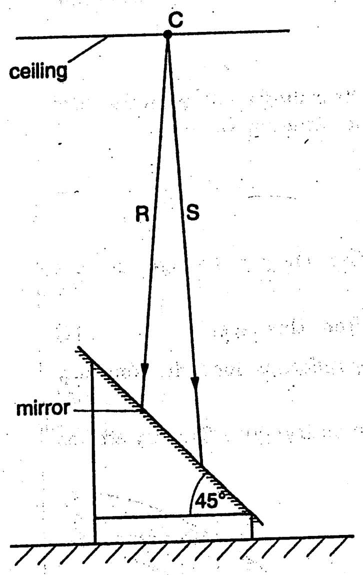


Fig. 9.1

The mirror is set on a stand at head-height immediately below the centre C of the pattern. R and S are two rays of light from C that strike the mirror.

(a) (i) On Fig. 9.1, continue the rays R and S after they strike the mirror. **[1]**

(ii) On Fig. 9.1, show how these rays are used to locate the image of C and mark and label the position of this image with the letter I. **[2]**

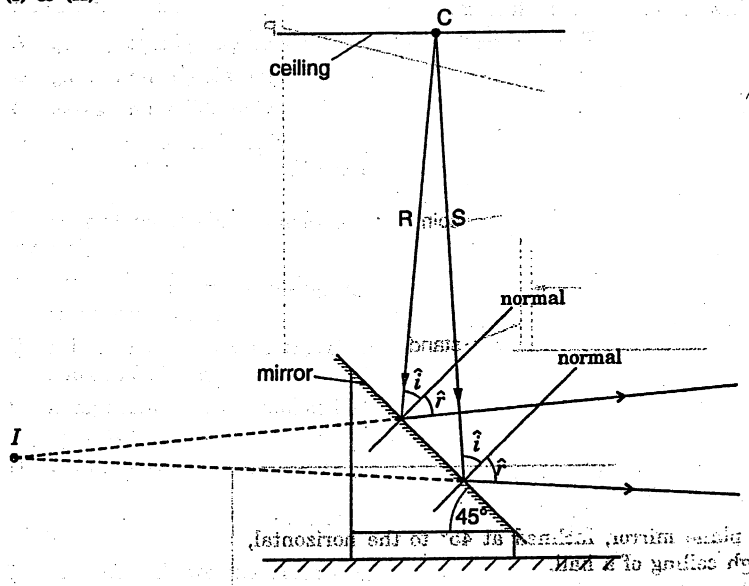
(iii) State two characteristics of this image. **[2]**

(iv) Suggest how the mirror helps visitors to the hall to see the pattern on the ceiling. **[1]**

[N10/P2/Q9(a)]

Solution

(a) (i) & (ii)



(iii) 1. **Virtual.**
2. **Same size.**

(iv) It is more comfortable for a visitor to see the ceiling's pattern in the mirror at his eyes level instead of looking up and straining his neck.

COMMENT on ANSWER

" (a) (iii) Also the image is:
- **laterally inverted,**
- **same distance from the mirror as C,**
- **dimmer. "**

Question 4

A laser produces red light of frequency 4.7×10^{14} Hz. The speed of light in glass is 2.0×10^8 m/s.

(a) Calculate the wavelength in glass of light from this laser. [2]

(b) Describe an experiment to verify *the law of reflection* for light. You may include a diagram in your answer. [5]

(c) Fig. 10.1 shows a ray of light travelling in an optical fibre. The ray strikes the side of the fibre at P.

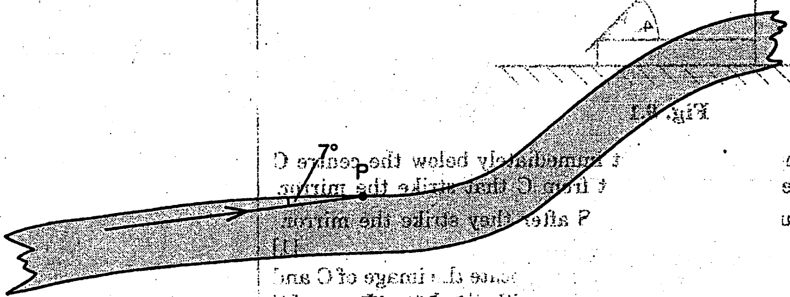


Fig. 10.1

The angle between the ray and the side of the fibre is 7°.

(i) Determine the angle of incidence of the ray at P. [1]

(ii) State and explain what happens to the ray at P. [2]

(d) A room is illuminated by wall lamps. Fig. 10.2 shows a mirror on the wall behind one of the lamps.

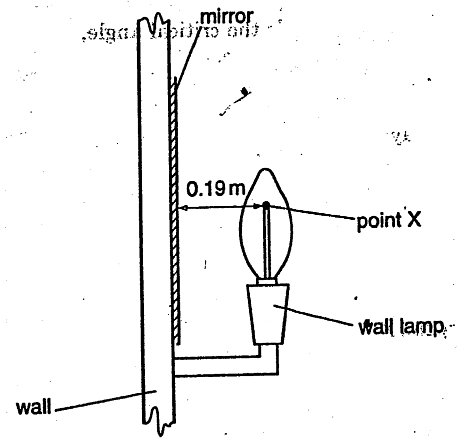


Fig. 10.2 (not to scale)

X is a point on the filament of the lamp. It is 0.19 m in front of the mirror.

(i) On Fig. 10.2, draw rays from X and locate the image of X. Label the image I. [3]

(ii) State the distance between I and the mirror. [1]

(iii) Suggest one advantage of placing a mirror behind the lamp in the room. [1]

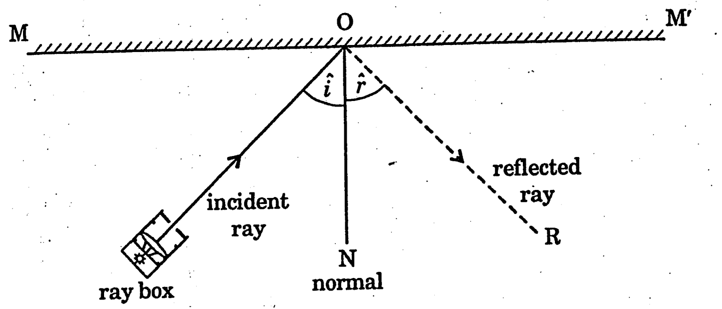
[N12/P2/Q10]

Solution

(a) $\lambda = \dfrac{v}{f}$

$= \dfrac{2.0 \times 10^{8}}{4.7 \times 10^{14}} = 4.3 \times 10^{-7}\ \text{m}$

(b)



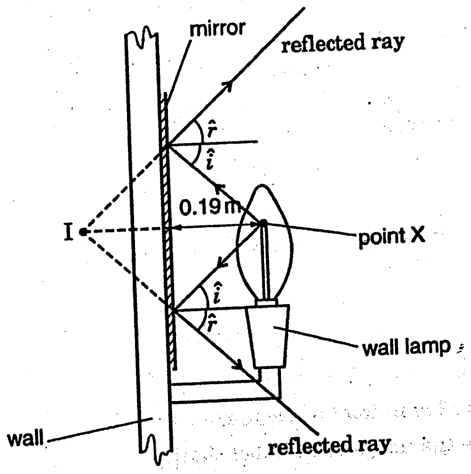
A horizontal line MM′ and a normal ON is drawn as shown. A mirror strip is placed vertically on the line MM′ and a ray box is used to shine a ray of light at 45° of angle of incidence on the mirror. The ray is reflected along OR. Mark the positions of the incident ray and the reflected ray. Remove the apparatus from the paper and measure the angle of reflection $\hat{r}$. If the value of the angle of reflection is the same as that of the angle of incidence i.e. $\hat{i} = \hat{r}$, then it verifies the law of reflection.

Repeat the experiment for $\hat{i} = 60°$ and compare the values of $\hat{i}$ and $\hat{r}$ to confirm the results.

(c) (i) $\hat{i} = 90° - 7°$
$= 83°$

(ii) The angle of incidence of the ray of light at P exceeds the critical angle, so the ray of light undergoes the total internal Reflection.

(d) (i)



(ii) distance = 0.19 m

(iii) The light travelling towards the wall is reflected back into the room by the mirror. This makes the room brighter and no light is wasted.

COMMENT on ANSWER

"(d) (i) The diagram shows three rays of light from the point X falling on the mirror. One is perpendicular to the mirror falling in the middle of the mirror. Second ray is falling in the upper part and third ray is falling in the lower part of the mirror. When their reflected rays are extended backwards, they intersect at a point behind the mirror and locate the position of the image of X."

Topic 18 *Electromagnetic Waves*

M C Q Section

1. Which wave is part of the electromagnetic spectrum?

	speed m/s	type
A	330	longitudinal
B	330	transverse
C	3×10^8	longitudinal
D	3×10^8	transverse

[J06/P1/Q25]

2. Which type of wave is used to send telephone signals to and from a satellite?

A infra-red waves
B light waves
C microwaves
D sound waves

[J07/P1/Q22]

3. Which does **not** normally use infra-red radiation?

A electric grill
B intruder alarm
C television remote controller
D sunbed

[N07/P1/Q22]

4. A flash of lightning and the corresponding thunder clap are detected 6 s apart. It is calculated that the lightning struck about 1800 m away.

On which assumption is the calculation based?

A Light reaches us almost instantaneously, but sound travels at 300 m/s.
B Light travels 300 m/s faster than sound.
C Sound reaches us almost instantaneously, but light travels at 300 m/s.
D The sound of the thunder was emitted 6 s after the flash.

[N07/P1/Q23]

5. Which colour, red or blue, has the higher frequency and which has the longer wavelength?

	higher frequency	longer wavelength
A	blue	blue
B	blue	red
C	red	blue
D	red	red

[J08/P1/Q25]

6. A hospital needs to sterilise medical equipment.

Which electromagnetic waves could be used?

A infra-red **B** microwaves
C radiowaves **D** ultraviolet

[J10/P1/Q21]

7. Which pair of emissions travels with the same speed in air?

A alpha-particles and gamma-rays
B gamma-rays and infra-red waves
C infra-red waves and sound waves
D sound waves and alpha-particles

[N10/P1/Q22]

8. Which application may use the part of the electromagnetic spectrum called microwaves?

A cooking vegetables
B detecting small cracks in metals
C gaining a sun-tan
D lighting a fluorescent tube

[J11/P1/Q20]

9. How do the speed and the wavelength of red light in air compare with the speed and the wavelength of violet light in air?

	speed of red light	wavelength of red light
A	greater	greater
B	greater	less
C	same	greater
D	same	less

[N11/P1/Q22]

MCQ Answers

1. D It is a fact that all the components of the electromagnetic spectrum are transverse waves and they **all** travel with the **same** speed of 3.0×10^8 **m/s**.

2. C The micro waves are useful in telephone communications e.g. mobile phones.

3. D A Sunbed mostly uses ultraviolet radiation for skin tanning.

4. A The light travels at a speed of 3.0×10^8 m/s so it reaches us instantaneously but the sound travels at 300 m/s which is comparatively a much lower speed, so it reaches us 6 second later after covering a distance of 1800 m at this speed.

5. B It is a fact that the red light has a longer wavelength than the blue light and the blue light has a higher frequency than the red colour.

6. D The ultraviolet radiations have the property of killing micro-organisms (bacteria) and hence they are used for sterilising medical equipment.

7. B The gamma rays and infra-red rays are both e.m.waves that travel with the same speed in air.

8. A Fact.

9. C All electromagnetic waves travel with the same speed in air i.e. 3.0×10^8 ms^{-1}. Also, the wave length of red light is greater than the wave length of violet light.

10. The diagram shows the main sections of the electromagnetic spectrum in order of increasing frequency. Some of the sections are labelled.

radio waves		R	light			gamma-rays

⟶ increasing frequency

The section R has a frequency just below that of light.

Which application uses the section R?

A killing cancerous cells
B satellite television
C sterilisation
D television remote controller

[N11/P1/Q23]

11. Which device uses ultra-violet radiation?

A electric grill
B intruder alarm
C television remote controller
D sunbed

[J12/P1/Q25]

12. Which statement is correct for all electromagnetic waves?

A They are transverse.
B They cannot travel in a vacuum.
C They have the same frequency.
D They travel through lead.

[J14/P1/Q27]

13. Which application uses microwaves?

A detecting small cracks in metals
B gaining a sun-tan
C lighting a fluorescent tube
D satellite television

[N14/P1/Q17]

14. Which component of the electromagnetic spectrum is used for television transmission from satellites?

A microwaves
B radio waves
C ultra-violet
D X-rays

[J15/P1/Q28]

15. Which statement is correct?

A Infra-red radiation cannot travel in a vacuum.
B Infra-red radiation cannot travel in solids or in gases.
C Infra-red radiation can only travel in a vacuum.
D Infra-red radiation can travel in a vacuum and in gases.

[N15/P1/Q20]

MCQ Answers

10. D Section R is infra-red radiations and infra-red radiations are used in television remote controller.

11. D It is a fact that an electric grill, an intruder alarm and a television remote controller, all the three use the infra-red radiation, whereas a sunbed uses ultra-violet radiation.

12. A Fact.

13. D Certain microwave radiation wavelengths pass through the Earth's atmosphere and can be used to transmit data in satellite television applications.

14. A Satellite televisions use microwaves to receive television programmes via satellites in space.

15. D Fact.

Topic 18 Electromagnetic Waves

THEORY Section

Question 1

(a) Each object in the table below emits one main type of electromagnetic wave.
Complete the table by writing in the name of the type of wave.
One line has been written for you.

Object	Main type of electromagnetic wave emitted
radio transmitter	radio wave
remote control for a television	
radioactive source	

[2]

(b) X-rays are used in hospitals to produce images of bones and to show whether bones are broken.

(i) State what is used to detect X-rays. [1]

(ii) Explain the properties of X-rays that enable an image of a bone to be produced. [2]

[J08/P2/Q5]

Solution

(a)

Object	Main type of electromagnetic wave emitted
radio transmitter	radio wave
remote control for a television	**infra-red**
radioactive source	**gamma rays**

(b) (i) A fluorescent screen or a photographic plate can be used to detect X-rays.

(ii) The long-wavelength X-rays are less penetrating and are used in Radiology, the science of applying X-rays to medicine to produce pictures of internal organs in the body. They can pass through flesh but are stopped by the bones, so bones will show up on an X-ray photograph.

COMMENT on ANSWER

“(b) (ii) Short-wavelength X-rays are extremely penetrating. A dense metal like lead can only reduce their strength, but not stop them. They are used to treat cancer and tumours by killing the abnormal cells but it should be noted that healthy cells are also killed when concentrated beams of short wavelength are used.”

***Question* 2**

Fig. 6.1 shows a ray of white light from a ray-box passing into a glass prism. A spectrum is formed between P and Q on the screen.

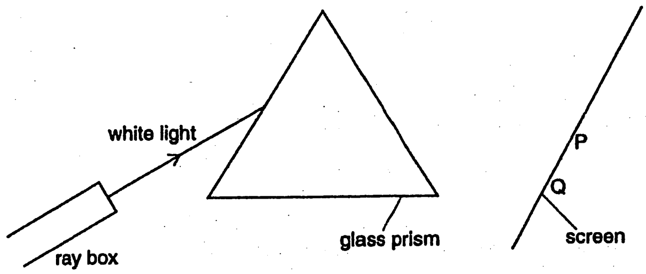


Fig. 6.1

(a) State the colour of the light at end P of the spectrum. [1]

(b) State whether the value of each of these properties for blue light is greater than, equal to or less than the value for red light.

(i) speed in a vacuum [1]

(ii) wavelength [1]

(c) Fig. 6.2 shows the ray passing through a red filter before it reaches the prism.

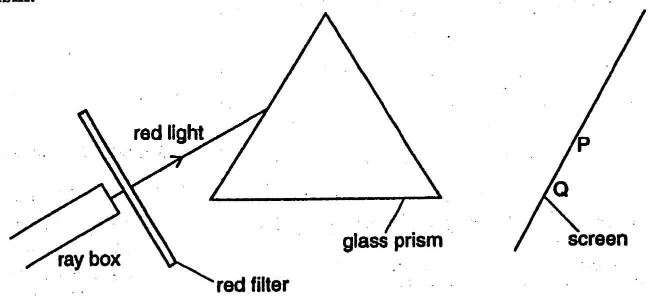


Fig. 6.2

Complete Fig. 6.2 to show the ray of red light passing through and emerging from the prism. [2]

[N08/P2/Q6]

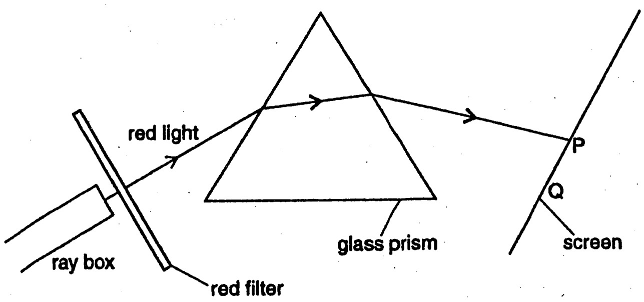
Solution

(a) Red

(b) (i) speed in a vacuum: equal to the red light.

(ii) wavelength: less than the red light.

(c)



COMMENT on ANSWER

❝ (c) When drawing the path of red light, make sure that a clear bending of ray is seen towards the normal when it enters the glass prism and away from the normal as it leaves the prism i.e. in both cases the ray bends towards the thicker part of the glass prism. ❞

Question 3

Fig. 9.1 shows a very large plane mirror, inclined at 45° to the horizontal, beneath a pattern on the high ceiling of a hall.

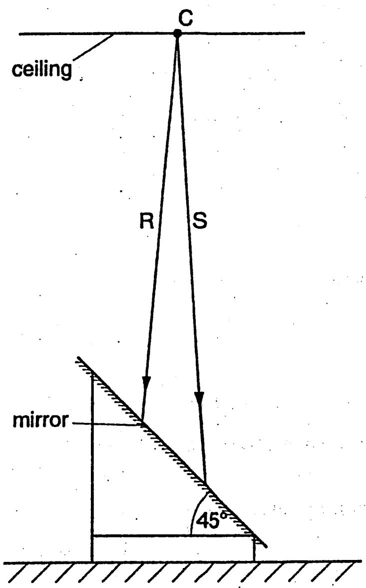


Fig. 9.1

The mirror is set on a stand at head-height immediately below the centre C of the pattern. R and S are two rays of light from C that strike the mirror.

(b) Violet light from C has a wavelength of 4.0×10^{-7} m.

(i) Calculate the frequency of this light, clearly stating the value of any constant used in the calculation. [3]

(ii) State two different components of the electromagnetic spectrum that have wavelengths smaller than the wavelength of violet light. [2]

(iii) 1. Discuss a medical application of **one** of these components of the electromagnetic spectrum. [3]

2. State a health risk associated with this component of the electromagnetic spectrum. [1]

[N10/P2/Q9(b)]

Solution

(b) (i) $f = \dfrac{v}{\lambda} = \dfrac{3.0 \times 10^8}{4.0 \times 10^{-7}} = 7.5 \times 10^{14}$ Hz

(ii) 1. Ultra-violet radiation.
2. Gamma radiation.

(iii) 1. The high energy and highly penetrating gamma radiations are used to kill the cells of the malignant tumour by penetrating deep into the patient's body and stop the multiplying of the cancerous cells.

2. Strong doses of gamma radiation can cause the burning of the skin and tissues similar to those caused by fire and delayed effects such as cancer and eye cataracts.

Question 4

Fig. 4.1 represents a microwave travelling in air through points A and B.

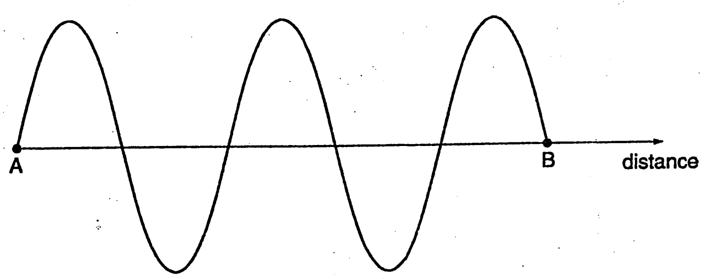


Fig. 4.1 (not to scale)

The distance between A and B is 40 cm.

(a) State the speed of microwaves in air. [1]

(b) Determine the wavelength of the microwave shown in Fig. 4.1. [1]

(c) Describe how microwaves are used in the transmission of television signals by satellite. [3]

(d) State two properties common to all electromagnetic waves. [2]

[N11/P2/Q4]

Solution

(a) speed $= 3.0 \times 10^8$ m/s

(b) wavelength, $\lambda = \dfrac{40}{2.5} = 16$ cm

(c) The transmitted signals from earth pass through the atmosphere and travel through space. These signals are received and amplified or boosted by a satellite. The boosted signals are then transmitted by the satellite and are received by a dish, back on Earth.

(d) 1. They all travel with speed of light in a vacuum.
2. They all do not need a medium to travel through.

COMMENT on ANSWER

“ (a) All electromagnetic waves travel in air with speed of light.

(d) *Alternatively*:
All electromagnetic waves,
- are transverse waves.
- obey the laws of reflection and refraction.
- cannot be deflected by electric field and magnetic field. ”

Question 5

(a) The list below contains three components of the electromagnetic spectrum.

infra-red **gamma rays** **visible light**

Arrange the components in order of increasing wavelength. [1]

(b) Satellites are used in the transmission of some television signals.

Fig. 4.1 shows a satellite above the television station where a television signal is generated.

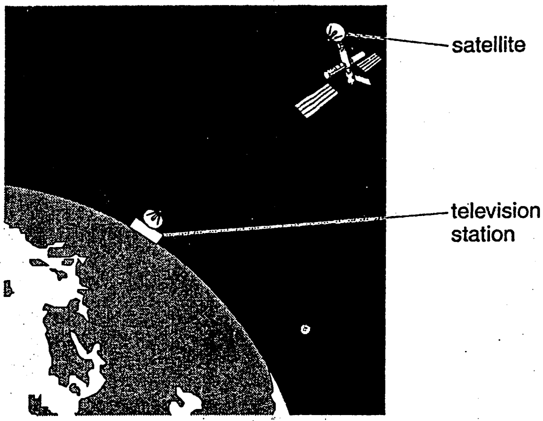


Fig. 4.1 (not to scale)

(i) State which component of the electromagnetic spectrum is used to transmit the television signal to the satellite. [1]

(ii) Explain how the satellite is used. [1]

(iii) Suggest one advantage of using a satellite to transmit television signals. [1]

[J13/P2/Q4]

Solution

(a) gamma rays, visible light, infra-red.

(b) (i) Microwaves

(ii) The satellite receives a signal from the television station, boosts it and transmits it to the consumers on the earth.

(iii) A satellite gives a greater coverage of the signal.

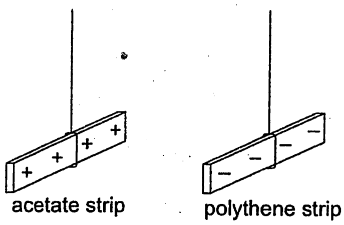
COMMENT on ANSWER

" **(b) (iii)** Another advantage is that only one satellite is required whereas in the case of transmission on ground, the signals are weakened due to the hinderence of tall buildings, hills and trees etc. So a large number of boosters are required to carry the signals from the television station to various parts of the region. "

Topic 19 *Static Electricity*

MCQ Section

1. The diagram shows a positively charged acetate strip and a negatively charged polythene strip that are freely suspended.



Two rods **X** and **Y** are brought up in turn to these two strips. Rod **X** attracts the acetate strip but repels the polythene strip. Rod **Y** does not repel either the acetate strip or the polythene strip.

Which type of charge is on each rod?

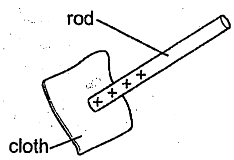
	rod **X**	rod **Y**
A	negative	positive
B	negative	uncharged
C	positive	negative
D	positive	uncharged

[J05/P1/Q26]

2. In an electrostatics experiment, a plastic rod is rubbed with a cloth. The cloth becomes negatively charged.

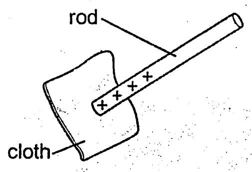
Which diagram shows the charge on the rod, and describes the movement of charge?

A



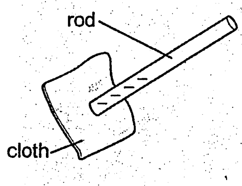
electrons move from the rod onto the cloth

B



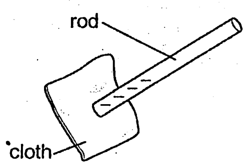
protons move from the cloth onto the rod

C



electrons move from the cloth onto the rod

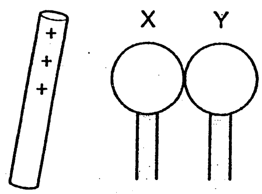
D



protons move from the rod onto the cloth

[J06/P1/Q29]

3. Two insulated and uncharged metal spheres X and Y are touching. While a positively charged rod is near X, the spheres are moved apart. After this action, X has a negative charge.



What will be the charge on Y?

A negative and smaller than that on X

B negative and the same size as that on X

1. B Repulsion occurs between two like charges whereas attraction may occur between two unlike charges or between a charged body and an uncharged body due to the induction of an opposite charge on the uncharged body.

2. A During rubbing the rod loses electrons which move on to the cloth so the rod becomes positively charged and the cloth on gaining electrons becomes negatively charged.

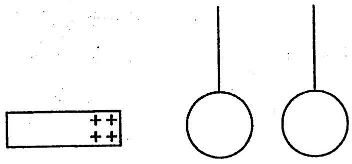
3. D Two set of induced charges with be produced on X and Y. These induced charges will be opposite in sign but equal in magnitude. The induced charges on X will be negative whereas those on Y will be positive.

C positive and smaller than that on X

D positive and the same size as that on X

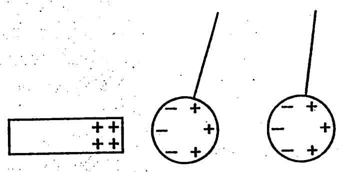
[N06/P1/Q26]

4. Two uncharged metal spheres, not touching one another, are suspended by means of cotton thread. A positively charged rod is brought near.

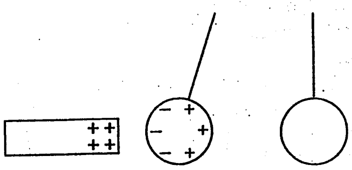


Which diagram shows what happens to the spheres?

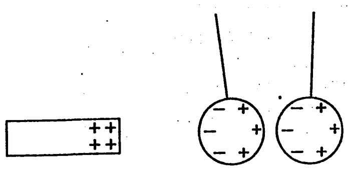
A



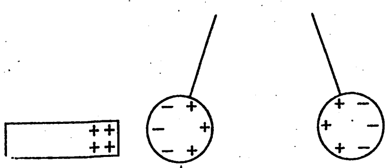
B



C

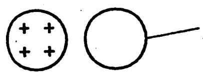


D



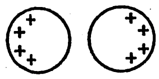
[J07/P1/Q26]

5. A positively charged insulated metal sphere is brought close to, but not touching, a similar uncharged metal sphere.

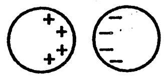


Which diagram shows the charge distribution on the spheres?

A



B



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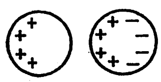

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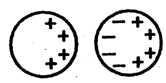


[N07/P1/Q26]

6. A perspex rod can be charged positively by rubbing it with a woollen cloth.

How does the rod gain its charge?

A The rod gains electrons.

B The rod gains protons.

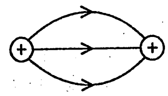
C The rod loses electrons.

D The rod loses protons.

[J08/P1/Q28]

7. Which diagram correctly shows the electric field lines between two point charges?

A



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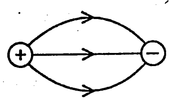

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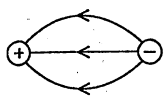

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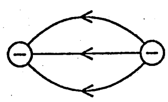


[J08/P1/Q29]

8. A piece of polythene is rubbed with a cloth duster. The polythene becomes negatively charged and the cloth becomes positively charged.

ThinkinG ProcesS

MCQ Answers

4. A The positive charge on the rod induces two sets of equal and opposite charges on the left sphere which in turn causes electrostatic induction on the right sphere. Since unlike charges attract so the left sphere is attracted towards the rod and the right sphere is attracted towards the left sphere.

5. D The positive charge on the charged metal sphere causes electrostatic induction on the uncharged metal sphere. The negative charges are induced on the left end and the positive charges on the right end of the uncharged metal sphere. The positive charge on the charged metal sphere is then attracted to its right end due to the attraction from the induced negative charge on the uncharged sphere.

6. C The perspex rod gains a net positive charge on it, if it loses some of its electrons.

7. B The electric field lines are always directed from positive charge to negative charge.

8. B During rubbing, the piece of polythene gains electrons from the cloth due to friction and the net charge on the polythene becomes negative, while the net charge on the cloth becomes positive due to its losing electrons to the polythene.

What happens to the polythene and to the cloth to cause this?

	polythene	cloth
A	gains electrons	gains protons
B	gains electrons	loses electrons
C	loses protons	gains protons
D	loses protons	loses electrons

[N08/P1/Q27]

9. A negatively-charged balloon is brought towards a wall.

Which statement explains what happens?

A Negative charges on the balloon attract the negative charges in the wall.

B Negative charges on the balloon have no effect on the charges in the wall.

C Negative charges on the balloon repel the negative charges in the wall.

D Negative charges on the balloon repel the positive charges in the wall.

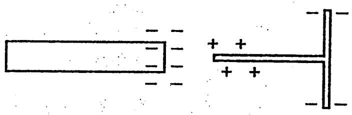
[J09/P1/Q25]

10. A negatively-charged rod is brought close to an isolated T-shaped piece of metal.

Initially, the metal is uncharged.

Which diagram shows the induced charge on the metal?

A



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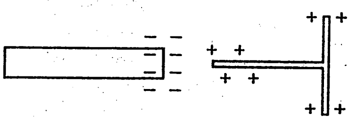

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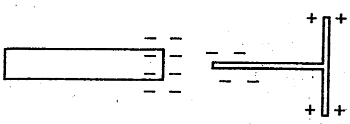

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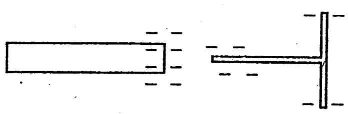
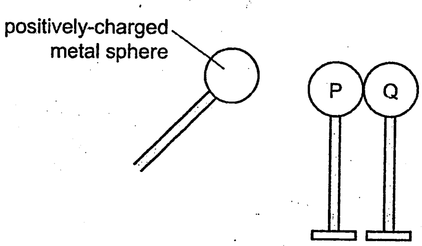


[N09/P1/Q25]

11. Two metal spheres P and Q are mounted on insulating stands and are touching each other. They are uncharged.

A positively-charged metal sphere on an insulating handle is brought close to P but does not touch it. This induces charges on P and Q.



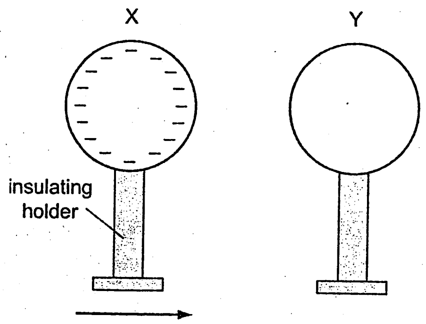
The positively-charged metal sphere is held in this position and sphere Q is moved to the right, away from sphere P.

What are the signs of the induced charges on P and Q and how do the sizes of these charges compare?

	charge on P	charge on Q	sizes of the charges
A	negative	positive	equal
B	negative	positive	unequal
C	positive	negative	equal
D	positive	negative	unequal

[J10/P1/Q24]

12. A negatively-charged sphere X is brought up to an identical uncharged sphere Y. The spheres do not touch.



ThinkinG ProcesS

MCQ Answers

9. C The like charges repel each other according to the law of electrostatics.

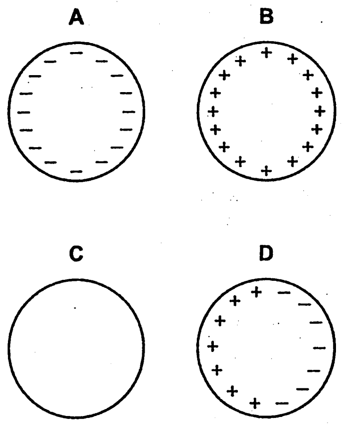
10. A Fact.

11. A Fact.

12. B When sphere Y is placed close to sphere X, a positive charge is induced on the left side of Y and a negative charge on its right side.
On touching sphere Y, its negative charge is neutralised, bearing positive charges on its left side.
When sphere X is taken away, the positive charge spreads over the whole surface of the sphere Y.

Sphere Y is 'earthed' by touching it with a finger, which is then removed. Sphere X is then moved away from sphere Y.

What is the final charge, if any, on sphere Y?



[N10/P1/Q29]

13. To charge an isolated metal sphere by induction, the following four processes are required.

P The sphere is earthed by touching it.

Q The earth connection is removed from the sphere.

R A charged rod is brought close to the sphere.

S The charged rod is removed.

In which order can these stages be carried out to charge the isolated metal sphere?

A $P \rightarrow Q \rightarrow R \rightarrow S$

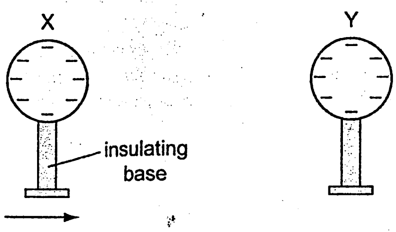
B $P \rightarrow R \rightarrow S \rightarrow Q$

C $R \rightarrow P \rightarrow Q \rightarrow S$

D $R \rightarrow P \rightarrow S \rightarrow Q$

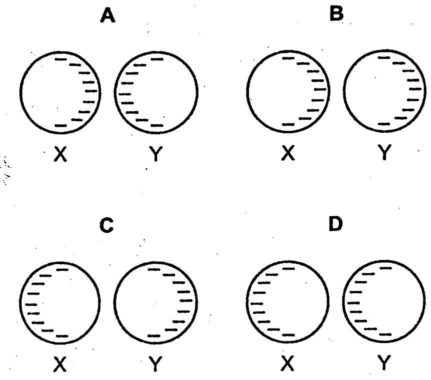
[J11/P1/Q29]

14. Two metal spheres X and Y are on insulating bases. Both spheres are negatively charged.



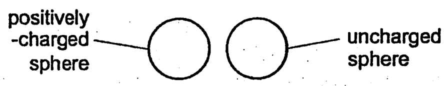
Sphere X is moved towards sphere Y until they almost touch.

Which diagram shows the final pattern of charges?

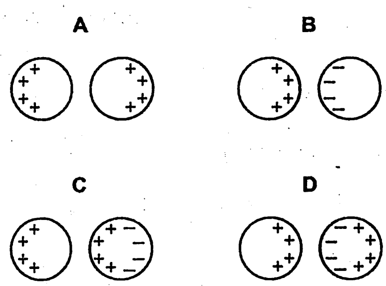


[N11/P1/Q33]

15. A positively-charged insulated metal sphere is brought close to, but does not touch, a similar uncharged metal sphere.



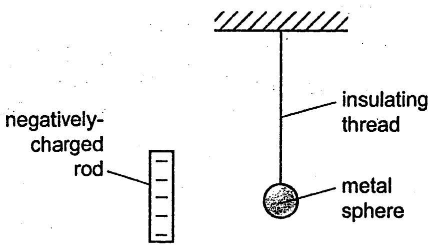
Which diagram shows the charge distribution on the spheres?



[J12/P1/Q27]

16. A small uncharged metal sphere hangs from an insulating thread.

A negatively-charged rod moves close to the sphere.



ThinkinG ProcesS

MCQ Answers

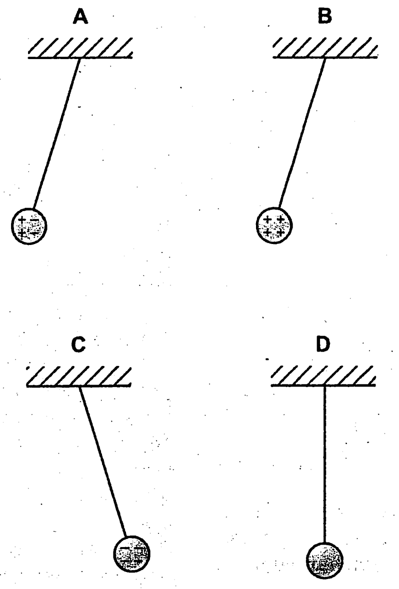
13. C Fact.

14. C Like charges repel and unlike charges attract.

15. D The positive charge on the charged metal sphere causes electrostatic induction on the uncharged metal sphere. As a result, the negative charges are induced on the left and the positive charges on the right end of the uncharged metal sphere.
The positive charge on the charged metal sphere is then attracted to its right end due to the attraction from the induced negative charge on the uncharged sphere.

16. A The sphere is charged by electrostatic induction with positive charge on its left and the negative charge on its right.
Due to the force of attraction between unlike charges, the sphere is deflected towards the negative rod.

Which diagram shows the charges on the sphere and its final position?



[N12/P1/Q27]

17. A student rubs a rod held in his hand.

Which action causes the rod to gain a large electrostatic charge?

A rubbing an iron rod with a steel magnet
B rubbing an iron rod with a woollen duster
C rubbing a polythene rod with a steel magnet
D rubbing a polythene rod with a woollen duster

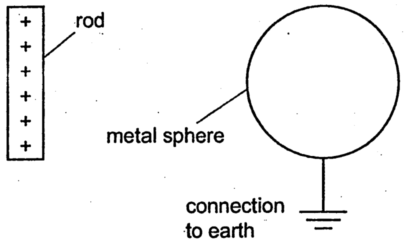
[J13/P1/Q31]

18. Which row shows an electrical conductor and an insulator?

	electrical conductor	insulator
A	aluminium	rubber
B	copper	aluminium
C	plastic	copper
D	rubber	plastic

[J14/P1/Q31]

19. A metal sphere is connected to earth. A positively charged rod approaches the sphere and stops before touching it.

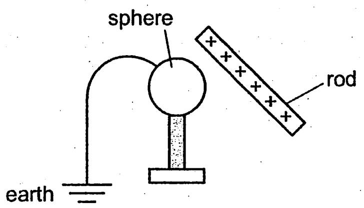


What is the movement of charge on the sphere and what is the final charge on the sphere?

	movement of charge	final charge on sphere
A	negative charge moves from earth to the sphere	negative
B	negative charge moves from earth to the sphere	neutral
C	positive charge moves from the sphere to earth	negative
D	positive charge moves from the sphere to earth	neutral

[J14/P1/Q32]

20. A positively charged rod is held close to an earthed metal sphere.



What describes the charge on the metal sphere?

A It is negative because electrons are attracted towards the rod.
B It is neutral because electrons are attracted towards the rod and protons are repelled.
C It is neutral because it is earthed.
D It is positive because protons are repelled by the rod.

[N14/P1/Q22]

MCQ Answers

17. D Fact.

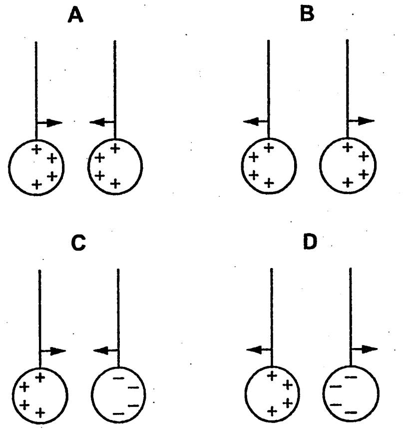
18. A Fact.

19. A Since the sphere is neutral, all the negative charges in the sphere will be attracted towards the positively charged rod while the positive charges in the sphere will be neutralized by negative charges from the earth. Therefore, the sphere would end up being negatively charged.

20. A Negative charges in the sphere are attracted towards the rod, whereas the positive charges in the sphere are neutralized by negative charges from the earth.

21. Two charged metal spheres are suspended close to each other.

Which diagram shows the charge distribution on the spheres and the directions of the forces on the spheres?



[N14/P1/Q23]

22. Which list contains only electrical insulators?

A glass, plastic, rubber

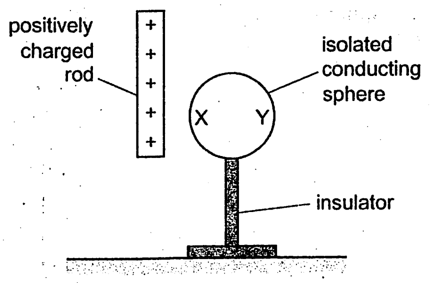
B glass, plastic, steel

C glass, rubber, steel

D plastic, rubber, steel

[N14/P1/Q24]

23. A positively charged rod is brought near to an isolated uncharged conducting sphere.



What are the charges on sides X and Y of the sphere?

A Both X and Y are positively charged.

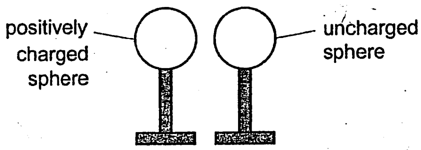
B Both X and Y are negatively charged.

C X is positively charged and Y is negatively charged.

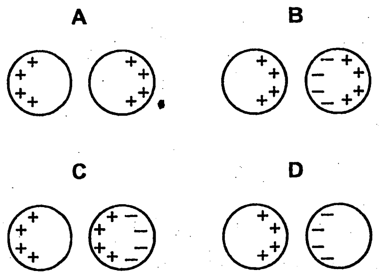
D X is negatively charged and Y is positively charged.

[J15/P1/Q32]

24. A positively charged insulated metal sphere is brought close to an uncharged insulated metal sphere.



Which diagram shows the charge distribution on the spheres?



[N15/P1/Q30]

Thinking Process

MCQ Answers

21. B Like charges repel. Opposite charges attract.

22. A Note that steel is a conductor of electricity.

23. D By the concept of electrostatic induction, a negative charge is induced at X and a positive charge is induced at Y.

24. B The positive charge on the charged metal sphere causes electrostatic induction on the uncharged metal sphere. The negative charges are induced on the left end and the positive charges on the right end of the uncharged metal sphere. The positive charge on the charged metal sphere is then attracted to its right end due to the attraction from the induced negative charge on the uncharged sphere.

Topic 19 Static Electricity

THEORY Section

Question 1

Two conducting spheres are rubbed and become charged, as shown in Fig. 5.1.

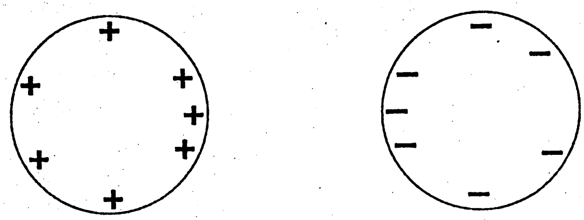


Fig. 5.1

(a) The spheres are uncharged before they are rubbed.

Explain, in terms of the movement of electrons, how they become charged. [1]

(b) On Fig. 5.1, draw the electric field pattern between the spheres. Show the direction of the field lines. [2]

(c) A metal wire is used to connect the two spheres together. In a time of 2.0×10^{-3} s, a charge of 1.8×10^{-13}C passes through the wire.

Calculate the current in the wire.

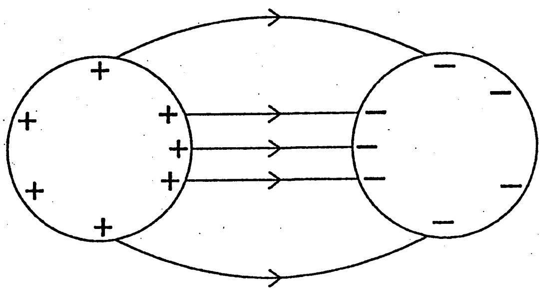
current = ... [2]

[J06/P2/Q5]

Solution

(a) During the process of rubbing, the electrons move from the right sphere onto the left sphere. As the right sphere loses electrons, so it becomes positively charged and the left sphere, on gaining the electrons, becomes negatively charged.

(b)



(c) As $Q = I \times t$

$\therefore\ 1.8\times10^{-13} = I\times2.0\times10^{-3}$

$$I = \frac{1.8\times10^{-13}}{2.0\times10^{-3}} = 9\times10^{-11}\ \text{A}$$

Question 2

A plastic rod is rubbed with a cloth and becomes negatively charged.

(a) Explain how the rod becomes negatively charged when rubbed with a cloth. [2]

(b) An uncharged metal-coated sphere hangs from an insulating thread. The sphere is brought near to the rod. The sphere is attracted to the rod, as shown in Fig. 11.1.

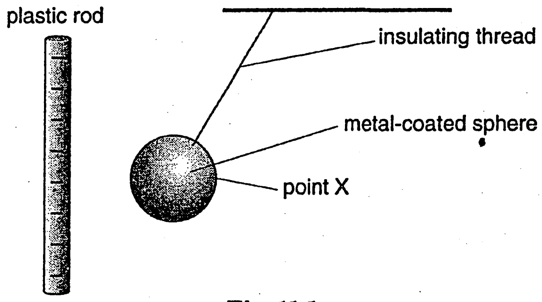


Fig. 11.1

(i) Describe and explain what happens to the free electrons in the metal-coated sphere as it approaches the rod. [2]

(ii) Draw a diagram to show how charge is distributed on the sphere. [1]

(iii) Explain why the uncharged sphere is attracted to the negatively-charged rod. [2]

(c) With the charged rod still close, point X on the metal-coated sphere is earthed.

(i) State what is meant by earthing the sphere. [1]

(ii) Describe and explain what happens to the free electrons in the metal-coated sphere as it is earthed. [2]

(iii) Draw a diagram to show how the charge is now distributed on the sphere. [1]

(d) Describe **one** device where electrostatic charging is used. In your answer include a diagram and explain how and why the charge is produced. [4]

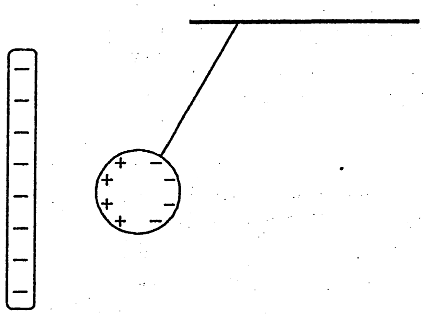
[J07/P2/Q11]

Solution

(a) The negative charges move from the cloth to the rod during their rubbing with each other. As the rod gains negative charges so it becomes negatively charged.

(b) **(i)** The electrons move to the right of the sphere due to the repulsion from the negative rod because like charges always repel.

(ii)

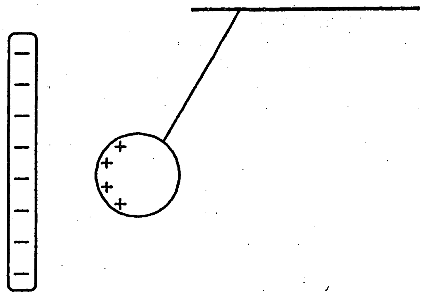


(iii) The sphere is attracted towards the negatively charged rod due to the force of attraction between the positive charges on the sphere and the negative charges on the rod which is stronger than the other force of repulsion between the negative charges on the rod and the negative charges on the sphere.

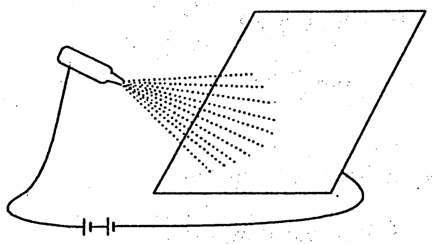
(c) (i) It means the connection of the sphere to the Earth.

(ii) The free electrons from the sphere move into the earth due to the repulsion between the electrons and the negatively charged rod.

(iii)



(d) It is used in electrostatic spray painting of metal sheets or car bodies. The metal sheet and the spray paint nozzle are given opposite charges by connecting a battery between them as shown below:



Since the nozzle is positively charged so all the droplets of paint coming out of the nozzle are positively charged and due to repulsion between like charges spread out and are attracted towards the negatively charged metal sheet. As a result a uniform coating of the paint is obtained on the surface of the metal sheet.

Question 3

A hockey player trains on a nylon-fibre surface. As he runs around, his shoes rub against the surface and he becomes positively charged.

(a) (i) Explain, in terms of the particles involved, how he becomes positively charged. [2]

(ii) State what happens to the nylon-fibre surface as he becomes positively charged. [1]

(b) At the end of the training session, the hockey player touches a metal gate and feels an electric shock.

(i) State how this shock is produced. [1]

(ii) The shock lasts for 0.15 ms. During this time, the current has an average value of 1.6 mA. Calculate the size of the charge on the hockey player just before he touches the gate. [3]

[N09/P2/Q3]

Solution

(a) (i) When the player runs around on the nylon surface and his shoes rub against the surface, some electrons are transferred from his body to the nylon-fibre surface. So, he gains a net positive charge.

(ii) As the nylon-fibre surface gains negative charges from the players' body, it becomes negatively charged.

(b) (i) On touching the metal gate, he re-gains electrons from the metal gate into his positively charged body which causes an electric shock.

(ii) $Q = I \times t$

$$= (1.6 \times 10^{-3}) \times (0.15 \times 10^{-3})$$

$$= 2.4 \times 10^{-7}\ \text{C}$$

Question 4

(a) An aeroplane becomes positively-charged as it flies through the air, because it loses particles from its metal surface.

(i) State the name of the particles lost from the metal surface. [1]

(ii) The tyres of the aeroplane are made from an electrical conductor. Explain what happens to the charge on the aeroplane when it lands. [2]

(b) Suggest why it is necessary to keep an aeroplane connected electrically to earth during refuelling. [2]

[J10/P2/Q6]

Solution

(a) (i) Electrons

(ii) The positive charge on the outer surface of the aeroplane is neutralised by the flow of electrons from the earth when the aeroplane lands on the ground.

(b) During refuelling, electrostatic charges build up on the fuel and the pipe. These opposite charges may produce sparks if they come in contact with each other. The sparks in turn may ignite the fuel and cause fire or explosion. Earthing the aeroplane, conducts the charge away to the ground and prevents explosion or fire.

Question 5

Fig. 7.1 shows two charged metal spheres.

One sphere has a positive charge and the other sphere has a negative charge.

(a) On Fig. 7.1, draw the electric field between the two spheres. [2]

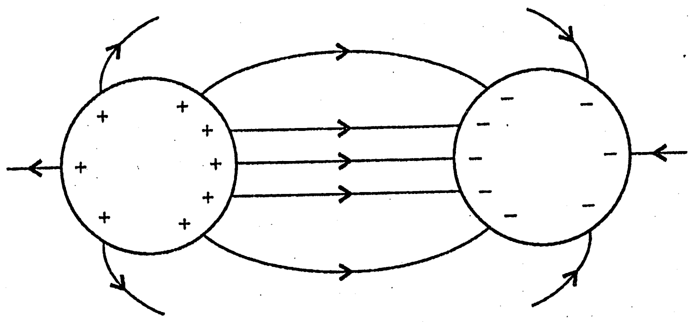
(b) The negative charge on the sphere is removed and a wire is used to connect the positive sphere to earth. The charge on the positive sphere decreases from 4.8×10^{-9} C to zero in a time of 2.0×10^{-6} s.

Calculate the average current in the wire. [2]

[J12/P2/Q7]

Solution

(a)



COMMENT on ANSWER

" (a) Draw three straight lines from one sphere to the other and some lines should spread out as they have one sphere and come together nearing the other.

Show the direction of the electric field (from +ve to −ve) on at least one line. "

(b) $Q = It \Rightarrow I = \dfrac{Q}{t}$

$$= \frac{4.8 \times 10^{-9}}{2.0 \times 10^{-6}} = 2.4 \times 10^{-3}$$

$\therefore$ current in the wire $= 2.4 \times 10^{-3}$ A.

Question 6

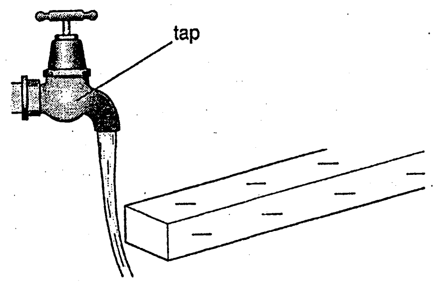
A student rubs a polythene rod with a dry cloth. The polythene rod becomes negatively charged and the cloth becomes positively charged.

(a) Describe, in terms of the movement of electrons, what happens during the charging process. [2]

(b) There is an electric field around the charged rod.

Explain what is meant by an *electric field.* [1]

(c) The charged rod is placed near a stream of water from a tap, as shown in Fig. 5.1.



The stream of water bends because the rod is charged.

(i) Explain how the charge on the rod causes positive and negative particles in the water to move. [2]

(ii) On Fig. 5.1, draw the charge present on the stream of water. [1]

[J13/P2/Q5]

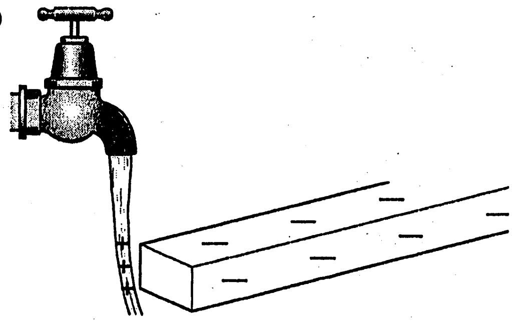
Solution

(a) During rubbing electrons move from the cloth on to the polythene rod.

(b) An electric field is a region where an electric charge experiences a force.

(c) (i) The rod attracts the positive particles of water and repels the negative particles of water.

(ii)



COMMENT on ANSWER

" (a) When charging a polythene rod by rubbing with a dry cloth, note that it is the electrons that are transferred from the surface of the cloth to the polythene rod. The positive charges are not transferred at all.

(c) According to the fundamental law which is also called the first law of electrostatics: "Like charges repel, unlike charges attract." "

Question 7

At an airport, fuel is pumped through a pipe from a tanker to an aeroplane, as shown in Fig. 6.1.

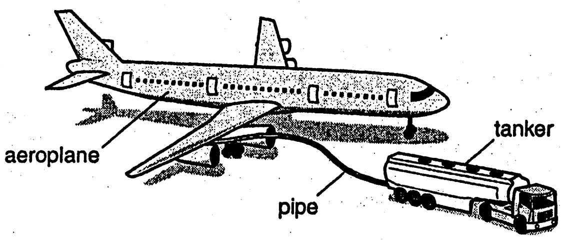


Fig. 6.1

As it rubs against the pipe, the fuel becomes negatively charged and this charges the aeroplane.

(a) Explain, in terms of the particles involved, how the fuel becomes negatively charged. [2]

(b) Suggest and explain one problem that can arise when an aeroplane becomes charged. [2]

(c) To prevent an aeroplane becoming charged, a metal cable connects the aeroplane to the ground.

Explain

(i) why the cable is made of metal, [1]

(ii) how the cable prevents the aeroplane becoming charged. [1]

[N13/P2/Q6]

Solution

(a) As the fuel rubs with the pipe, the electrons are transferred from the pipe to the fuel which makes the fuel negatively charged.

(b) A spark may jump from the charged surface of the aeroplane and ignite the fuel.

(c) (i) A metal is a good conductor of electricity due to its low resistance.

(ii) The charges on the aeroplane are earthed through the cable.

COMMENT on ANSWER

" (b) If an aeroplane becomes charged, a current may flow from the ground which may cause electric shock to the workers and the passengers of the aeroplane. "

Question 8

When a balloon is rubbed on hair, the balloon becomes negatively charged. The balloon is shown in Fig. 5.1.

Fig. 5.1

(a) Explain how rubbing causes the balloon to become negatively charged. [2]

(b) Explain why the hair is pulled towards the balloon. [2]

(c) Explain why it is important that the balloon is made from an electrical insulator. [1]

(d) State one example where static electricity is useful. [1]

[J15/P2/Q5]

Solution

(a) When the balloon is rubbed on hair, the negative charges (electrons) are transferred from the hair to the balloon. As a result, the balloon becomes negatively charged.

(b) During rubbing, the hair lose their negative charges to the balloon and they become positively charged. As the opposite charges attract, so the positively charged hair are attracted towards the negatively charged hair.

(c) It is important so that the excess negative charges on the balloon stay on it and do not flow away into the earth through the conducting body of the person.

(d) Electrostatic spray painting.

COMMENT on ANSWER

“ **(d)** Some other examples are:
- electrostatic precipitator,
- photocopier,
- flu-ash remover,
- electrostatic printing,
- crop spraying. ”

Topic 20 *Current Electricity*

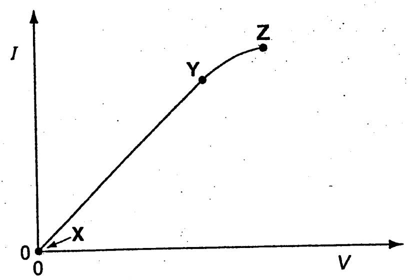
MCQ Section

1. An electrical quantity is defined as 'the energy converted by a source in driving a unit charge round a complete circuit.'
What is this quantity called?

A current
B electromotive force
C potential difference
D power

[J06/P1/Q30]

2. The diagram shows the current I / voltage V graph for a length of resistance wire.



Where can Ohm's law be applied to the wire?

A at **Y** only
B at **Z** only
C from **X** to **Y**
D from **X** to **Z**

[J06/P1/Q31]

3. Diagram 1 shows a resistor connected to a battery, an ammeter and a voltmeter.
The ammeter reading is 0.5 A and the voltmeter reading is 3.0 V.
A second identical resistor is now connected in parallel with the first resistor, as shown in diagram 2.

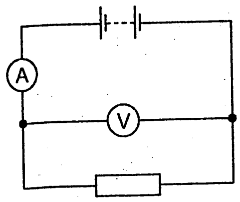


diagram 1

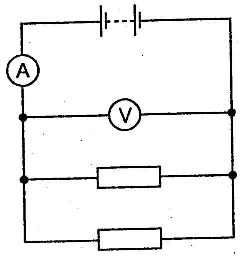


diagram 2

What are the ammeter and voltmeter readings in the circuit shown in diagram 2?

	ammeter reading/A	voltmeter reading/V
A	1.0	3.0
B	1.0	1.5
C	0.5	6.0
D	0.5	3.0

[J06/P1/Q32]

4. How much energy is converted in a resistor of 5.0 Ω carrying a current of 2.0 A for 10 seconds?

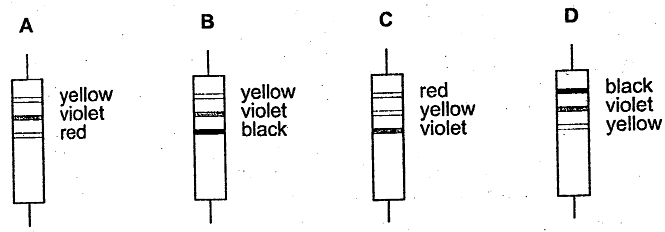
A 4.0 J
B 25 J
C 100 J
D 200 J

[J06/P1/Q33]

5. The table shows part of the colour code for resistors.

black	brown	red	orange	yellow	green	blue	violet
0	1	2	3	4	5	6	7

Which resistor has a value of 4700 Ω?



[J06/P1/Q37]

MCQ Answers

1. **B** Fact.
2. **C** Fact.
3. **A** The resistance of the resistor in diagram 1
$= \frac{V}{I} = \frac{3.0}{0.5} = 6\ \Omega$.
The effective resistance of two identical resistors in parallel $= \frac{6 \times 6}{6+6} = 3\ \Omega$.
So the current in diagram 2
$= \frac{V}{R} = \frac{3.0}{3} = 1.0$ A.
Note that the voltage of the battery remains the same in both circuits i.e. 3.0 V.
4. **D** Energy $= I^2 Rt$
$= (2.0)^2 \times (5.0) \times 10$
$= 200$ J
5. **A** Reading the colour bands from left to right, the first colour band represents the first digit, the second colour band represents the second digit and the third colour band represents the number of zeroes following the first and second digit.

6. A wire has a resistance of 8 Ω. A second wire, made of the same material, has half the length and twice the cross-sectional area.

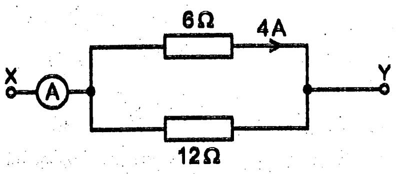
What is the resistance of the second wire?

A 1 Ω **C** 8 Ω
B 2 Ω **D** 16 Ω

[N06/P1/Q27]

7. Two resistors of 6 Ω and 12 Ω are arranged in parallel. A p.d. is connected across the terminals X and Y.

The current through the 6 Ω resistor is 4 A.



What is the current in the ammeter?

A 4 A **C** 8 A
B 6 A **D** 12 A

[N06/P1/Q28]

8. Which of the following would cost the **least** if operated from the same voltage supply?

A a 5000 W electric cooker used for 1 minute
B a 1000 W electric fire used for 10 minutes
C a 500 W electric iron used for 1 hour
D a 100 W lamp used for 1 day

[N06/P1/Q29]

9. A house-owner replaces a failed fuse for the lights of the house. When the lights are switched on, the second fuse also fails. The house-owner then uses a third fuse with a higher rating than the previous two.

Why is this **not** a sensible thing to do?

A Fuses only allow the circuit to work if the rating is exactly right.
B The third fuse will melt because the rating is too high.
C Using a fuse with too high a rating causes electric shocks.
D The circuit may work, but the fault is not corrected.

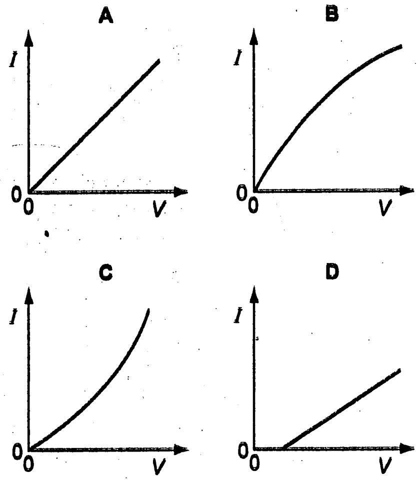
[N06/P1/Q30]

10. Which factors will both increase the resistance of a wire in a circuit?

	size of wire	temperature of wire
A	longer	lower
B	shorter	lower
C	thicker	higher
D	thinner	higher

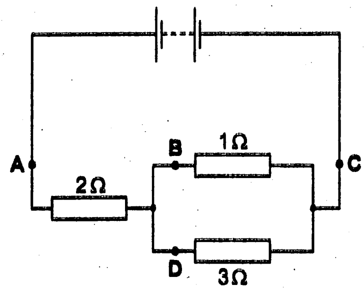
[J07/P1/Q27]

11. Which graph best represents how current I varies with voltage V in a component in which the resistance **increases** as the current **increases**.



[J07/P1/Q28]

12. At which point in the circuit is the current the smallest?



[J07/P1/Q29]

T h I n k I n G P r o c e s S

MCQ Answers

6. B Since resistance is proportional to length, the second wire should have half the resistance of the first. Since resistance is inversely proportional to cross-sectional area, the thicker second wire should have half the resistance of the first. Taking both effects into account, the resistance of the second wire is now one-quarter that of the first.

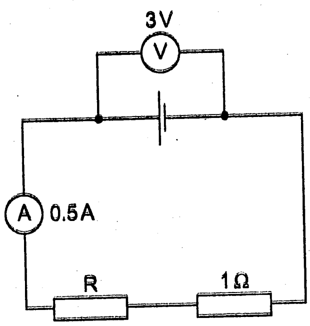
7. B Using Ohm's Law, p.d. across the 6 Ω resistor = IR = (4)(6) = 24 V. Since both resistors are in parallel, p.d. across 12 Ω resistor = p.d. across 6 Ω resistor = 24 V. Current in the 12 Ω resistor = $\frac{V}{R} = \frac{24}{12}$ = 2.0 A. Current in the ammeter = sum of currents in both resistors = 4.0 + 2.0 = 6.0 A.

8. A Using E = Pt where P is in kW and t is in hours, we can calculate the energy used in each case in kWh and compare their values.

9. D The fuse blows due to an unusually high current in the circuit. This is due to some electrical fault. Replacing the fuse with a higher rating will not correct the fault.

10. D It is a fact that the resistance of a wire increases with the increase in its temperature and decrease in its thickness since, resistance of wire ∝ temperature, and Resistance of wire ∝ $\frac{1}{\text{thickness of wire}}$

13. The diagram shows a circuit.



The ammeter has negligible resistance.

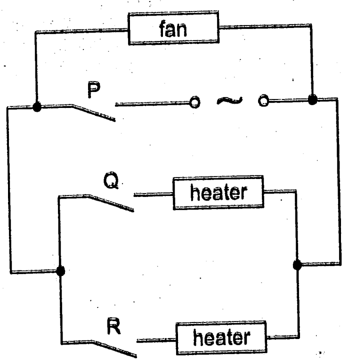
What is the resistance of the resistor R?

A 0.5 Ω **B** 1.5 Ω

C 5 Ω **D** 6 Ω

[J07/P1/Q30]

14. The diagram shows the circuit for a hair-dryer.



The fan has a power rating of 0.1 kW and the heaters each have a rating of 0.4 kW. The cost of electricity is 8 cents/kWh.

What is the cost of running the dryer for two hours with switches P and Q closed and switch R open?

A 1.6 cents

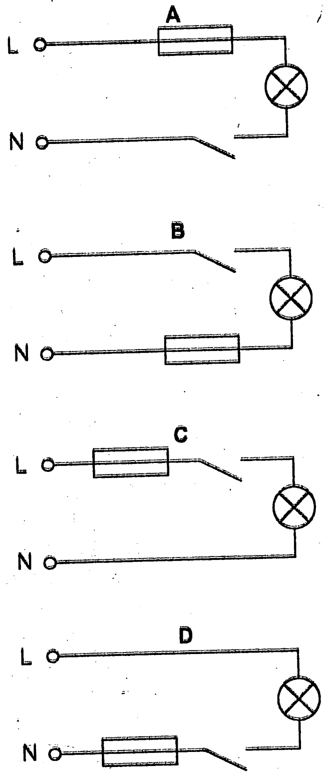
B 3.2 cents

C 6.4 cents

D 8.0 cents

[J07/P1/Q31]

15. Which circuit shows the correct positions for the fuse and the switch in the lighting circuit of a house?



key

L = live wire

N = neutral wire

[J07/P1/Q32]

16. Under which condition does Ohm's law apply?

A The current must be constant.

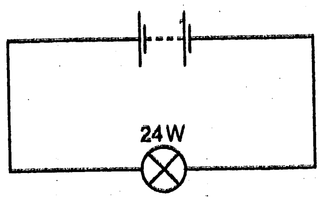
B The power must be constant.

C The temperature must be constant.

D The voltage must be constant.

[N07/P1/Q27]

17. A battery is used to light a 24 W electric lamp. The battery provides a charge of 120 C in 60 s.



MCQ Answers

11. B For increasing current (I), the graph **B** shows that the ratio $\frac{I}{V}$ (gradient) is decreasing i.e. $\frac{V}{I}$ = resistance is increasing.

12. D Current at **A** = current at **C** = (current at **B** + current at **D**). In a parallel connection, the lower current is found in the branch with a higher resistance.

13. C The combined effective resistance of the two resistors in the series circuit is:

effective resistance $= \frac{\text{voltage}}{\text{current}}$

or $(R+1) = \frac{3}{0.5}$

$R = 5\Omega$

14. D One heater and the fan work on closing the switches P and Q.

Energy consumed = Pt

$= (0.4 + 0.1) \times 2 = 1.0$ kWh

cost $= 1.0 \times 8 = 8.0$ cents

15. C The fuse and the switch must always be connected in the live wire.

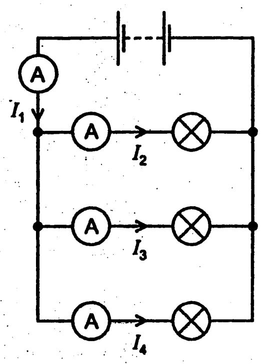
16. C This is a fact that the Ohm's law $V \propto I$ is applicable if the temperature of the conducting wire remains constant otherwise an increase in temperature of the metal conducting wire increases the resistance of the wire. As a result, the current through the wire decreases, and then the current (I) through the wire is not directly proportional to the P.D. (V) between the ends of the wire.

What is the potential difference across the bulb?

A 5 V **B** 12 V
C 24 V **D** 120 V

[N07/P1/Q28]

18. A student sets up the circuit shown.



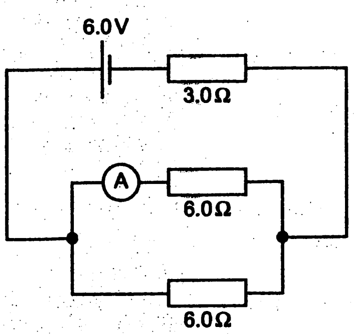
The currents measured with the ammeters are shown.

Which equation is correct?

A $I_1 = I_2 + I_3 + I_4$
B $I_1 = I_2 = I_3 = I_4$
C $I_2 + I_3 = I_4 + I_1$
D $I_4 = I_3 + I_2 + I_1$

[N07/P1/Q29]

19. The following circuit is set up.



What is the reading on the ammeter?

A 0.33 A
B 0.50 A
C 0.67 A
D 1.0 A

[N07/P1/Q30]

20. Energy is represented by the letter E, current by I, power by P, charge by Q, p.d. by V and time by t.

Which pair of equations is correct?

A $E = It$ and $P = VIt$
B $E = VQ/t$ and $P = VI$
C $E = VIt$ and $P = VI$
D $E = VQ$ and $P = VI/t$

[N07/P1/Q31]

21. The case of an electric fan is earthed. The plug to the fan contains a 5 A fuse. There is a current of 4 A when the fan works normally.

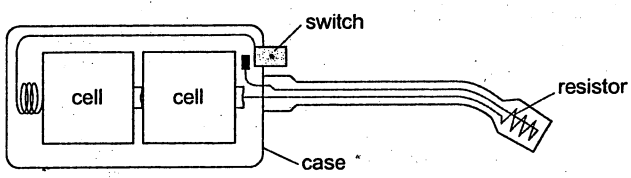
The cable to the fan becomes so worn that the live wire makes electrical contact with the metal case.

What happens?

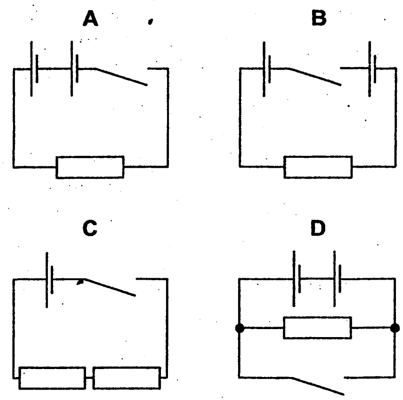
A The current flows to earth and the fuse is not affected.
B The fuse melts and switches off the circuit.
C The metal case becomes live and dangerous.
D The metal case becomes very hot.

[N07/P1/Q32]

22. The diagram shows the components of a lighter for a gas cooker.



Which circuit diagram is correct for this lighter?



[J08/P1/Q31]

MCQ Answers

17. B The current passing through the bulb

$I = \frac{Q}{t} = \frac{120}{60} = 2.0$ A.

Hence, the P.D. across the bulb is

$V = \frac{W}{I} = \frac{24}{2} = 12$ V.

18. A In a parallel circuit, the current supplied by the battery is equal to the sum of the currents passing through its branches.

19. B The effective resistance of the circuit

$= \frac{6 \times 6}{6+6} + 3 = 6.0\,\Omega$.

The total current through the battery

$= \frac{V}{R} = \frac{6.0}{6.0} = 1.0$ A

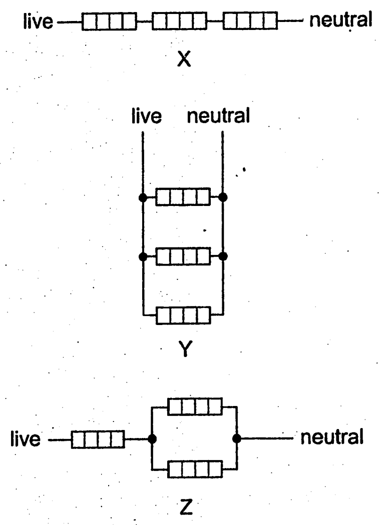
This current from the battery is equally divided in the parallel combination of two 6.0 Ω resistors.

20. C Fact.

21. B In the case of short circuiting, a large current passes through the fuse and melts it. The circuit is then switched off.

22. A The diagram of the lighter shows two cells connected in series one immediately after the other. The rest of the components are also connected in series with the battery. This arrangement is shown correctly in diagram A.

23. Three identical heating elements are wired up to the mains supply in the three arrangements shown.



In which arrangement is the current from the supply lowest and in which is it highest?

	lowest current	highest current
A	X	Z
B	X	Y
C	Y	X
D	Y	Z

[J08/P1/Q30]

24. The current in an electric heater is 10 A. It is switched on for five minutes.

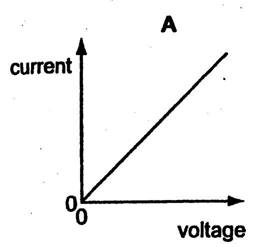
How much charge flows through the heater?

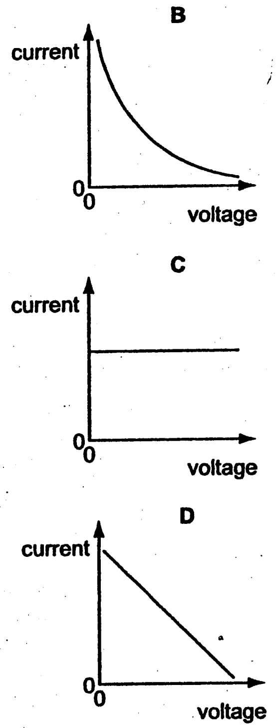
A 0.5 C **B** 2 C

C 50 C **D** 3000 C

[N08/P1/Q28]

25. Which graph shows how the current changes when the voltage across a fixed resistance is varied?

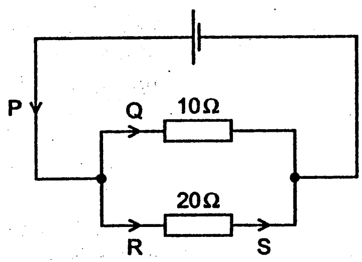




[N08/P1/Q29]

26. The circuit diagram shows a parallel arrangement of resistors.

P, Q, R and S represent the current at the points shown.



Which statement is correct?

A P is greater than Q.

B Q is equal to R.

C R is greater than S.

D S is equal to P.

[N08/P1/Q30]

27. An electric heater is rated at 3kW. Electrical energy costs 20 cents per kWh.

What is the cost of using the heater for five hours?

A 12 cents **B** 60 cents

C 100 cents **D** 300 cents

[N08/P1/Q31]

T h i n k i n G P r o c e s S

MCQ Answers

23. B The resistors arrangement X has the highest effective resistance while the arrangement Y has the lowest effective resistance and since $I \propto \frac{1}{R}$, so the lowest value of current will flow through X and the highest value of current through the Y-arrangement.

24. D $Q = I \times t$
$= 10 \times (5 \times 60)$
$= 3000$ C

25. A The gradient of a V–I graph is equal to the resistance. The graph which gives a constant (fixed) resistance is the one shown in diagram **A**. Which shows that current ∝ voltage.
It is the graph for Ohmic conductors.

26. A The current P is the total current supplied by a cell into the circuit which splits into the current Q and the current R in the two parallel branches. So, current P = current Q + current R. Hence, current P > current Q.

27. D Electrical energy consumed = 3 × 5 = 15 kwh
Total cost of the electrical energy consumed = No. of kwh used × cost per kwh = 15 × 20 = 300 cents.

28. What is the purpose of a circuit breaker in an electric circuit?

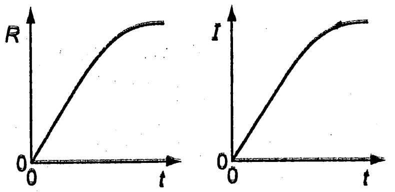
A to change alternating current into direct current
B to keep the current constant
C to prevent the current from becoming too large
D to reduce the current to a safe value.

[N08/P1/Q32]

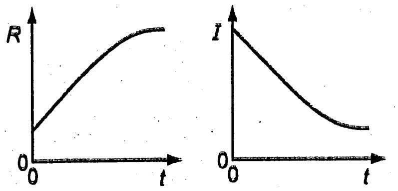
29. When a filament lamp is switched on, there is a current in the lamp. As the temperature of the filament rises, its resistance changes.

Which pair of graphs shows how the resistance R of the filament and the current I vary with time after the lamp is switched on?

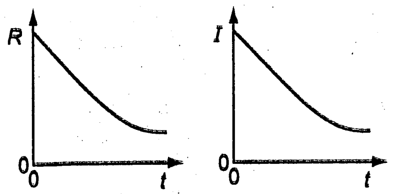
A



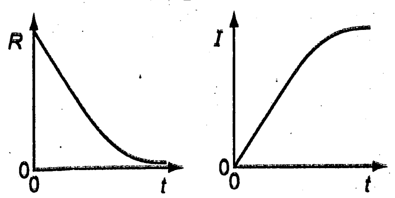
B



C



D



[J09/P1/Q26]

30. One volt can also be written as

A one coulomb per ampere.
B one coulomb per joule.
C one joule per ampere.
D one joule per coulomb.

[J09/P1/Q27]

31. A student has a chain of 20 lamps. These are wired in series and connected to the mains.

One lamp blows and all the others go out.

The student wants to find the faulty lamp and replace it.

Where should the student begin?

A anywhere, because the current was the same in each lamp
B at the live end of the chain, because the current was greatest there
C at the middle of the chain, because the current was greatest there
D at the neutral end of the chain, because the current was least there

[J09/P1/Q28]

32. An electric iron is marked 240 V, 2500 W.

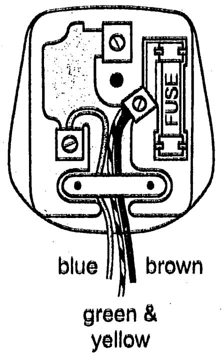
Four fuses are available with values of 5 A, 10 A, 13 A and 30 A.

Which fuse should be used?

A 5 A **B** 10 A
C 13 A **D** 30 A

[J09/P1/Q29]

33. A plug is wrongly wired as shown. It is connected to an old vacuum cleaner, which has a metal case.



Thinking Process

MCQ Answers

28. C A circuit breaker is a modified form of a fuse used to limit the amount of current in an electric circuit and prevents the flow of a large current in the circuit.

29. B When a current passes through the filament of a lamp, the temperature of the filament increases due to the heating effect of current. The increase in temperature increases the atomic vibrations in the filament and hence the resistance of the filament increases. As a result, the flow of the charge through the filament decreases.

30. D By definition, Potential difference $= \frac{\text{workdone required}}{\text{charge}}$ or 1 V = 1 J/C

31. A It is a fact that the magnitude of current is the same every where in a series circuit.

32. C The normal operating current for the electric iron $= \frac{P}{V} = \frac{2500}{240}$ = 10.42 A.

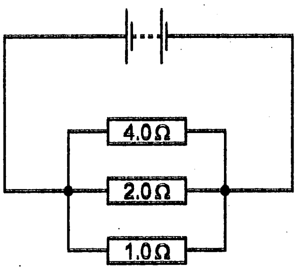
Hence, the appropriate value for the fuse for the electric iron is 13 A which is greater than but as close as possible to the normal operating current.

What is the effect of using the plug wired in this way?

A The fuse in the plug blows.
B The metal case is live.
C The neutral wire melts.
D The vacuum cleaner catches fire.

[J09/P1/Q30]

34. The circuit diagram shows three resistors in parallel with a battery.



What is the effective resistance of these three resistors?

A 0.57 Ω **B** 0.86 Ω
C 1.75 Ω **D** 7.00 Ω

[N09/P1/Q26]

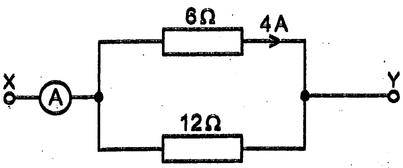
35. Ohm's law states that the current in a conductor is proportional to the potential difference across it, provided that a certain quantity remains constant.

What is this quantity?

A length **B** pressure
C temperature **D** thickness

[N09/P1/Q27]

36. Two resistors of 6 Ω and 12 Ω are arranged in parallel. A potential difference is connected across the terminals X and Y. The current in the 6 Ω resistor is 4 A.

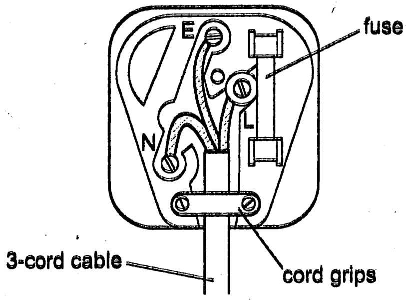


What is the current in the ammeter?

A 4 A **B** 6 A
C 8 A **D** 12 A

[N09/P1/Q28]

37. The diagram shows a standard mains plug.



key
N = neutral
E = earth
L = live

What are the correct colours for the wires?

	N	E	L
A	blue	brown	green and yellow
B	blue	green and yellow	brown
C	brown	green and yellow	blue
D	green and yellow	brown	blue

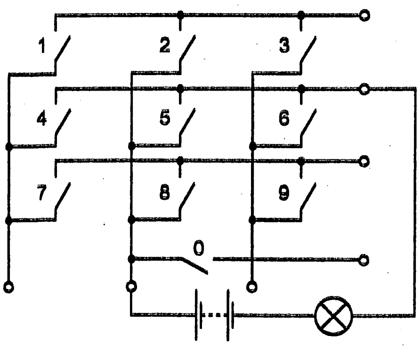
[N09/P1/Q29]

38. Which costs the **most** if operated from the same mains supply?

A a 5000 W electric cooker used for 1 minute
B a 1000 W electric fire used for 10 minutes
C a 500 W electric iron used for 1 hour
D a 100 W lamp used for 1 day

[N09/P1/Q30]

39. A student tests the circuit of a press-button telephone with a lamp and a battery.



Thinking Process

MCQ Answers

33. B The earth wire is wrongly connected to the live terminal of the plug. On Switching on the current, the metal case of the vacuum cleaner will become live and the user may get an electric shock on touching it.

34. A Let the effective resistance = R_e

$$\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R_e} = \frac{1}{4} + \frac{1}{2} + \frac{1}{1}$$

$$\frac{1}{R_e} = 0.25 + 0.5 + 1$$

$$\frac{1}{R_e} = 1.75$$

$$R_e = 0.57\,\Omega$$

35. C Fact.

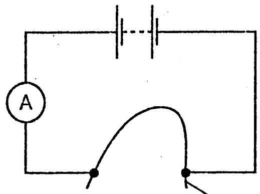
Which single switch can be pressed to make the lamp light?

A 0 **B** 1

C 5 **D** 6

[J10/P1/Q26]

40. A length of resistance wire is used as a resistor in a simple circuit.



Four separate changes are made to the wire.

Which change will **not** reduce the value of the resistance of the wire?

A It is covered in an insulating sleeve.

B Its cross-sectional area is increased.

C Its length is decreased.

D Its temperature is decreased.

[J10/P1/Q27]

41. Which quantity is measured in kilowatt-hours?

A charge **B** current

C energy **D** power

[J10/P1/Q28]

42. The metal case of an electric heater is earthed. The plug to the heater contains a 5 A fuse. There is a current of 4 A when the heater works normally.

The cable to the heater becomes so worn that the live wire makes electrical contact with the case.

What happens?

A The current flows to earth and the fuse is not affected.

B The fuse melts and switches off the circuit.

C The metal case becomes live and dangerous.

D The metal case becomes very hot.

[J10/P1/Q29]

43. Sets of voltage-current readings are obtained for different electrical components.

Which set of readings is for a 100 Ω resistor?

A	voltage/V	–3	–2	–1	0	+1	+2	+3
	current/mA	–30	–15	–5	0	+5	+15	+30
B	voltage/V	–3	–2	–1	0	+1	+2	+3
	current/mA	–30	–20	–10	0	+10	+20	+30
C	voltage/V	–3	–2	–1	0	+1	+2	+3
	current/mA	–60	–40	–20	0	+20	+40	+60
D	voltage/V	–3	–2	–1	0	+1	+2	+3
	current/mA	–60	–45	–30	0	+30	+45	+60

[J10/P1/Q30]

MCQ Answers

36. B According to the Ohm's law, P.D. across the 6Ω resistor = $IR = 4 \times 6 = 24$V

Since both resistors are in parallel, so P.D. across 12Ω resistor = P.D. across 6Ω resistor. Hence,

current in 12Ω resistor $= \frac{V}{R} = \frac{24}{12} = 2$A.

Current in ammeter = Sum of currents in both resistors

$= 4.0 + 2.0 = 6.0$A

37. B Fact.

38. D Using $E = Pt$, calculate the energy consumed in each case. The 100 W lamp used for one day consumes energy more than the others.

$E = Pt$

$= \frac{100}{1000}$kW × 24 hours = 2.4 kWh

39. C The lamp lights when the switch 5 is closed because the electric circuit is completed only when the switch 5 is closed.

40. A The covering of insulating material (e.g. plastic) on a wire does not affect the resistance of a wire because the current does not flow through the covering.

41. C In the unit 'Kilowatt-hours', the 'Kilowatt' is the unit of power and the 'hour' is the unit of time. So, kilowatt-hour = $P \times t$, where Pt = energy.

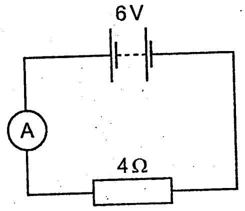
42. B The current starts flowing from the mains into the metal body of the heater and then into the ground through the earth wire.

This causes short circuiting and results in the flow of a large current. As a result the fuse melts and the circuit is switched off.

43. B All the pairs of values of V and I in option **B** give the value of $R = 100\ \Omega$, eg.

$$R = \frac{V}{I} = \frac{1}{10 \times 10^{-3}} = \frac{2}{20 \times 10^{-3}} = \frac{3}{30 \times 10^{-3}} = 100\ \Omega$$

44. A 6 V supply is connected in series with an ammeter and a 4 Ω resistor.



What is the reading on the ammeter?

A 0.67 A **B** 1.5 A
C 10 A **D** 24 A

[J10/P1/Q31]

45. Many electrical appliances have metal cases.

To prevent the case from becoming 'live', with the possibility of an electric shock, the earth wire of the electric cable is attached to the case.

How does the earth wire prevent an electric shock?

A It allows a current to flow to earth, so that the appliance continues working.

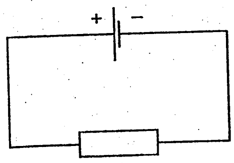
B It allows a large current to flow to earth, blowing the fuse.

C It prevents the fuse from blowing.

D It reduces the current to a safe level.

[N10/P1/Q26]

46. The diagram shows a simple electric circuit.

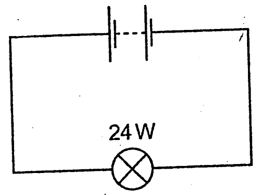


Which row describes the charge on an electron and the direction of electron flow through the resistor?

	charge on an electron	direction of electron flow
A	negative	– to +
B	negative	+ to –
C	positive	– to +
D	positive	+ to –

[N10/P1/Q28]

47. A battery is used to light a 24 W electric lamp. The battery provides a charge of 120 C in 60 s.

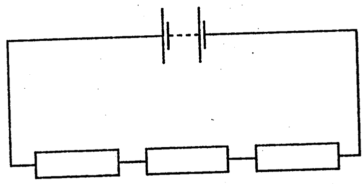


What is the potential difference across the lamp?

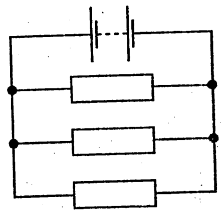
A 5 V **B** 12 V
C 24 V **D** 120 V

[N10/P1/Q30]

48. When three identical resistors are connected in series, their combined resistance is 6 Ω.



series



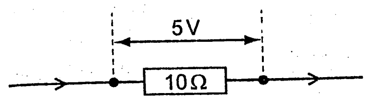
parallel

What is their combined resistance when they are connected in parallel?

A $\frac{1}{6}\Omega$ **B** $\frac{2}{3}\Omega$
C $\frac{3}{2}\Omega$ **D** 6Ω

[N10/P1/Q31]

49. The potential difference (p.d.) across a 10 Ω resistor is 5 V.



MCQ Answers

44. B By Ohm's law,
$V = IR$
$6 = I \times 4$
$I = \frac{6}{4} = 1.5\,A$

45. B The metal case of an appliance becomes live if the live wire comes in contact with the metal case. The current flows directly from the live wire to the earth via the metal case. Since the main circuit of the appliance is by passed, the resistance of this connection is largely reduced. Hence a large current flows which overheats the fuse and it blows.

46. A The electrons always flow from the negative terminal to the positive terminal of a battery and the conventional current flows from the positive terminal to the negative terminal of the battery.

47. B As $Q = It$
$120 = I \times 60$
$\therefore I = 2A$

Also $P = VI$
$24 = V \times 2$
$V = 12\,V$

48. B In series, the combined resistance of three resistors = 6 Ω
So, the resistance of each resistor = 2 Ω
When connected in parallel, their combined resistance will be:
$\frac{1}{R_C} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$
$= \frac{1}{2} + \frac{1}{2} + \frac{1}{2}$
$R_C = \frac{2}{3}\,\Omega$

How much charge passes through the 10 Ω resistor in 30 seconds?

A 2 C **B** 15 C
C 60 C **D** 1500 C

[J11/P1/Q27]

50. Which changes both cause a decrease in the resistance of a copper wire?

	size of wire	temperature of wire
A	decrease in length	lower
B	increase in length	lower
C	decrease in thickness	higher
D	increase in thickness	higher

[J11/P1/Q28]

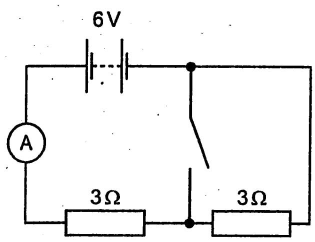
51. A lamp rated 6 V, 2 A is switched on for 60 s.

How much energy is used?

A 0.2 J **B** 20 J
C 180 J **D** 720 J

[J11/P1/Q30]

52. The diagram shows a circuit.

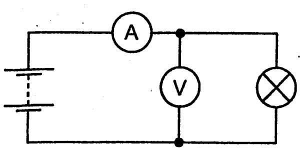


What is the reading on the ammeter when the switch is open, and the reading when it is closed?

	ammeter reading when open / A	ammeter reading when closed / A
A	1	1
B	1	2
C	2	1
D	2	2

[J11/P1/Q31]

53. The diagram shows a circuit.



The lamp is a 12 W lamp and is working at normal brightness.

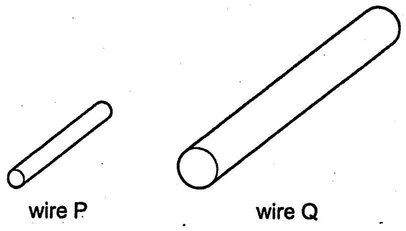
What are the readings on the meters?

	voltmeter reading / V	ammeter reading / A
A	6	0.5
B	12	0.5
C	12	1
D	24	2

[J11/P1/Q32]

54. The resistance of a cylindrical wire P is 80 Ω. A second wire Q is made from the same material.

The cross-sectional area of Q is four times that of P. The length of Q is twice the length of P.



What is the resistance of Q?

A 10 Ω **B** 40 Ω
C 160 Ω **D** 640 Ω

[N11/P1/Q27]

55. Which appliance used on a 240 V supply is **most** likely to burn out its fuse?

	appliance	fuse
A	100 W lamp	1 A
B	1 kW vacuum cleaner	5 A
C	2 kW fan heater	3 A
D	3 kW electric fire	13 A

[N11/P1/Q30]

56. The current in a filament lamp is 0.25 A when working normally. The lamp is connected to a plug and the mains a.c. supply.

When the lamp is switched on, it does not light.

What is a possible cause for this?

MCQ Answers

49. B
Charge = current × time
where
current $= \frac{V}{R} = \frac{5}{10} = 0.5$ A
Hence $Q = I \times t$
$= 0.5 \times 30$
$= 15$ C

50. A Since $R \propto \frac{l}{A}$.
Hence a decrease in the length of a wire and a decrease in its temperature, both cause a decrease in the resistance of the wire.

51. D $E = VIt$
$= 6 \times 2 \times 60 = 720$ J

52. B When the switch is open, the two resistors are in series and the total resistance in the circuit $= 6\ \Omega$. Hence the current in the circuit and the reading of the ammeter $= \frac{V}{R} = \frac{6}{6} = 1.0$ A.
When the switch is closed, the resistor on the right is short-circuited and the current does not pass through it. So the total resistance in the circuit is then 3 Ω and the value of the current through the ammeter is:
$I = \frac{V}{R} = \frac{6}{3} = 2$ A.

53. C $P = V \times I$
$= 12 \times 1 = 12$ W

54. B As $R \propto \frac{l}{A}$, if the length of the wire is doubled, the resistance is doubled. If the crosssectional area is made four times, the resistance becomes one fourth. The combination of the two will reduce the resistance to half.

A The earth wire in the plug is not connected.

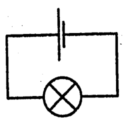
B The fuse in the plug is 3 A.

C The lamp only works on a d.c. power supply.

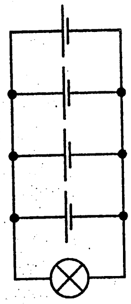
D The live wire in the plug is not connected.

[N11/P1/Q31]

57. A lamp, designed to work at 1.5 V, is connected to a cell of electromotive force (e.m.f.) 1.5 V. The lamp lights at normal brightness.



The lamp is now connected to four similar cells, each of e.m.f. 1.5 V, arranged in parallel.



What is the effect of connecting the extra cells in this way?

A The lamp burns out.

B The lamp is dimmer.

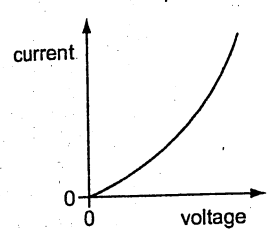
C The lamp produces light for a longer time.

D The lamp produces light for a shorter time.

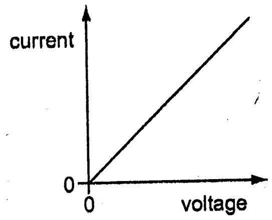
[N11/P1/Q32]

58. The current / voltage graphs are for different electrical components

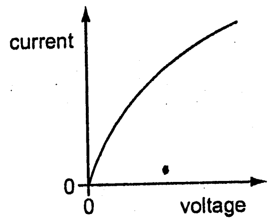
1



2



3

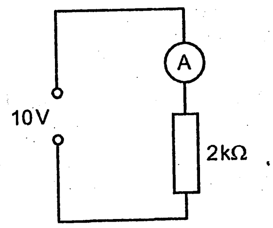


Which graph is for a resistor at constant temperature and which is for a filament lamp?

	resistor	lamp
A	1	2
B	2	1
C	2	3
D	3	2

[J12/P1/Q28]

59. The diagram shows an ammeter connected in a circuit.



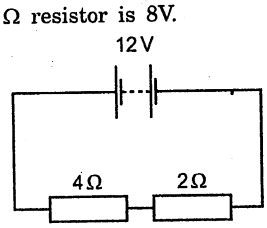
What is the current in the ammeter?

A 5 mA **B** 20 mA

C 0.2 A **D** 5 A

[J12/P1/Q29]

60. In the circuit shown, the potential difference (p.d.) across the 4 Ω resistor is 8V.



MCQ Answers

55. C Power = p.d. × current. The normal operating current for fan heater is $I = \frac{2000}{240} = 8.33$ A. This value is more than the given fuse rating. Hence the fan heater is most likely to burn out its fuse.

56. D The normal operating current for filament lamp is 0.25 A which is less then the fuse rating (3A). So the possible cause is "the live wire in the plug is not connected".

57. C When cells are connected in parallel, there is less drain on the cells since they share the total current, therefore they have a longer battery life.

58. C At a constant temperature, the current through a fixed resistor is directly proportional to the voltage applied ($I \propto V$) and graphically, it is represented by a straight line passing through the origin as shown in graph 2.
In a filament lamp, the resistance of its filament increases as the current passes through it. Due to the increase in the resistance, the amount of current does not increase proportionally with the increase in voltage i.e. less increase in current takes place than before although the increase in voltage is the same as before, as shown in graph 3.

59. A By Ohm's law,

$$V = IR$$
$$10 = I \times 2000$$
$$I = \frac{10}{2000}$$
$$= 0.005 \text{ A}$$
$$= 5.0 \text{ mA}$$

What is the p.d. across the 2 Ω resistor ?

A 4 V **B** 6 V
C 8 V **D** 16 V

[J12/P1/Q30]

61. A lamp is rated at 12 V, 600 mW. What is the current in the lamp?

A 20mA **B** 50mA
C 2.0A **D** 5.0A

[J12/P1/Q31]

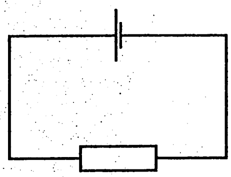
62. A water heater uses 6kW of electric power when connected to a 240 V circuit.

Which fuse is **most** suitable for use in this circuit?

A 5A **B** 13A
C 30A **D** 50A

[J12/P1/Q32]

63. The electrical circuit shown consists of a cell connected to a resistor.



What are the directions of the electron flow and of the conventional current in the **resistor**?

	electron flow	conventional current
A	→	→
B	→	←
C	←	←
D	←	→

[J12/P1/Q37]

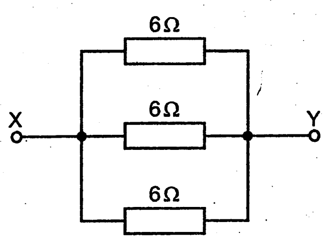
64. A metal wire has length l and cross-sectional area A.

What is the resistance proportional to?

A $A+l$ **B** $\frac{A}{l}$
C $\frac{l}{A}$ **D** $l \times A$

[N12/P1/Q28]

65. A student joins three 6Ω resistors as shown in the diagram.

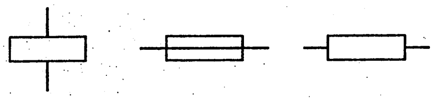


What is the total resistance between points X and Y?

A 0.5 Ω **B** 2 Ω
C 6 Ω **D** 18 Ω

[N12/P1/Q29]

66. P, Q and R are electrical symbols.



P Q R

What do these symbols represent?

	P	Q	R
A	fuse	resistor	relay coil
B	relay coil	fuse	resistor
C	relay coil	resistor	fuse
D	resistor	fuse	relay coil

[N12/P1/Q30]

67. A lamp is rated at 60 W on a 240 V supply.

What is the current in the lamp when used normally?

A 0.25 A **B** 4.0 A
C 60 A **D** 180 A

[N12/P1/Q31]

68. The cost of electricity is 16 c per kWh.

What is the cost of using a 3 kW heater for 4 hours?

A $\frac{3\times4}{16}$c

B $\frac{3\times16}{4}$c

C $4\times3\times16$c

D $4\times3\times60\times16$c

[N12/P1/Q32]

Thinking Process

60. A By definition, Total EMF of battery = [P.D. across 4Ω resistor + P.D. accross 2Ω resistor]

Total EMF $= V_1 + V_2$

$12 = 8 + V_2$

Hence, $V_2 = 12 - 8$

P.D. accross 2Ω resistor $= 4$ V

OR

Current in the series circuit (I) $= \frac{V}{R} = \frac{12}{6} = 2$ A

Hence, the P.D. accross 2Ω resistor (V) $= IR = 2\times2 = 4$ V

61. B By definition, $P = V\times I \Rightarrow I = \frac{P}{V}$

$I = \frac{600\times10^{-3}}{12}$

$= 50\times10^{-3}$ A $= 50$mA

62. C The normal operating current (I)

$I = \frac{P}{V} = \frac{6000}{240} = 25$ A

Since the value of the fuse must be a little higher than the normal operating current of this water heater. So, the suitable value of the fuse for the heater is 30 A.

63. D Fact

64. C Fact.

65. B Let the total resistance $= R_T$

So, $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$= \frac{1}{6} + \frac{1}{6} + \frac{1}{6}$

$\frac{1}{R_T} = \frac{1+1+1}{6} = \frac{3}{6}$

$R_T = 2$Ω

66. B Fact.

67. A $P = VI$

$60 = 240\times I$

or $I = \frac{60}{240} = 0.25$ A

68. C Cost = (no. of Kwh used) × (cost of one Kwh)

= (3Kw × 4 hours) × (16 c)

$= 3\times4\times16$

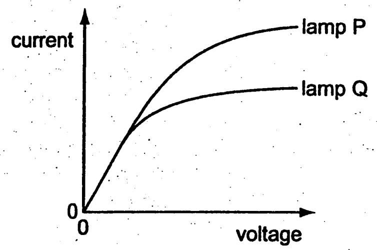
69. A lightning flash carries 40 C of charge and lasts for 5.0 ms.

What is the average current in the flash?

A 0.20 A **B** 8.0 A
C 200 A **D** 8000 A

[J13/P1/Q32]

70. The diagram shows the current-voltage graph of two filament lamps.



Which statement is correct?

A Lamp P has a lower resistance than lamp Q at all currents.

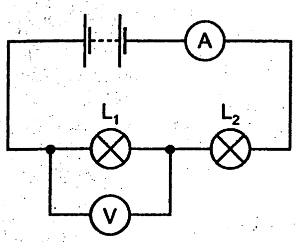
B Lamp P has the same resistance as lamp Q at low currents.

C Lamp P has the same resistance as lamp Q at high currents.

D Lamp P has a higher resistance than lamp Q at all currents.

[J13/P1/Q33]

71. A circuit containing two lamps L_1 and L_2 is connected as shown.



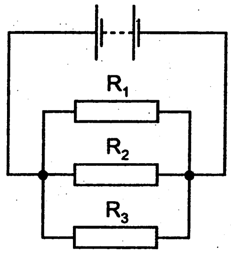
A voltmeter measures the potential difference across the lamp L_1.

The filament of lamp L_1 breaks. What happens to the readings of the ammeter and of the voltmeter?

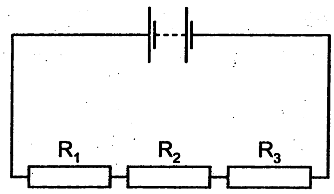
	reading on the ammeter	reading on the voltmeter
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

[J13/P1/Q34]

72. In the circuits P and Q below, resistors R_1, R_2 and R_3 have different resistances.



circuit P



circuit Q

In which circuit are the currents in the resistors equal and in which circuit are the potential differences across the resistors equal?

	currents equal	potential differences equal
A	P	P
B	P	Q
C	Q	P
D	Q	Q

[J13/P1/Q35]

73. Five electrical appliances are connected to the same socket and there is a very large current.

Why is this dangerous?

A The fuses blow in the appliances.

B There is a greater risk of an electrical shock.

C There is overheating in each appliance.

D There is overheating in the socket.

[J13/P1/Q36]

MCQ Answers

69. D $I = \frac{Q}{T}$
$= \frac{40}{5.0\times10^{-3}}$
$= 8{,}000\,A$

Note: Change the time = 5.0 millisecond into seconds.

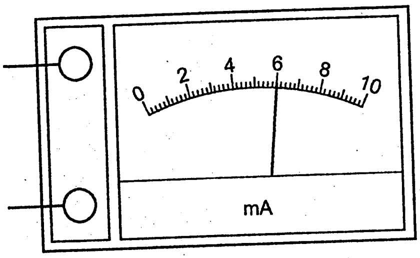
70. B The graph shows that at low values of currents, the resistance of both the lamps is the same but at high values of currents, the resistance of the lamp Q is greater than the lamp P.

71. B When the filament of lamp L_1 breaks, the current in the circuit decreases to zero. This causes a decrease in the voltage across lamp L_2. With less voltage across L_2 the voltage across L_1 increases.

72. C The circuit Q is a series circuit, so the amount of current passing through each resistor is equal and in circuit P, being a parallel circuit, the potential differences across the resistors are equal.

73. D The flow of current in a conductor produces heating effect. Connecting several electric appliances to the same socket and draw a large amount of current from one socket causes overheating in the socket.

74. An ammeter is used to measure the current in a 300 Ω resistor. The ammeter is shown below.

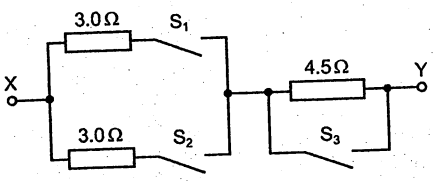


What is the potential difference across the resistor?

A 0.050 V **B** 1.8 V
C 50 V **D** 1800 V

[N13/P1/Q28]

75. The diagram shows a circuit in which all the switches are open.

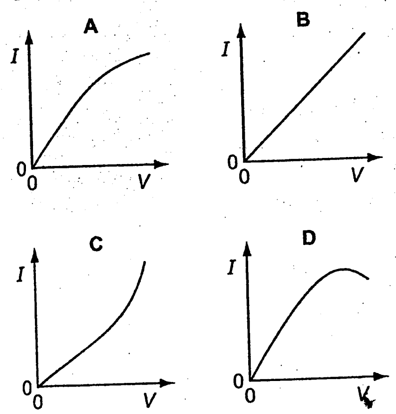


Which switch positions give a resistance of 6.0 Ω between X and Y?

	S_1	S_2	S_3
A	closed	closed	closed
B	closed	closed	open
C	closed	open	closed
D	closed	open	open

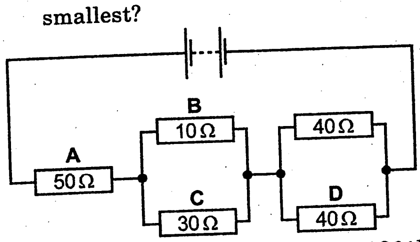
[N13/P1/Q29]

76. Which is the current/voltage (I/V) graph of a filament lamp?



[N13/P1/Q30]

77. The diagram shows a circuit containing five resistors connected to a battery.
In which resistor is the current the smallest?



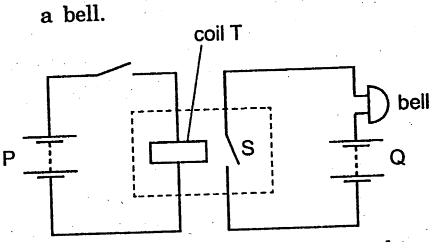
[N13/P1/Q31]

78. An appliance uses a current of 3 A.
Which row is correct for the fuse in this appliance?

	most suitable fuse rating / A	fuse connected in
A	5	earth wire
B	5	live wire
C	13	earth wire
D	13	live wire

[J14/P1/Q33]

79. A relay is used in a circuit containing a bell.



How can the apparatus be altered to make the sound of the bell louder?

A increase the number of turns on coil T

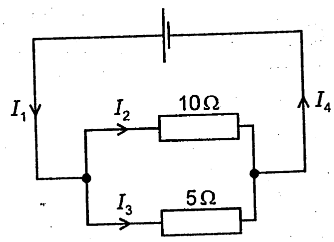
B increase the voltage of battery P

C increase the voltage of battery Q

D move the coil closer to switch S

[J14/P1/Q35]

80. The currents in different parts of the circuit are I_1, I_2, I_3 and I_4.



MCQ Answers

74. B $V = IR$

$\therefore V = (6\times10^{-3})(300)$
$= 1.8$ V

Note: change the value of current in milliamperes to Amperes.

75. B The total resistance between X and Y will be equal to 6.0 Ω if current passes through all the three resistors by closing the switches S_1 + S_2 and keeping the switch S_3 open.
Hence,

$$\text{Total } R = \frac{R_1 \times R_2}{R_1 + R_2} + R_3$$
$$= \frac{3.0\times3.0}{(3.0+3.0)} + 4.5$$
$$= 6.0\ \Omega$$

76. A At high voltages, the amount of current flowing through the filament decreases due to the increase in the temperature and hence the resistance of filament.

77. C A maximum current passes through the resistor **A** which divides when passing through the parallel resistors **B** and **C**. The resistor **C** being a greater resistance than **B**, a smaller current will pass through **C**.

78. B A fuse should always be connected to the live wire and it's value should be a little above the appliances current value.

79. C When coil T energizes, switch S closes. At this point, the voltage of battery Q is dissipated entirely across the bell, assuming that switch S is ideal. Hence, the more the voltage of battery Q, the louder the sound of the bell.

Which statement is correct?

A $I_1 = I_4$ and I_2 is greater than I_3.

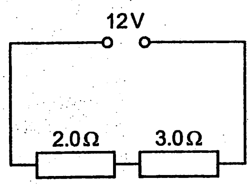
B $I_1 = I_4$ and I_3 is greater than I_2.

C I_2 is greater than I_1 and less than I_3.

D I_2 is greater than I_1 and greater than I_3.

[N14/P1/Q25]

81. The diagram shows a circuit that has two resistors in series with a 12 V supply.



What is the current in the circuit?

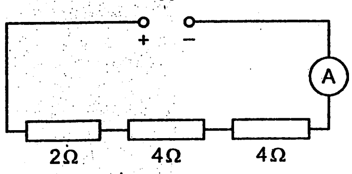
A 2.4 A **B** 10 A
C 14 A **D** 60 A

[N14/P1/Q26]

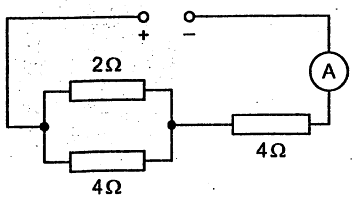
82. An ammeter is connected to three resistors and a power supply.

Which arrangement of resistors gives the greatest ammeter reading?

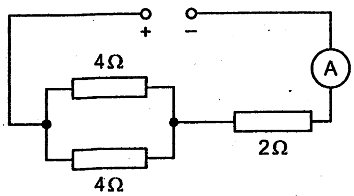
A



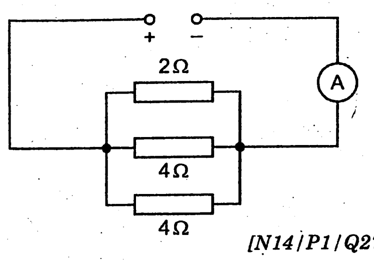
B



C



D



[N14/P1/Q27]

83. There is a current of 0.25 A in a lamp connected to a 240 V supply.

What is the input power to the lamp?

A 15 W **B** 60 W
C 240 W **D** 960 W

[N14/P1/Q28]

84. Which unit measures the energy input to an electrical appliance?

A ampere **B** kilowatt-hour
C volt **D** watt

[N14/P1/Q29]

85. An electric lamp is marked 0.5 A. It is connected to a socket marked '30 A maximum'.

Which fuse is best to use in the lamp?

A 0.5 A **B** 3 A
C 30 A **D** 40 A

[N14/P1/Q30]

86. Why is a reed relay used in a switching circuit?

A to switch on a small current using a large current

B to switch on a small voltage using a large voltage

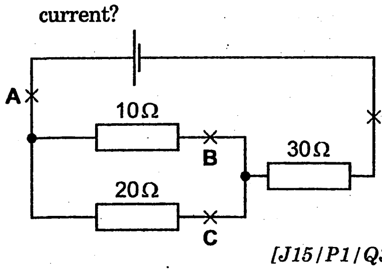
C to switch on a large current using a small current

D to switch on a large voltage using a large current

[N14/P1/Q37]

87. The diagram shows a circuit.

Where must an ammeter be connected to measure the smallest current?



[J15/P1/Q33]

MCQ Answers

80. B $I_1 = I_2 + I_3$
Since the voltage across the 10 Ω and 5 Ω resistor is same, $I_2 < I_3$.

81. A Total resistance = 5.0 Ω
Current in the circuit $= \frac{V}{R} = \frac{12}{5} = 2.4$ A.

82. D When all three resistors are connected in parallel, they provide the least combined resistance. Hence the ammeter reading is greatest in option **D**.

83. B Input power
= voltage × current
= 0.25 × 240
= 60 W.

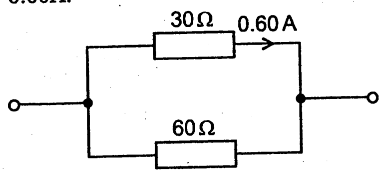
84. B Fact.

85. B The value of the fuse should be a little higher than the marked value of current on the appliance.

86. C Fact.

87. C The total current coming out of the battery passes through **A** when entering the circuit and the same maximum current passes through point **D** on returning back to the battery. This maximum current splits up and a larger portion of this current passes through the branch **B** and a smaller portion of it passes through **C**. Hence, an ammeter connected at **C** will measure the smallest amount of current.

88. Two resistors of resistances 30 Ω and 60 Ω are arranged in parallel. The current in the 30 Ω resistor is 0.60A.

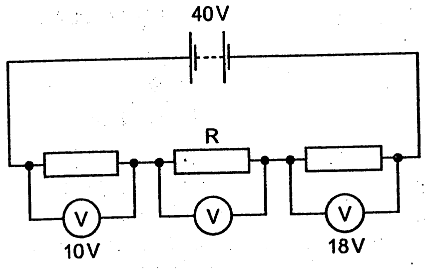


What is the potential difference across the 60 Ω resistor?

A 9.0 V **B** 18 V
C 36 V **D** 54 V

[J15/P1/Q34]

89. The circuit shows three resistors in series connected to a battery. Each resistor has a voltmeter across it and two of the voltages are shown.



What is the potential difference (p.d.) across the resistor R?

A 12 V **B** 22 V
C 30 V **D** 68 V

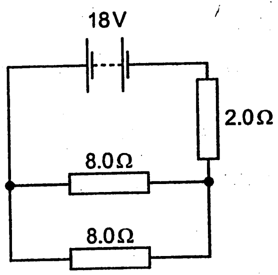
[J15/P1/Q35]

90. Which row correctly names an electrical conductor and an insulator?

	electrical conductor	insulator
A	aluminium	iron
B	iron	rubber
C	plastic	aluminium
D	rubber	plastic

[N15/P1/Q29]

91. A power supply of 18 V is connected to three resistors, as shown.



What is the potential difference across the 2.0 Ω resistor?

A 2.0 V **B** 3.6 V
C 6.0 V **D** 12 V

[N15/P1/Q33]

92. An immersion heater is labelled 24 V, 120 W.

What is the current in the heater when it is connected to a 24 V supply?

A 0.20 A **B** 5.0 A
C 24 A **D** 120 A

[N15/P1/Q34]

MCQ Answers

88. B The potential difference across 30 Ω resistor is given by
$V = IR$
$= 0.60 \times 30 = 18$ V
As both 30 Ω and 60 Ω resistors are parallel to each other, so the P.D. across the 60 Ω resistor is also 18 V.

89. A It is a fact, that in a series circuit, the sum of the potential differences across each component is equal to the potential difference across the whole circuit which is known as the EMF of the battery.
So, EMF of battery
$= V_1 + V_2 + V_3$
$40 = 10 + V + 18$
$V = 12$ V

90. B Fact

91. C
Total resistance in the circuit $= 2 + \left(\frac{8\times 8}{8+8}\right) = 6\Omega$
total current in the circuit:
$I = \frac{V}{R} = \frac{18}{6} = 3A$
p.d. across 2.0Ω resistor:
$V = IR$
$= 3 \times 2 = 6V$

92. B $P = V \times I$
$120 = 24 \times I$
$I = 5.0$ A

Topic 20 Current Electricity

THEORY Section

Question 1

Fig. 6.1 shows a mains extension lead. The six sockets allow several electrical appliances to be connected to the mains supply through one cable.

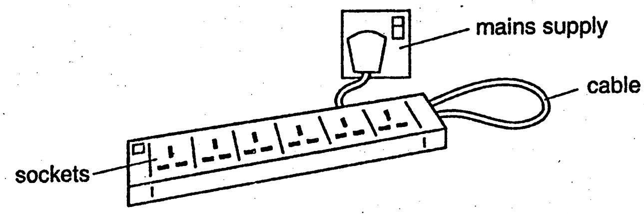


Fig. 6.1

(a) The cable connects the sockets to the mains supply.

The cable contains three wires: live, neutral and earth. State what is meant by

(i) *live,* [1]

(ii) *neutral,* [1]

(iii) *earth,* [1]

(b) Six powerful lamps are plugged into the sockets and switched on, one by one.

(i) State what happens in the cable as the lamps are switched on, one by one. [1]

(ii) Describe why it can be dangerous when a fuse of the wrong value is used in the plug. [1]

(c) Explain why your hands should be dry when you put a plug into a socket. [1]

[J06/P2/Q6]

Solution

(a) (i) The live wire means the wire at a high voltage.

(ii) The neutral wire means the wire at zero voltage.

(iii) The earth wire is at zero voltage and is connected to the ground.

(b) (i) The amount of current in the cable increases as the number of lamps switched on increases.

(ii) A fuse of a wrong value can allow more current to pass through the cable. This would cause overheating and melting of the cable.

(c) The hands of person should be dry when putting a plug into a socket to avoid an electric shock.

COMMENT on ANSWER

" **(a)** **(i), (ii), (iii)** The live wire being at a high potential is also called the dangerous wire and the neutral wire being at zero voltage or low potential, is considered as a safe wire.

The earth wire provides a connection between the body of an electrical appliance and the ground to allow the current to pass from the body of the electric appliance into the ground in case the body of the appliance becomes live due to some electrical fault.

(b) **(i)** The increase in the current also heats up the cable.

(c) The plastic body of a plug prevents the direct contact between the hands of a person and the high voltage in the socket.

A thin layer of water on wet hands makes the plug also wet and provides a contact between the wet hands and the metal conductor. The water being a conductor provides a path to the current to flow from the socket at high potential to the ground at low potential through the body of the person. Which may cause the electrocution of the person. "

Question 2

Fig. 11.1 shows a wiring diagram for two different lamps A and B.

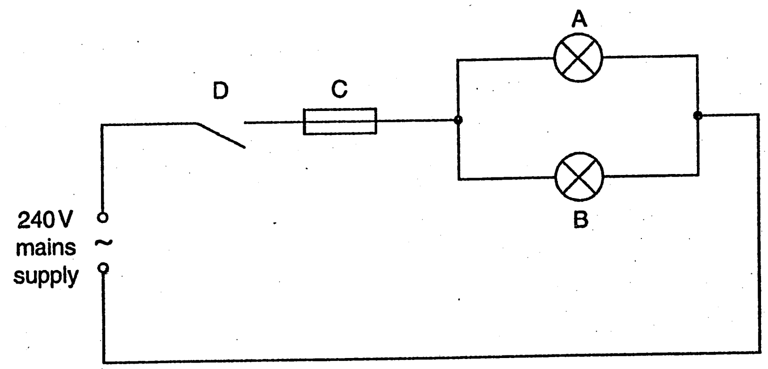


Fig. 11.1

(a) State the names of components C and D and explain the purpose, in this circuit, of each of these components. [4]

(b) When both lamps are working correctly, the current in C is 0.42 A. Lamp A is marked 240 V, 60 W. Calculate

(i) the current in lamp A, [2]

(ii) the current in lamp B, [2]

(iii) the resistance of lamp A. [3]

(c) The two lamps in Fig. 11.1 are connected in parallel. When wiring the circuit in a house, an electrician makes a mistake and connects the two lamps in series to the mains supply. He switches them on.

(i) Draw a circuit diagram showing the two lamps connected in series to the mains supply. [1]

(ii) State whether the current in the two lamps is larger than, the same as, or smaller than the currents you have calculated in **(b)**. Explain your answer. [2]

(b) Another lamp is made using the same material for the filament as lamp A.

The filament in this new lamp has the same length as the filament in lamp A but has half the cross-sectional area.

State the resistance of the new lamp. [1]

[J06/P2/Q11]

Solution

(a) The component C is a fuse which limits the amount of current in the circuit.

The component D is a switch which is used to turn the current ON and OFF in the circuit.

(b) (i) $P = V \times I$

$60 = 240 \times I$

$I = \frac{60}{240} = 0.25\text{ A}$

COMMENT on ANSWER

“ **(a)** Note that a fuse limits the value of the current in an electric circuit and it is wrong to say that it controls the current in the circuit. ”

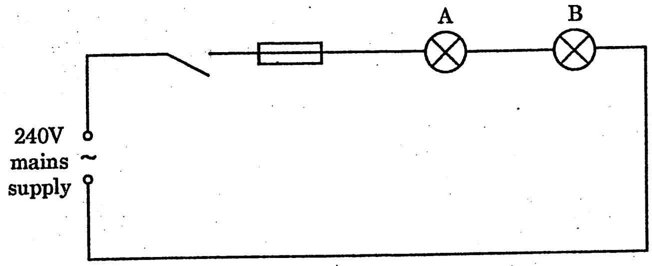
(ii) Current in C (I_C) = current in A (I_A) + current in B (I_B)

$$0.42 = 0.25 + I_B$$

$$I_B = 0.42 - 0.25 = 0.17 \text{ A}$$

(iii) resistance of lamp A: $R = \frac{V}{I} = \frac{240}{0.25} = 960\ \Omega$

(c) (i)



(ii) The effective resistance in the circuit increases when the lamps are connected in series so the amount of current passing through them now is smaller than the previous value as:

$$\text{current} \propto \frac{1}{\text{resistance}}$$

(d) As resistance of a wire $\propto \frac{1}{\text{cross-sectional area of wire}}$

So, the resistance of the filament of the new lamp becomes twice as large on reducing its cross-sectional area to half.

Hence, the resistance of the new lamp $= 2 \times 960 = 1920\ \Omega$

COMMENT on ANSWER

“(c) (ii) According to Ohm's law, $I = \frac{V}{R}$. since the voltage remains constant, therefore, $I \propto \frac{1}{R}$. Hence, the current in an electric circuit decreases with the increase in the total resistance in the circuit. Also, in parallel circuit, each lamp has a 240 V across it whereas in connecting the lamps in series, the voltage is divided between them and each lamp has now a p.d. of 120 V across it so the current through each lamp would be smaller than the previous value.”

Question 3

Fig. 8.1 shows an electrical circuit containing two resistors.

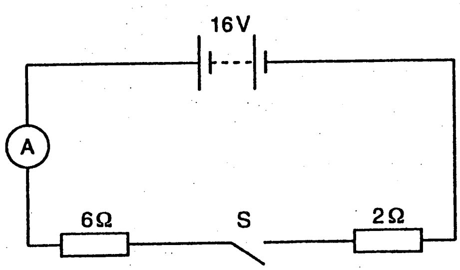


Fig. 8.1

(a) When switch S is open, the ammeter reading is zero. State the value of the potential difference across switch S. [1]

(b) Switch S is now closed.

(i) Calculate the current in the ammeter. State clearly the formula that you use. [3]

(ii) Calculate the potential difference across the 6 Ω resistor. [1]

(iii) The 2 Ω resistor is removed and replaced by a different resistor. The potential difference across the 6 Ω resistor becomes 9.0 V. Calculate the resistance of the new resistor. [3]

[N06/P2/Q8]

Solution

(a) 16 V

(b) (i) current = $\frac{V}{R} = \frac{16}{8}$ = 2.0 A.

(ii) p.d. = IR = (2.0)(6) = 12 V

(iii) new current in the 6 Ω resistor = $\frac{V}{R} = \frac{9.0}{6}$ = 1.5 A.

resistance of new resistor = $\frac{V}{I} = \frac{7.0}{1.5}$ = 4.7 Ω

COMMENT on ANSWER

“(a) Since there is no current, p.d. across both resistors and ammeter is 0. Hence the p.d. across the switch is equal to the p.d. across the power supply.

(b) (i) Since the two resistors are in series, effective resistance = (6 + 2) = 8 Ω.

(ii) Apply Ohm's Law to the fixed resistor.

(iii) Since the two resistors are still in series, they have the same current. Also the sum of the p.d. of both resistors = 16 V.”

Question 4

The table lamp shown in Fig. 10.1 is made from plastic. It has only two wires in the cable. The lamp has a power rating of 100 W and is used on a 230 V supply.

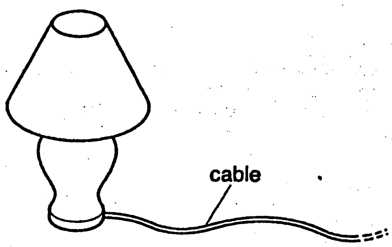


Fig. 10.1

(a) (i) State which wire, earth, live or neutral, is **not** needed in the cable for the table lamp. [1]

(ii) Explain why the lamp is safe to use even though it has only two wires. [2]

(b) (i) Explain what is meant by a *power rating of 100 W*. [2]

(ii) Calculate the value of the fuse that should be used in the plug for this table lamp. [3]

(iii) Calculate the electrical energy supplied to the lamp in 30 minutes. [2]

[N06/P2/Q10]

Solution

(a) (i) earth wire is not needed.

(ii) Since the exterior is an electrical insulator, there is no risk of getting an electric shock from the exterior.

(b) (i) The lamp converts 100 J of electrical energy to other forms of energy in 1 s.

COMMENT on ANSWER

“(a) (i) The live and neutral must be present in order for a current to flow.

(ii) The lamp uses double-insulation and so the earth wire is not required.”

(ii) When used with a 230 V supply, current = $\frac{P}{V} = \frac{100}{230}$ = 0.43 A

Fuse rating of fuse is 0.5 A.

(iii) energy supplied = Pt = (100)(30 × 60) = 180 000 J

COMMENT on ANSWER

" (b) (ii) The fuse rating of the fuse must be slightly greater than the normal operating current. "

Question 5

Fig. 7.1 shows an electrical circuit containing a 12 V power supply and a number of resistors.

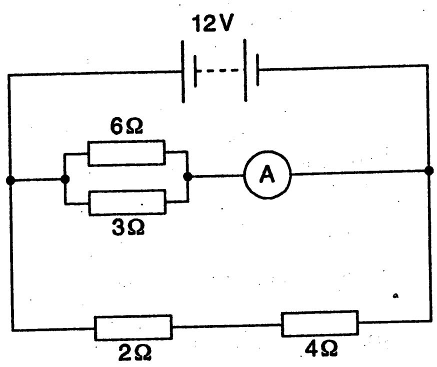


Fig. 7.1

(a) Calculate the combined resistance of

(i) the 2 Ω and 4 Ω resistors in series, [1]

(ii) the 3 Ω and 6 Ω resistors in parallel. [2]

(b) Calculate the reading of the ammeter in Fig. 7.1. [2]

(c) Determine the potential difference across the 4 Ω resistor. [2]

[J07/P2/Q7]

Solution

(a) (i) Combined resistance = 2 + 4 = 6 Ω

(ii) $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$,

$\frac{1}{R_T} = \frac{1}{3} + \frac{1}{6}$

$\frac{1}{R_T} = \frac{1}{2} \Rightarrow R_T = 2\ \Omega$

(b) $I = \frac{V}{R} = \frac{12}{2} = 6$ A

(c) Current in the lower branch, $I = \frac{V}{R} = \frac{12}{6} = 2$ A

So, the p.d. across the 4Ω resistor, $V = IR = 2 \times 4 = 8$ V

COMMENT on ANSWER

" (a) (ii) Alternatively:

combined resistance

$= \frac{R_1 \times R_2}{R_1 + R_2} = \frac{3 \times 6}{3 + 6}$

$= 2\ \Omega$

Question 6

(a) Describe an experiment to show the difference between an electrical insulator and an electrical conductor. Name one example of each. [4]

(b) Fig. 10.1 is a sketch graph of the current in a component P against the potential difference (p.d.) across it.

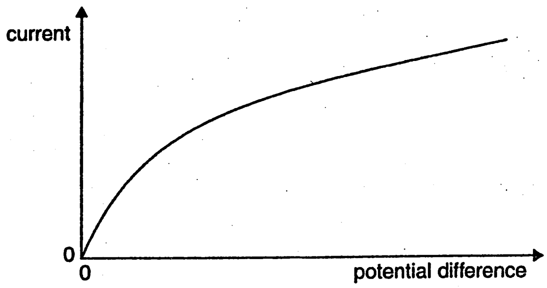


Fig. 10.1

(i) Define *resistance*. [1]

(ii) State how the resistance of P varies with the p.d. across it. [1]

(iii) Suggest what component P is. [1]

(iv) Explain why the resistance of P varies with the p.d. across it. [2]

(c) Component P is used in the electrical circuit shown in Fig. 10.2.

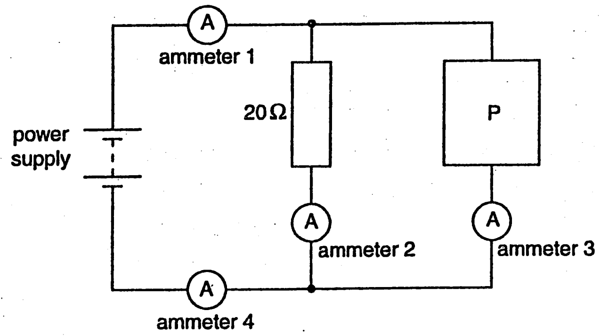


Fig. 10.2

The current in ammeter 2 is 0.40 A and the current in ammeter 3 is 0.60 A.

(i) Determine the readings of ammeters 1 and 4. [1]

(ii) Calculate the p.d. across the 20 Ω resistor. [2]

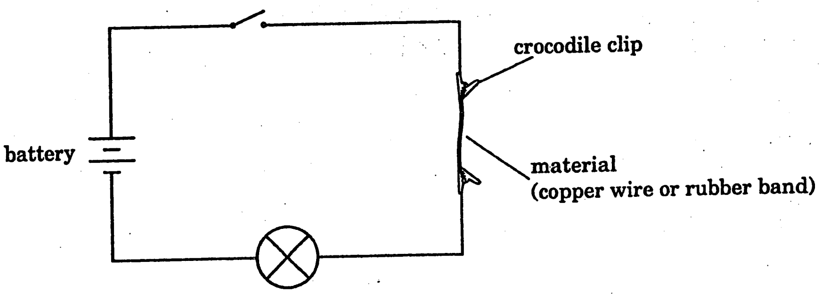
(iii) State the p.d. across the power supply. [1]

(iv) Calculate the resistance of P in this circuit. [2]

[N07/P2/Q10]

Solution

(a) A series circuit is connected using a battery, a bulb, a switch and two crocodile clips. A short length of copper wire and a piece of rubber band of same length are clipped in turn between the two clips as shown:



The copper wire is clipped between the clips and the switch is closed. The blub lights and shows that copper is an electrical conductor. The experiment is repeated with the piece of rubber band clipped between the clips. The blub does not light on closing the switch showing that rubber is an electrical insulator.

(b) (i) Resistance is a property of a material that hinders the movement of free electrons in the material. Its value is given as

$$\text{resistance} = \frac{\text{voltage}}{\text{current}}$$

(ii) The resistance of the component P increases when the P.D. across it becomes high.

(iii) The component P is a filament lamp.

(iv) The current through the filament of the lamp increases with the increase in the p.d. across it. The increase in the amount of current increases its heating effect in the filament and causes an increase in its temperature. As a result the resistance of the filament increases.

(c) (i) The reading of both the ammeters 1 and 4 is the same and equal to:

$0.40 + 0.60 = 1.0$ A.

(ii) $V = IR = 0.40 \times 20 = 8.0$ V

(iii) 8 V

(iv) resistance of P: $R = \dfrac{V}{I}$

$$= \frac{8.0}{0.60} = 13.3 \approx 13\ \Omega$$

COMMENT on ANSWER

“(a) All metals, carbon and graphite are conductors whereas plastic, rubber, paper, glass and wood are insulators.”

Question 7

A filament lamp is labelled 240 V, 0.20 A.

(a) Calculate the resistance of the lamp at normal brightness. [2]

(b) The lamp is connected to a 240 V supply and switched on at time $t = 0$.

Fig. 6.1 shows the variation with t of the resistance of the lamp.

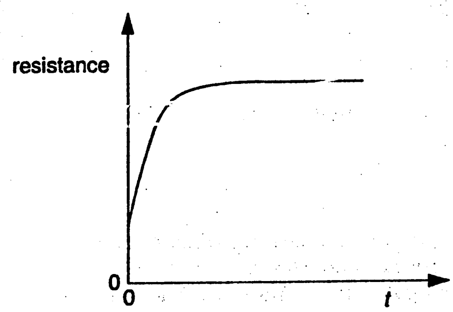


Fig. 6.1

Describe how the current in the lamp varies with t. [2]

(c) A second filament lamp has higher resistance.

State **two** differences between the two filaments that may cause the change in resistance.

1 The filament in the second lamp is

2 The filament in the second lamp is [2]

[J08/P2/Q6]

Solution

(a) $R = \dfrac{V}{I}$

$= \dfrac{240}{0.20} = 1200\ \Omega$

(b) The value of the current decreases with the increase in the resistance of the lamp and becomes constant at 0.20 A, when the resistance of the lamp becomes constant.

(c) 1. The filament in the second lamp is: longer.

2. The filament in the second lamp is: thinner.

COMMENT on ANSWER

" (c) 1. $R \propto l$

2. $R \propto \dfrac{1}{A}$ "

Question 8

A motorcycle battery consists of six 2.0 V cells in series. The battery supplies energy to the headlight.

(a) State the total electromotive force (e.m.f.) of the battery. [1]

(b) The motorcycle headlight contains two identical filament lamps F and G. Filament lamp F is always lit but filament lamp G is turned on and off by switch D.
Fig. 7.1 is the circuit diagram.

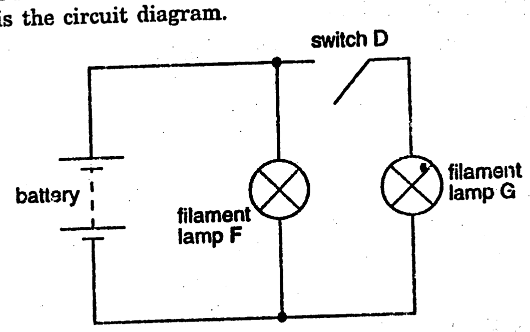


Fig. 7.1

When switch D is open, the battery supplies a current of 4.6 A.
Complete the table of Fig. 7.2.

	current supplied by battery / A	current in filament lamp F / A	current in filament lamp G / A
switch D open	4.6		
switch D closed			

Fig. 7.2 [3]

(c) Calculate the energy supplied by the battery as an electric charge of 200 C moves through the circuit. [2]

[N08/P2/Q7]

Solution

(a) 12 V

(b)

	current supplied by battery / A	current in filament lamp F / A	current in filament lamp G / A
switch D open	4.6	4.6	0
switch D closed	9.2	4.6	4.6

(c) Energy $= VQ = 12 \times 200 = 2400$ J

COMMENT on ANSWER

" (b) As the two identical lamps are connected in parallel, so the P.D. across them is the same (i.e. 12 V). Hence the same amount of current (i.e. 4.6 A) flows through their filaments when switched on together or separately.

(c) By definition, EMF is equal to the energy needed to move a unit electric charge through a complete circuit, i.e.

$$\text{EMF} = \frac{\text{Energy}}{\text{Charge}} \quad \text{Or}$$

$$V = \frac{E}{Q}$$

$\therefore\ E = VQ.$ "

Question 9

(a) A lamp is marked 24 V, 100 W. Describe an experiment to check that the electrical power supplied to the lamp is 100 W when the potential difference (p.d.) across it is 24 V.
In your account you should

- include a circuit diagram,
- state the readings that are taken,
- show how the result is calculated from the readings. [4]

(b) Two lamps are connected in parallel to a 240 V mains supply, as shown in Fig. 9.1.

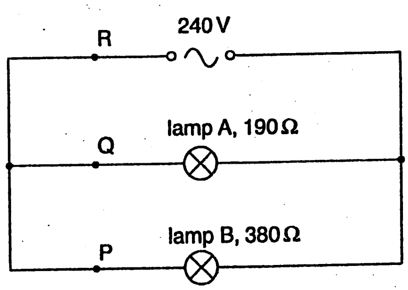


Fig. 9.1

Lamp A has a resistance of 190 Ω and lamp B has a resistance of 380 Ω.

(i) Calculate the current at points P, Q and R. [3]

(ii) Calculate the total resistance of the circuit. [2]

(c) Fig. 9.2 shows the same lamps connected in series to the mains supply.

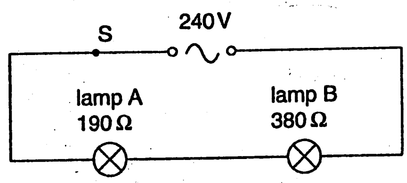


Fig. 9.2

(i) Calculate the current at point S. [2]

(ii) Calculate the p.d. across lamp A. [1]

(d) In a house, all lamps are connected in parallel to the mains supply, not in series.

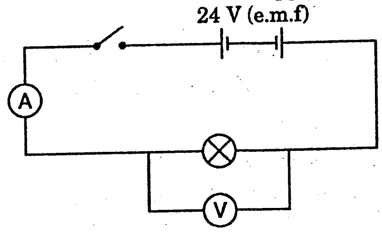
State and explain two reasons for this.

In your explanation you may refer to the results of your calculations in **(b)** and **(c)**. [3]

[J09/P2/Q9]

Solution

(a) A power supply of EMF of 24 V, a 100 W lamp, a switch and an ammeter are connected in series and a voltmeter is connected across the lamp as shown.



The switch is closed and the readings of the ammeter and the voltmeter are noted down. The value of the power supplied to the lamp can then be calculated as follows.

Power = voltage × current

i.e. $P = V \times I$

(b) (i) At point P, $I = \frac{V}{R} = \frac{240}{380} = 0.63$ A

At point Q, $I = \frac{V}{R} = \frac{240}{190} = 1.26$ A

At point R,

Total current sulpplied by the mains $= \text{current P} + \text{current Q}$
$= 0.63 + 1.26 = 1.89$ A

(ii) Let the total resistance be = R

Hence

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{190} + \frac{1}{380}$$

$R = 127\Omega$

(c) (i) $I = \frac{V}{R} = \frac{240}{570} = 0.42$ A

(ii) $V = IR = 0.42 \times 190 = 80$ V

(d) Connecting the lamps in parallel has some advantages over connecting them in series.

Advantage 1: In parallel circuit, if a lamp blows the others continue working normally whereas in a series circuit, if one lamp blows, the others also go out.

Advantage 2: All the lamps (and other electric appliances too) are designed to work normally at 240 V. When connected in parallel, each lamp gets its required potential difference of 240 V across it and lights with normal brightness. Whereas in a series circuit, the voltage is divided between them and each lamps gets a lesser voltage and hence a smaller current than its required working voltage and current. So, they light with lesser brightness.

Advantage 3: In a parallel circuit, each lamp can be operated and switched ON/OFF independently but in a series circuit if one lamp is switched off, the others also go out.

COMMENT on ANSWER

“ (b) (i) The current at R is the total current supplied by the mains. Which can also be calculated as follows.

Total current $= \frac{\text{Total voltage}}{\text{Total resistance}} = \frac{240}{127} = 1.89$ A

(ii) *Alternatively:*

1. the total resistance (R) can also be found as follows.

Total $R = \frac{\text{Total } V}{\text{Total } I} = \frac{240}{1.89} = 127\Omega$

2. $R = \frac{R_1 \times R_2}{R_1 + R_2} = \frac{190 \times 380}{190 + 380} = 127\Omega$ ”

Question 10

A microwave oven is rated at 650 W and is connected to a 230 V mains supply.

(a) (i) Calculate the current from the supply when the microwave oven is switched on. [2]

(ii) Suggest a rating of the fuse for use with this oven. [1]

(b) The insulation of the mains cable has worn away. The live wire touches the outer metal casing of the microwave oven.

(i) Explain the hazard that results if the outer metal casing is not earthed. [2]

(ii) Explain how connecting the earth wire to the outer casing and using a fuse of a suitable rating removes this hazard. [2]

[N09/P2/Q6]

Solution

(a) (i) $I = \frac{P}{V} = \frac{650}{230} = 2.83\ \text{A}$

(ii) Suggested rating of the fuse = 4.0 A.

(b) (i) The metal casing of the microwave oven becomes live and the user will get an electric shock on touching it.

(ii) The earth wire directs the current into the ground and the flow of an excessive current causes the fuse to melt which disconnects the flow of current.

Question 11

Fig. 11.1 shows a 9.0 V battery connected in series with a 16.0 Ω resistor and a small metal conductor X at room temperature.

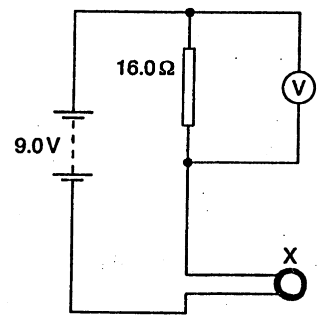


Fig. 11.1

A voltmeter measures the potential difference (p.d.) across the 16.0 Ω resistor. At room temperature the resistance of X is 4.0 Ω.

(a) (i) Calculate the current supplied by the battery. [1]

(ii) Calculate the p.d. across the 16.0 Ω resistor. [1]

(b) X is heated slowly to a very high temperature.

(i) Sketch a graph to show how the resistance of a metal conductor depends on its temperature. [2]

(ii) State and explain how the voltmeter reading changes as the temperature of X rises. [2]

(iii) Suggest a suitable range for the voltmeter. [2]

(c) (i) Describe in outline how the circuit in Fig. 11.1 can be used as a thermometer. [2]

(ii) State two advantages of a thermometer such as this over a liquid-in-glass thermometer. [2]

(iii) The change in voltmeter reading with temperature is non-linear. Explain what is meant by *non-linear*. [2]

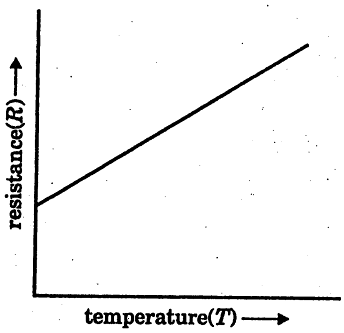
[N09/P2/Q11 (a,b,c) Either]

Solution

(a) (i) $I = \frac{V}{R} = \frac{9.0}{20} = 0.45\ A$

(ii) $V = IR = 0.45 \times 16 = 7.2\ V$

(b) (i)



(ii) On heating, the resistance of the metal conductor increases. As a result, the total resistance of the circuit increases and the current supplied by the battery decreases.
The reading of the voltmeter then decreases and the potential difference across the metal conductor X increases.

(iii) The suitable range for the voltmeter $= 0 \rightarrow 10\ V$

(c) (i) If the voltmeter is calibrated and temperature values are marked on its scale using the known values of temperature then this circuit can be used as a thermometer to measure the temperature of a hot body by using the small metal conductor (X) as a probe.
On touching the probe with a hot body, the voltmeter will show the temperature of the hot body directly.

(ii) Advantages:

1. It can measure high temperatures.
2. It can give a quick reading due to its low heat capacity.

(iii) The change in voltmeter reading with temperature is non-linear because equal changes in temperature do not produce equal changes in the voltmeter readings; i.e. the change in V is not uniform.

COMMENT on ANSWER

“ (b) (ii) *Alternatively:*
On heating the metal conductor, the voltmeter reading decreases as the metal conductor then takes greater proportion of P.D. and 16 Ω resistor takes smaller proportion of P.D. ”

Question 12

(a) Describe an experiment, including an ammeter and a voltmeter, to show how the resistance of a wire varies with temperature. Draw a circuit diagram. [4]

(b) The filament in a lamp is made from metal wire.

(i) Describe the variation with temperature of the resistance of the filament lamp. [2]

(ii) On Fig. 11.1, sketch a graph of the variation of the current in the filament against the potential difference (p.d.) across it.

Fig. 11.1 [2]

(c) Fig. 11.2 is a circuit used to monitor changes in room temperature.

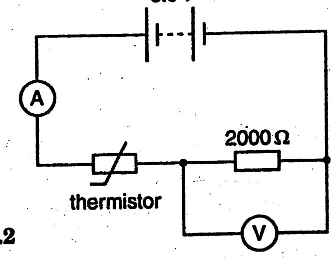


Fig. 11.2

A thermistor is connected in series with a 6.0 V battery and a 2000 Ω resistor.

(i) The temperature of the room increases. State and explain what happens to

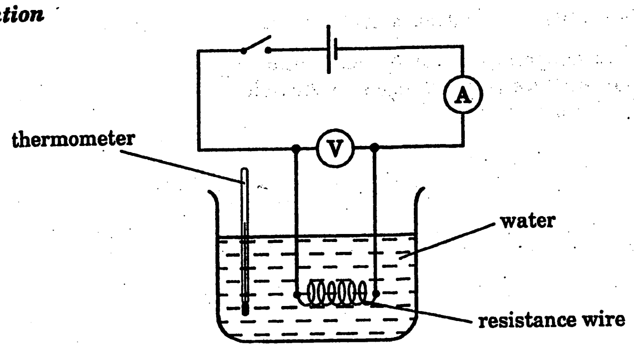
1. the reading on the ammeter, [2]
2. the reading on the voltmeter. [2]

(ii) At a certain temperature, the reading on the voltmeter is 3.8 V. Calculate the resistance of the thermistor at this temperature. [3]

[J10/P2/Q11]

Solution

(a)

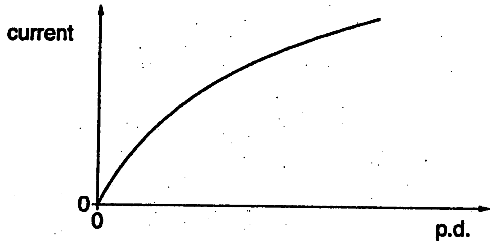


The switch is closed and the readings of V, I and θ are noted down. The resistance of the wire is calculated using the equation $R = \frac{V}{I}$, the temperature of the wire is then raised by 10° C using a bunsen burner. The resistance of the wire is calculated again using the new values of V, I and θ. A few more sets of these values are measure after raising the temperature of the wire every time and the corresponding value of R is calculated.

A graph is then plotted between the resistance R/Ω and the temperature θ /°C of the wire. The graph shows that the resistance of the wire increases linearly with temperature.

(b) (i) There is a linear variation between the temperature and the resistance of a filament lamp. The resistance of its filament increases linearly with the increase in its temperature.

(ii)



(c) (i) 1. The reading on the ammeter increases due to the decrease in the resistance of the thermistor and increase in the current in the circuit.

2. The reading of the voltmeter increases because in a series circuit, $V \propto R$. Since the resistance of the thermistor has decreased and the voltage across it has also decreased so the voltage across the 2000 Ω resistor increases.

(ii) Current through the thermistor $= \frac{V}{R} = \frac{3.8}{2000} = 1.9 \times 10^{-3}$ A

Hence, the Resistance of thermistor $= \frac{V}{I} = \frac{2.2}{1.9 \times 10^{-3}} = 1158\ \Omega$

Question 13

At night, a bright floodlight is used to illuminate a building. The floodlight is a metal filament lamp. It is connected in series with a variable resistor and a 230 V mains power supply.

When the floodlight is first switched on, the resistance of the variable resistor is at its maximum value. In the following few minutes the variable resistor is adjusted so that its resistance decreases slowly to zero. This causes the brightness of the lamp to increase until it reaches a maximum. At maximum brightness, the current in the lamp is 12 A.

(a) Calculate the resistance of the lamp at maximum brightness. [2]

(b) State and explain what happens to the resistance of the lamp as its brightness increases. [2]

(c) Suggest how, by using the variable resistor in this way, the filament lamp is protected from damage. [2]

[N10/P2/Q4]

Solution

(a) $R = \dfrac{V}{I} = \dfrac{230}{12} = 19.2\ \Omega$

(b) The current in the lamp increases gradually and the lamp becomes brighter. The increase in current increases the temperature of the filament, and the increase in temperature then increases its resistance.

(c) The use of the variable resistor in this way prevents the flow of high current due to the low resistance of the filament and protects it from damage.

Question 14

Fig. 5.1 shows part of a low-voltage lighting circuit.

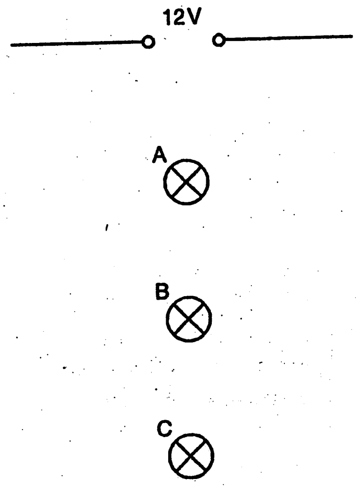


Fig. 5.1

The power supply voltage is 12 V.

(a) On Fig. 5.1, complete the circuit, adding components as necessary, so that:

- the total current in the circuit can be measured,
- lamp A is on all the time,
- lamps B and C are in series with each other and are switched on or off together. [3]

(b) All the lamps are on. The potential difference (p.d.) across lamp B is 8.0V and the current in lamp B is 50 mA.

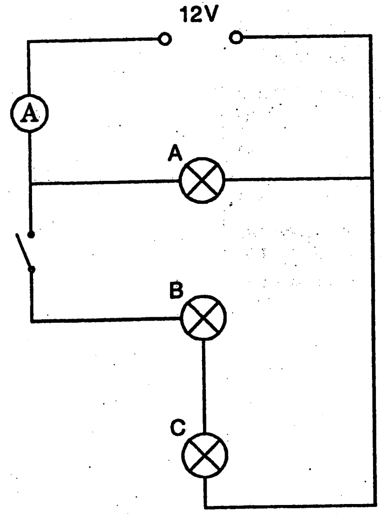
(i) Calculate the resistance of lamp B. [2]

(ii) State the current in lamp C. [1]

[J11/P2/Q5]

Solution

(a)



(b) (i) $V = IR$

$8.0 = (50 \times 10^{-3}) \times R$

$R = 160\ \Omega$

(ii) Current = 50 mA

COMMENT on ANSWER

"(b) (i) Convert milliamperes into Amperes before substituting the value of current in the formula. i.e.
50 mA = 50×10^{-3}A.

(ii) Lamp C is in series with lamp B, so the current in both lamps is same i.e. 50 mA."

Question 15

The cable from the mains plug to a washing machine contains a live wire, a neutral wire and an earth wire. The earth wire is connected to the metal case of the washing machine.

(a) Explain how connecting the earth wire to the metal case makes the washing machine safer. [2]

(b) When in use, the average input power to the washing machine is 500 W. Calculate the number of kW h of energy used by the washing machine in 45 minutes of use. [2]

[J11/P2/Q6]

Solution

(a) In case the live wire touches the metal case of the washing machine, the metal case becomes live. The earth wire then directs the current from metal case into the ground and the user does not get an electric shock on touching the machine.

(b) Number of kWh = number of Kilowatts × number of hours

$$= \frac{500}{1000} \times \frac{45}{60}$$

$$= 0.375 \approx 0.38 \text{ kWh.}$$

Question 16

An electrical engineer measures the potential difference across a length of metal wire and the current in the wire. He does this for different values of the current.

(a) (i) Draw a labelled circuit diagram of a circuit that enables the engineer to do this. [3]

(ii) Describe how the circuit is used. [2]

(iii) State the equation that defines resistance. [1]

(b) The engineer performs the experiment and notices that the potential difference across the wire is directly proportional to the current in it. He calculates the resistance of the wire and plots a graph of the resistance against the current.

On Fig. 6.1, sketch the shape of this graph.

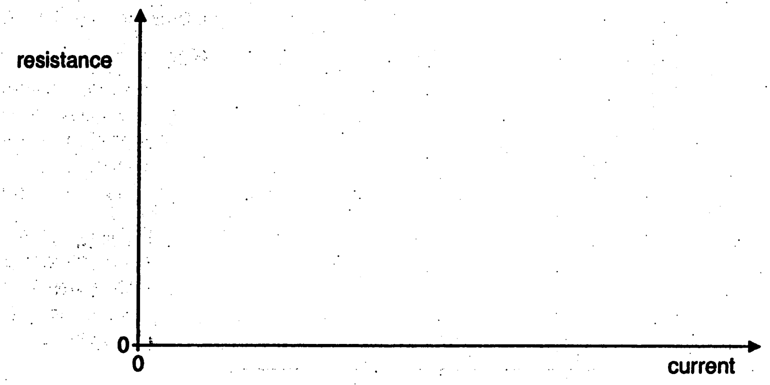
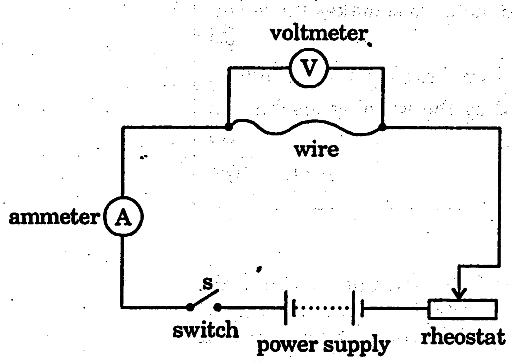


Fig. 6.1 [1]

[N11/P2/Q6]

Solution

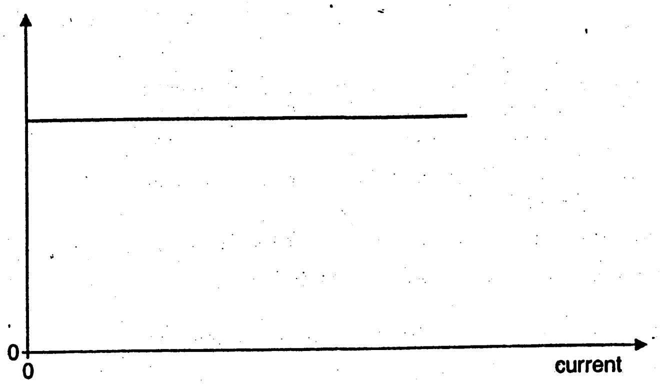
(a) (i)



(ii) After closing the circuit, the voltage and current readings are taken with the help of a voltmeter an and ammeter respectively. The rheostat is then altered several times to get a series of suitable values of voltage and current.

(iii) $R = \frac{V}{I}$

(b)



COMMENT on ANSWER

"(b) Since potential difference is directly proportional to current, so,

$\frac{V}{I} = R$ (constant)."

Question 17

The current in the transmission line used to supply electrical power to a village is 65 A. The power is transmitted at a voltage of 23 000 V.

(a) Calculate the power supplied to the village. [2]

(b) The transmission line has a resistance of 3.0 Ω. Calculate

(i) the potential difference across a 3.0 Ω resistor that carries a current of 65 A, [2]

(ii) the thermal energy (heat) produced in 1.0 s in a 3.0 Ω resistor that carries a current of 65 A. [1]

(c) (i) State one advantage of transmitting electrical power at a high voltage. [1]

(ii) Suggest one reason why the mains power supply to the houses in the village is at a voltage much lower than 23 000 V. [1]

[N11/P2/Q7]

Solution

(a) Power = Voltage × Current

$= 23000 \times 65 = 1.5 \times 10^6$ W

(b) (i) Potential difference, $V = IR$

$= 65 \times 3.0 = 195$ V

(ii) Heat energy $= VIt$

$= 195 \times 65 \times 1$

$= 12675 \approx 1.27 \times 10^4$ J

(c) (i) There is less energy loss at higher voltage.

(ii) The mains power supply to houses is at a voltage much lower than 23000 V to minimize the chance of electric shock.

COMMENT on ANSWER

"(c) (i) When electrical energy is transmitted at high voltage and low current, power loss is reduced due to Joule heating ($I^2 R$)

Alternatively:
At high voltage and low current, thinner wires are needed.

(c) (ii) *Alternatively:*
At low voltage, there is less danger of sparking and hence fire."

Question 18

A student investigates how the resistance of a wire depends upon its length. The student uses an ammeter, a voltmeter, a battery, a fixed resistor and the wire under test, all connected in an electrical circuit.

(a) (i) In the space below, draw a circuit diagram of the apparatus. Label the wire under test with the letter W. [3]

(ii) Describe how the student obtains one complete set of results. [2]

(iii) During the experiment, the student keeps the temperature of the wire constant.

1. Suggest why it is sensible to keep the temperature of the wire constant. [1]

2. Suggest how the student keeps the temperature of the wire constant. [1]

(b) Fig. 8.1 shows part of a circuit containing three resistors X, Y and Z.

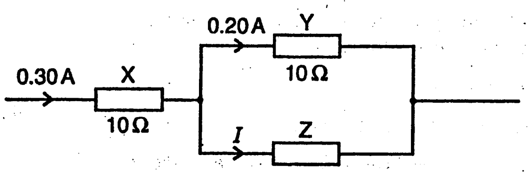


Fig. 8.1

The resistance of X and the resistance of Y are each 10 Ω. The current through X is 0.30 A. The current through Y is 0.20 A.

(i) Calculate the potential difference (p.d.) across Y. [2]

(ii) Calculate the current I in resistor Z. [1]

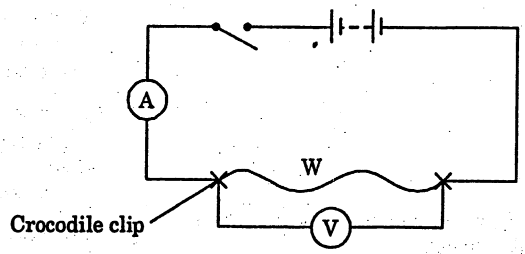
(iii) Explain in words, rather than by calculation, how Fig. 8.1 shows that the resistance of Z is larger than the resistance of Y. Use ideas about p.d. and current in your answer. [2]

(iv) Calculate the total resistance of the resistors X, Y and Z in this circuit. [3]

[J12/P2/Q8]

Solution

(a) (i)



(ii) Measure the length of wire and connect it in the circuit as shown. Then close the switch and note down the values of V and I. The resistance of the wire is then found by using the equation $R = \frac{V}{I}$. Change the length of the wire and repeat the above steps.

(iii) 1. The resistance of the wire is directly proportional to the temperature of the wire. So a change in the temperature of the wire also changes the resistance of the wire, but as we are measuring the change in the resistance due to the change in its length, so the temperature of the wire must be kept constant.

2. Take the readings quickly and switch off the current in the circuit in between two sets of readings.

(b) (i) $V = IR$

$= 0.20 \times 10 = 2.0$

$\therefore$ p.d. $= 2.0$ V.

(ii) $I_X = I_Y + I_Z$

$0.30 = 0.20 + I_Z$

$I_Z = 0.10$

$\therefore$ current in resistor Z = 0.10 A

(iii) The P.D. is the same across both the resistors Y and Z in parallel. So, a smaller current through Z than Y shows that the resistance of Z is greater than the resistance of Y.

(iv) p.d. across X = $0.3 \times 10 = 3.0$ V

total voltage = $3.0 + 2.0 = 5.0$ V

$$\text{total resistance} = \frac{\text{total } V}{\text{total } I} = \frac{5.0}{0.3} = 16.7\ \Omega$$

COMMENT on ANSWER

" (a) (iii) 1. *Alternatively:*

The temperature of the wire is kept constant because:

— Other wise the wire gets hot and may melt.

— V ∝ I only at constant temperature.

2. *Alternatively:*

— use a water bath.

— use a heat sink.

— use small currents.

(b) (iv) *Alternatively:*

Resistance of Z

$= \frac{V}{I} = \frac{2}{0.1} = 20\ \Omega$

Resistance of Y and Z:

$\frac{1}{R_{Y+Z}} = \frac{1}{R_Y} + \frac{1}{R_Z}$

$= \frac{1}{10} + \frac{1}{20} = \frac{3}{20}$

$\therefore R_{Y+Z} = \frac{20}{3}$

Total Resistance

$= 10 + \frac{20}{3} = 16.7\Omega$ "

Question 19

Fig. 6.1 shows the current-voltage graph for a filament lamp.

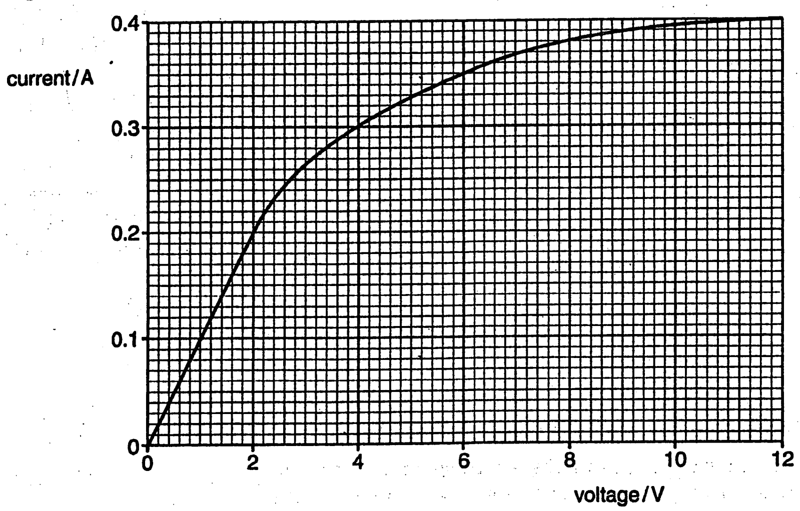


Fig. 6.1

(a) (i) State the range of voltages where the resistance increases. [1]

(ii) State why the resistance of the lamp increases as the voltage increases. [1]

(b) The filament lamp is connected in the circuit shown in Fig. 6.2.

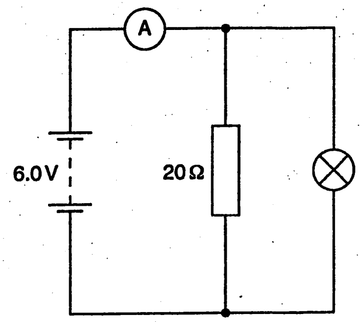


Fig. 6.2

There are currents in the lamp, the 20 Ω resistor and the ammeter.

(i) State what is meant by an *electric current*. [1]

(ii) Use Fig. 6.1 to determine the current in the filament lamp. [1]

(iii) Determine the current in the ammeter. [3]

[J13/P2/Q6]

Solution

(a) (i) 2 V — 12 V

(ii) The resistance of the lamp increases due to the increase in the temperature of the lamp.

(b) (i) Electric current is the flow of charge per unit time.

(ii) current = 0.35 A

(iii) Current in ammeter = current in lamp + current in 20 Ω resistor

$$= 0.35 + \frac{V}{R}$$
$$= 0.35 + \frac{6}{20}$$
$$= 0.35 + 0.30 = 0.65\text{ A}$$

Question 20

A student places a small electrical heater inside a cup of water, as shown in Fig. 11.1.

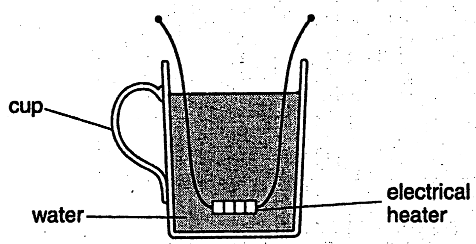


Fig. 11.1

The student determines the electrical power of the heater.

(a) In the space above the cup on Fig. 11.1, draw the electrical circuit that the student uses. Include an ammeter, a voltmeter and a power supply. [2]

(b) The voltage of the power supply is 12 V and the current is 4.2 A.

(i) Calculate the electrical power input to the heater. [2]

(ii) Calculate the energy input to the heater in 8.0 minutes. Give your answer in kW h.

[J13/P2/Q11(a,b)]

COMMENT on ANSWER

“ (a) (ii) As the voltage increases the current in the filament also increases. Which causes an increase in the heating effect of current. As a result the resistance of the filament increases.

(b) (i) Eelectric current I is given as $I = \frac{Q}{t}$

i.e. electric current I is the rate of flow of charge.

(ii) The parallel circuit in Fig. 6.2 shows that p.d. across the lamp is 6 V and the Fig. 6.1 shows that the value of the current through the lamp is 0.35 A corresponding to the p.d. of 6.0 V across it.

(iii) Alternatively:

The ammeter shows the total current in the circuit

Total $I = \frac{\text{total } V}{\text{total } R}$

where total $V = 6.0\text{V}$

Resistance of resistor = 20 Ω

Resistance of lamp

$= \frac{6}{0.35} = 17.1\,\Omega$

Total R in parallel

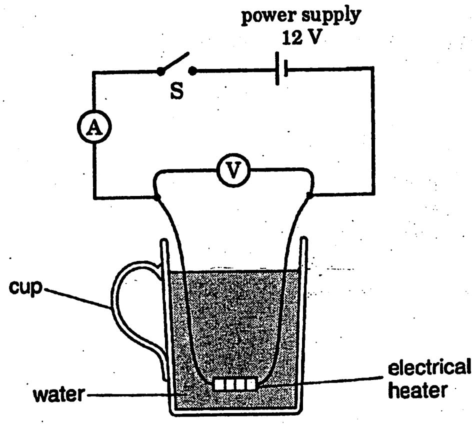
$= \frac{\text{product}}{\text{sum}} = \frac{20 \times 17.1}{20 + 17.1}$
$= 9.2\,\Omega$

Hence, total I

$= \frac{6.0}{9.2} = 0.65\text{ A}$

Solution

(a)



(b) (i) Electrical power, $P = VI$

$= 12 \times 4.2 = 50.4$ W

(ii) Energy, $E = P \times t$

$= \frac{50.4}{1000} \times \frac{8}{60}$

$= 0.0067$ kWh

Question 21

An electric saw is rated at 1200 W. When working on a job that lasts for four days, a workman uses the saw, on average, for 75 minutes each day. The cost of 1 kW h of electrical energy is 21 cents.

(a) Calculate the cost of using the saw for this job. [3]

(b) The metal case of the electric saw is earthed.
Explain how this protects the workman. [2]

[N13/P2/Q7]

Solution

(a) Cost $= P(\text{kW}) \times t(\text{hours}) \times$ unit price

$= \left(\frac{1200}{1000}\right) \times \left(\frac{75}{60} \times 4\right) \times 21$

$= 126$ cents

(b) If the metal case of the electric saw becomes live, the earth wire directs the current into the ground and protects the workman from an electric shock.

COMMENT on ANSWER

“ **(a)** *Alternatively:* First of all, find the total amount of electricity consumed in KWh and then find its cost as follows:

$E = \text{power(kW)} \times \text{time(h)}$

$= (\frac{1200}{1000}) \times (\frac{75}{60} \times 4)$

$= 6$ KWh

Total cost

= electricity consumed × unit cost

$= 6 \times 21 = 126$ cents

(b) If the metal casing of the electric saw becomes live due to the live wire touching the case, a large current flows into the ground through the earth wire and the fuse blows immediately which protects the workman from an electric shock. ”

Question 22

A metal filament lamp is connected to a power supply. The electromotive force (e.m.f.) produced by the supply can be varied. Fig. 11.1 is the circuit diagram.

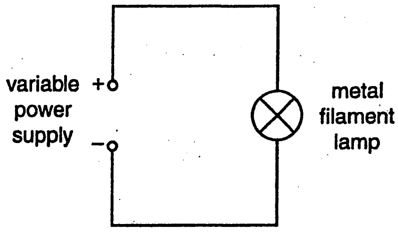


Fig. 11.1

(a) State what is meant by *electromotive force (e.m.f.)*. [2]

(b) Add appropriate circuit symbols to Fig. 11.1 to show the position of

(i) an ammeter that measures the current in the circuit, [1]

(ii) a voltmeter that measures the voltage across the lamp. [1]

(c) A student adds meters to the circuit and makes measurements of the current and voltage. He then plots the current/voltage graph shown in Fig. 11.2.

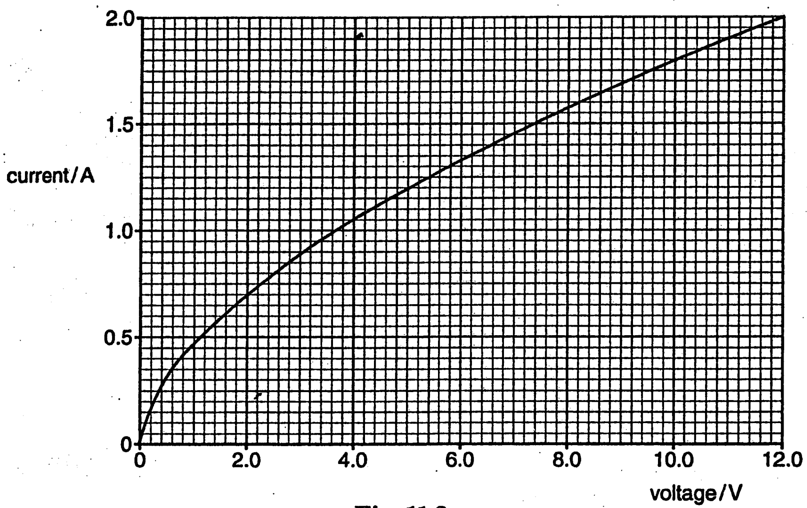


Fig. 11.2

(i) Using values from Fig. 11.2, calculate the resistance of the lamp when the current is 0.70 A. Give your answer to an appropriate number of significant figures. [3]

(ii) State what, if anything, happens to the resistance of the lamp as the voltage increases. [1]

(d) In normal use, the lamp is connected to a 12 V supply.

Use Fig. 11.2 to determine the power of the lamp when it is used in this way. [2]

(e) When connected to a 12 V supply, thermionic emission occurs in the lamp.

(i) Describe what is meant by *thermionic emission*. [2]

(ii) Thermionic emission is used in a cathode-ray oscilloscope (c.r.o.) tube.

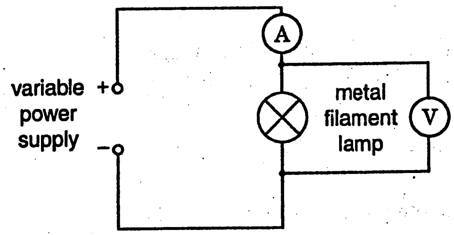
1. State why air must be removed from the tube of the c.r.o. [1]
2. A voltage is connected across the Y-plates in the c.r.o. State and explain the effect on the trace on the screen. [2]

[N13/P2/Q11]

Solution

(a) The e.m.f. of a cell is defined as the total work done required to drive one coulomb of electricity in a circuit in which the cell is connected.

(b) (i) & (ii)



(c) (i) From graph, when current = 0.70 A, voltage = 2.0 V

Resistance, $R = \dfrac{V}{I}$

$= \dfrac{2.0}{0.70} = 2.86\ \Omega$

(ii) The resistance of the lamp increases.

(d) Power $= VI$

$= 12 \times 2.0$

$= 24$ W

(e) (i) It is the process of emission of electrons from a heated metal surface.

(ii) 1. The air is removed from the tube to prevent the collisions of electrons with air molecules which may cause the deflection of the electron beam.

2. The negatively charged beam of electrons is attracted by the positive plate and repelled by the negative plate which causes the beam and hence the trace on the screen to move vertically up and down.

COMMENT on ANSWER

❝ (a) *Alternatively :*
The e.m.f. of a cell is defined as the energy converted from a non-electrical form to electrical form, when one coloumb of positive charge passes through the cell.

(e) (ii) 2. An electric field is set up between the Y-plates and it produces a deflection of the negatively charged beam that passes through it, in the opposite direction to the electric field. As a result, the trace on the screen is deflected vertically. ❞

Question 23

A student sets up the circuit shown in Fig. 11.1.

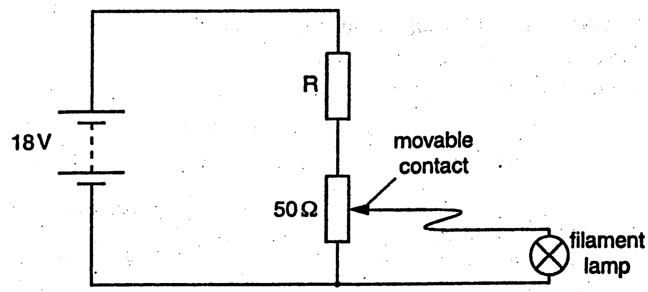


Fig. 11.1

R is a fixed resistor in the circuit. The filament lamp is marked 12 V, 0.25 A.

The circuit is used to produce a current/voltage graph for the filament lamp. The ammeter and voltmeter needed are not shown.

To obtain different readings, the student changes the position of the movable contact.

(a) On Fig. 11.1, draw the symbols for an ammeter and a voltmeter in the correct positions. [3]

(b) Explain why it is sensible to include the resistor R in this circuit. [2]

(c) (i) On Fig. 11.2, sketch a current/voltage graph for the lamp.

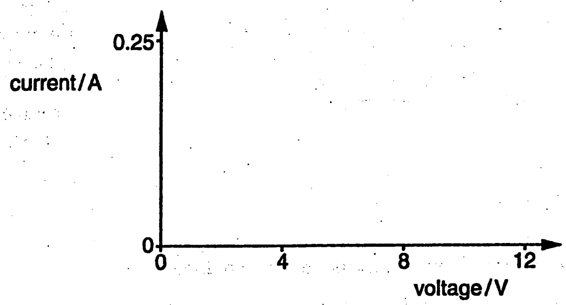


Fig. 11.2 [3]

(ii) State and explain how a current/voltage graph for a fixed resistor is different from the graph for a filament lamp. [2]

(d) Fig. 11.3 shows the position of the movable contact when the voltage across the lamp is 12 V and the current in the lamp is 0.25 A.

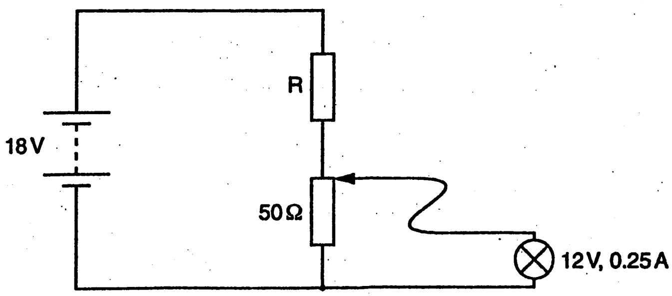


Fig. 11.3

Determine

(i) the current in the 50 Ω resistor, [2]

(ii) the current in R, [1]

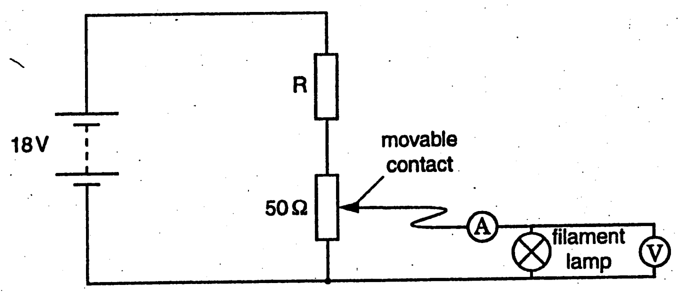
(iii) the potential difference (p.d.) across R, [1]

(iv) the resistance of R. [1]

[J14/P2/Q11]

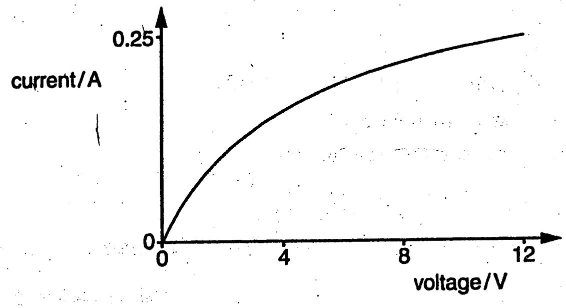
Solution

(a)



(b) R would limit the current passing through the circuit, and hence the voltage across the potential divider, thereby protecting the lamp from blowing up.

(c) (i)



(ii) A fixed resistor has a constant resistance. Therefore, the current/voltage graph of the fixed resistor is a straight line. On the other hand, the resistance of a filament lamp increases as the temperature of its filament increases. Therefore, the current/voltage graph for the lamp is non-linear.

(d) (i) Current, $I = \dfrac{V}{R}$

$= \dfrac{12}{50} = 0.24\text{ A}$

(ii) The current in R = 0.24 + 0.25 = 0.49 A

(iii) p.d. across R = 18 − 12 = 6.0 V

(iv) Resistance of R, $R = \dfrac{V}{I}$

$= \dfrac{6}{0.49} = 12.24\ \Omega$

Question 24

The circuit of Fig. 7.1 includes an ammeter, a 6.0 Ω resistor, a length of metal resistance wire and three 1.5 V cells connected in parallel.

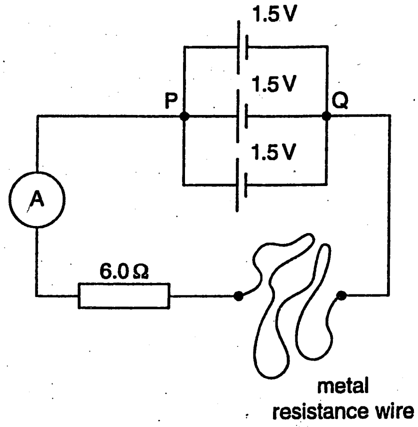


Fig. 7.1

(a) State

(i) one advantage of using cells in parallel rather than using a single cell, [1]

(ii) the potential difference (p.d.) between points P and Q in the circuit of Fig. 7.1. [1]

(b) (i) The ammeter in Fig. 7.1 reads 0.075 A.
Calculate the resistance of the resistance wire. [3]

(ii) The temperature of the metal resistance wire increases.
State and explain the effect of this temperature increase on the ammeter reading. [2]

[N14/P2/Q7]

Solution

(a) (i) The cells last longer.

(ii) p.d. = 1.5 V

(b) (i) Total resistance $= \frac{V}{I} = \frac{1.5}{0.075} = 20\ \Omega$

$\therefore$ resistance of wire $= 20\ \Omega - 6.0\ \Omega = 14\ \Omega$

(ii) With increase in temperature, the resistance of the metal wire increases. Since the battery voltage remains the same but the overall resistance of the circuit increases, the ammeter reading will decrease.

COMMENT on ANSWER

" (a) (i) Another advantage of using cells in parallel is that, if one cell fails, the other cells will keep on working and the faulty cell can be replaced without switching off the circuit.

(b) (ii) $I = \frac{V}{R}$, where R is the total circuit resistance. The value of V remains same but the value of R increases which causes the value of I to decrease. "

Question 25

An electric hairdryer and an electric heater are connected to the mains supply, as shown in Fig. 7.1.

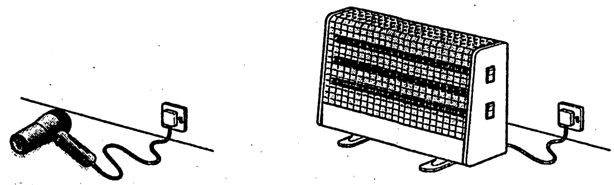


Fig. 7.1

The cable from the heater to the mains supply has a live, a neutral and an earth wire.

(a) State the purpose of the neutral wire. [1]

(b) The live wire in the electric heater touches the outer metal case.
Explain how the earth and the fuse together protect the user from electric shock. [2]

(c) The hairdryer does not have an earth wire. Explain why this hairdryer is still safe to use. [1]

(d) In some modern homes, circuit breakers are used instead of fuses.
Suggest one advantage of using a circuit breaker rather than a fuse. [1]

[J15/P2/Q7]

Solution

(a) The neutral wire is required to complete the circuit with the live wire in order to provide a return path for the current from the electronic device to flow back to the mains.

(b) The outer metal case of the heater becomes live if the live wire touches it, the metal case will then be at a high potential. The earth wire connected to the metal case then directs the flow of a large current into the earth. Consequently the flow of large currents blows the fuse and disconnect the flow of current.

(c) The hairdryer is doubly insulated. So the hairdryer does not need to have an earth wire.

(d) A circuit breaker can be reset and does not have to be replaced like a blown fuse.

COMMENT on ANSWER

“(a) The neutral wire is necessary
— to pass current back to the mains,
— to provide a return path for the current.”

Question 26

A spotlight in a television studio is at full brightness. The lamp inside the spotlight is powered by a 230 V supply and the current in the filament of the lamp is 27 A.

(a) Calculate the power of the lamp. [2]

(b) The spotlight is kept switched on at full brightness.

(i) Calculate the energy transformed by the lamp in 30 minutes. [1]

(ii) The cost of using one kilowatt-hour (kWh) of electricity is 23 cents.
Calculate the cost of using the spotlight for 30 minutes. [2]

[N15/P2/Q8]

Solution

(a) Power $= V \times I$

$= 230 \times 27$

$= 6210$ W.

(b) (i) Energy $= P \times t$

$= 6210 \times (30 \times 60)$

$= 11178000 \text{ J} \approx 1.12 \times 10^7 \text{ J}.$

(ii) Cost = number of kWh × unit cost

$= \left(\dfrac{6210}{1000} \times 0.5\right) \times 23$

$= 71.4$ cents.

COMMENT on ANSWER

"(b) (ii) Convert watts into kilowatts, i.e.

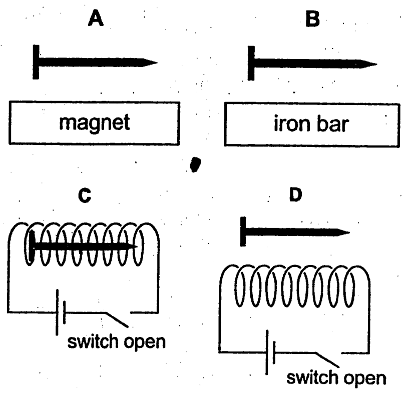
$6210 \text{ W} = \dfrac{6210}{1000} \text{ kW}.$"

Topic 21 Magnetism

MCQ Section

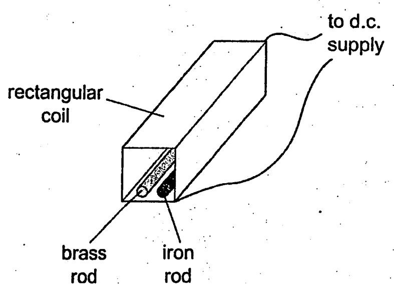
1. A student tries to magnetise a short steel rod.
Which of these tests will show that he has been successful?
A both ends of a permanent magnet attract the rod
B one end of a permanent magnet repels the rod
C the rod picks up a small piece of paper
D when freely suspended, the rod points in any direction
[N05/P1/Q25]

2. The diagrams show an iron nail in four different situations.
In which diagram will the nail become an induced magnet?



[J06/P1/Q27]

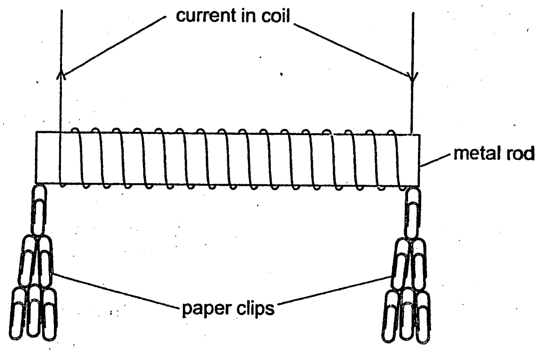
3. The diagram shows a brass rod and an iron rod beside each other at the bottom of a rectangular coil.



What happens when a d.c. current passes through the coil?

A Only the brass rod is magnetised.
B Only the iron rod is magnetised.
C The two rods attract each other.
D The two rods repel each other.
[J07/P1/Q24]

4. Four metal rods are placed, in turn, inside a coil of copper wire.



Each rod is used to pick up as many paper clips as possible. The current is then switched off.

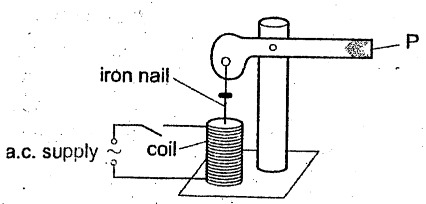
The table gives the results of the experiment.

Which rod is the most suitable core for a coil in a circuit breaker?

	Number of paper clips picked up when there is a current in the coil	Number of paper clips still attached after the current is switched off
A	1	0
B	20	2
C	35	0
D	35	30

[J07/P1/Q25]

5. The diagram shows a model railway signal.



MCQ Answers

1. B Only repulsion can be used to determine if the steel rod is magnetised (magnet) or unmagnetised.

2. A The magnetism is induced only if the iron nail is placed in a magnetic field of a magnet or of a solenoid with a direct current passing through it.
In **B**, an ordinary iron bar cannot have a magnetic effect on the nail. Similarly in **C** and **D**, no current is passing through the coils as the switch is open so the coil cannot have any magnetic effect on the nail.

3. B The iron rod becomes magnetised but the brass rod is not magnetised because brass is not a magnetic material. Also, the magnetised iron rod can not exert any magnetic force on a non-magnetic material.

What does the end P do when the switch is closed?

A It goes down and stays down.

B It goes up and stays up.

C It goes down and then returns to its original position.

D It goes up and then returns to its original position.

[N07/P1/Q24]

6. Which part of a video tape recording system does **not** rely on magnetic material for its operation?

A the drive motor

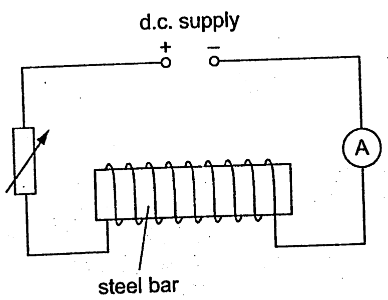
B the power lead

C the transformer

D the video tape

[N07/P1/Q25]

7. The diagram shows how a steel bar can be magnetised.



Which statement describes how the steel bar can be demagnetised?

A Reverse the d.c. supply and gradually decrease the current in the circuit.

B Reverse the d.c. supply and gradually increase the current in the circuit.

C Use an a.c. supply and gradu ally decrease the current in the circuit.

D Use an a.c. supply and gradually increase the current in the circuit.

[J08/P1/Q27]

8. Delicate instruments are often placed in a 'box' to protect them from stray magnetic fields.

What is the material used for the box and why is it chosen?

A Aluminium is used because it is a non-magnetic material.

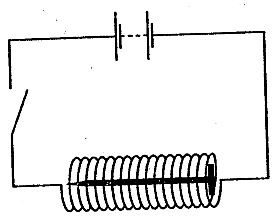
B Copper is used because it has a low electrical resistance.

C Polythene is used because it is a good electrical insulator.

D Soft iron is used because it is a magnetic material.

[N08/P1/Q26]

9. An iron nail can be magnetised using a coil.



How can the nail be demagnetised?

A leaving the apparatus switched on for a long time

B removing the nail from the coil while using an a.c. supply

C using a coil with fewer turns

D using more cells

[J09/P1/Q24]

10. Which row describes the ease with which iron or steel can be magnetised and demagnetised?

	metal	magnetised	demagnetised
A	iron	difficult	easy
B	iron	easy	difficult
C	steel	difficult	difficult
D	steel	easy	easy

[N09/P1/Q24]

11. Which properties make materials suitable for use as a core in an electromagnet?

A difficult to magnetise and easy to demagnetise

B difficult to magnetise and retains magnetic strength

C easy to magnetise and retains magnetic strength

D easy to magnetise and easy to demagnetise

[J10/P1/Q25]

MCQ Answers

4. C The core of the coil of a circuit breaker must be made of a soft magnetic material which is strongly magnetised when current passes through the coil and is immediately demagnetised completely when current is switched off.

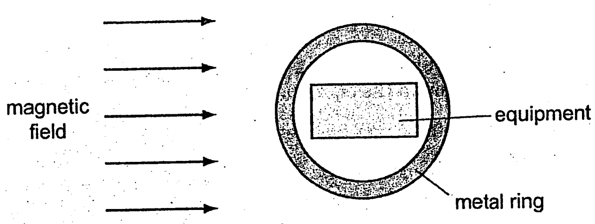
Note that option **C** attracts larger number of clips when there is current in the coil showing that it is strongly magnetised. The core **C** drops all the clips when current is switched off showing that it is completely demagnetised.

5. B The coil is magnetised when the alternating current passes through it. The magnetic poles at the ends of the coil alternate as the alternating current continuously reverses its direction. Whatever the magnetic pole (N or S) appears at the upper end of the coil, it attracts the iron nail by the magnetic induction. As a result the left end of the railway signal arm is pulled downward and its right end moves up.

6. B Fact.

7. C As the a.c. current in the coil reverses its direction 50 times each second, the direction of the magnetic field in the coil also reverses fifty times each second. This alters the alignment of the domains in the magnet fifty times each second and as the magnetic field becomes weaker and weaker until it is not strong enough to align the domains again. Thus they set in a haphazard manner and the steel rod is demagnetised.

12. A metal ring screens a piece of equipment from a magnetic field.



Which metal should be used for the ring, and why?

	metal	reason
A	copper	the metal carries the field lines around the equipment
B	copper	the metal is non-magnetic
C	iron	the metal carries the field lines around the equipment
D	iron	the metal is non-magnetic

[N10/P1/Q27]

13. Which list contains an example of a non-magnetic material, a magnetic material and a magnetised material?

A copper, iron, a compass needle
B copper, iron, polythene
C iron, steel, a compass needle
D iron, steel, polythene

[J11/P1/Q25]

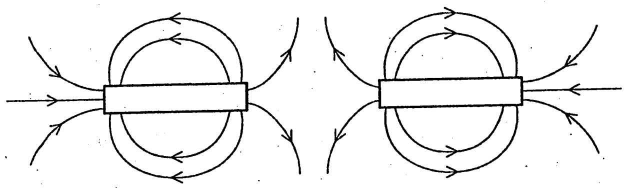
14. A magnet is placed close to an iron bar.

The iron bar becomes an induced magnet.
Which magnetic poles are formed at the ends X and Y of the bar?

	end X	end Y
A	N	N
B	N	S
C	S	N
D	S	S

[N12/P1/Q26]

15. The magnetic field around two bar magnets is shown.



Which diagram represents the correct arrangement of magnetic poles?

	left magnet	right magnet
A	N S	N S
B	N S	S N
C	S N	N S
D	S N	S N

[J13/P1/Q29]

16. Which material is used to magnetically screen electrical equipment from unwanted magnetic fields?

A aluminium
B copper
C iron
D steel

[J13/P1/Q30]

17. Which material is best for magnetic screening?

A copper **B** iron
C lead **D** plastic

[N13/P1/Q27]

18. What always produces a permanent bar magnet?

A an iron bar in a coil carrying alternating current (a.c.)

B an iron bar in a coil carrying direct current (d.c.)

MCQ Answers

8. D Fact

9. B As the nail is removed from the coil, the alternating current takes the magnetised nail through a series of ever-diminishing magnetic cycles until it is completely demagnetised.

10. C It is a fact that soft iron can be magnetised and demagnetised easily whereas it is difficult to magnetise or demagnetise steel.

11. D The core of an electromagnet is made of soft magnetic material which can be easily magnetised or demagnetised so that it can be used where rapid change or reversal of magnetism is required.

12. C An iron ring is used for magnetic sheilding which is quickly magnetised and carries the magnetic field lines around the equipment. The equipment placed inside the ring is therefore protected from the effect of the magnetic field.

13. A Copper is a non-magnetic material, Iron is a magnetic material and the needle of magnetic compass is a permanent magnet made of steel.

C a steel bar in a coil carrying alternating current (a.c.)

D a steel bar in a coil carrying direct current (d.c.)

[J14/P1/Q30]

19. A metal bar PQ hangs from a thin thread and always comes to rest with end P pointing north. Another bar XY of the same metal settles in no definite direction.

What happens if the two bars are brought near one another?

A End P and end Q both attract end X.

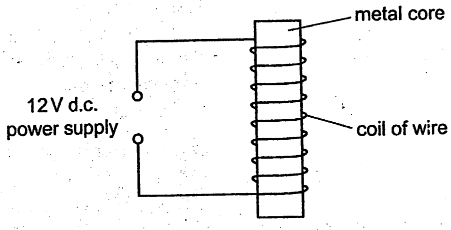
B End P attracts end X but repels end Y.

C End P neither attracts nor repels end X.

D End P repels end X but attracts end Y.

[N14/P1/Q20]

20. The diagram shows a 12 V d.c. power supply connected across a coil with a metal core.



The core becomes a magnet when the current is switched on. It remains a magnet after the current is switched off.

From which metal is the core made?

A aluminium

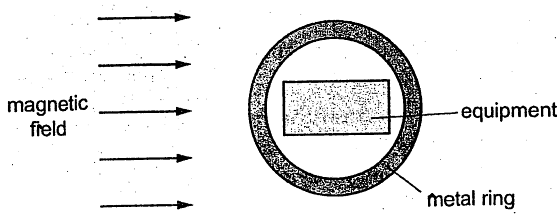
B copper

C soft iron

D steel

[N14/P1/Q21]

21. A metal ring screens a piece of equipment from a magnetic field.



Which metal should be used for the ring, and why?

	metal	reason
A	copper	the metal carries the field lines around the equipment
B	copper	the metal is non-magnetic
C	iron	the metal carries the field lines around the equipment
D	iron	the metal is non-magnetic

[J15/P1/Q31]

22. Which material can be picked up by a magnet?

A aluminium

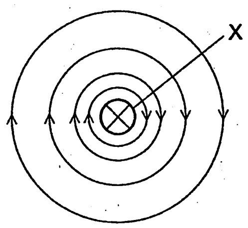
B copper

C iron

D plastic

[N15/P1/Q28]

23. The diagram shows the magnetic field around wire X which carries a current into the paper.



The arrows on the field lines show the direction of the force on

A a N-pole.

B a S-pole.

C a small negative charge.

D a small positive charge.

[N15/P1/Q31]

14. C Fact.

15. C The Pattern of the combined magnetic field of the two bar magnets and the direction of the field lines show that the N-poles of the two bar magnets are facing each other which results in the repulsive magnetic field between them.

16. C It is a fact that soft iron is used for the magnetic screening of electrical equipment from unwanted magnetic fields.

17. B Fact.

18. D Steel retains it's magnetism unlike iron. For a permanent magnet, all magnetic domains need to be aligned. This can only be done with a direct current.

19. A Bar PQ is magnetized. It will attract bar XY from either pole.

20. D Steel once magnetized retains it's magnetism and becomes a permanent magnet. It is very difficult to demagnetize a steel magnet.

21. C Fact.

22. C Iron is attracted by a magnet because it is a magnetic material. Aluminium, copper and plastic are non-magnetic materials.

23. A The direction of a magnetic field at any point is found by placing a N-pole at that point. The direction in which the N-pole experiences a force and moves, is the direction of the magnetic field.

Topic 21 Magnetism

THEORY Section

Question 1

Fig. 5.1 shows a magnet, two compasses and two nails.

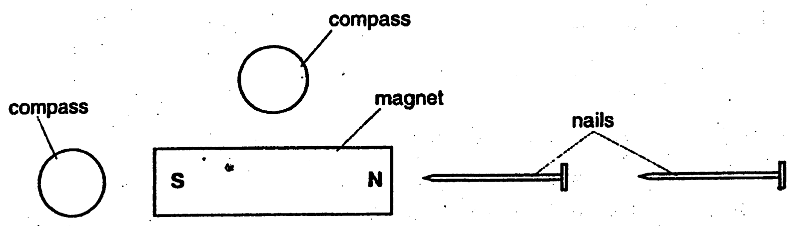


Fig. 5.1

(a) On Fig. 5.1, draw an arrow in each compass to show the direction of the magnetic field of the magnet at the two positions. [2]

(b) The magnet causes the nails to become magnetised by induction. Both ends of each nail become magnetic poles.

On Fig. 5.1, mark an N or an S at both ends of each nail to show the magnetic poles. [2]

(c) When the magnet is removed, the nails are still magnetised.

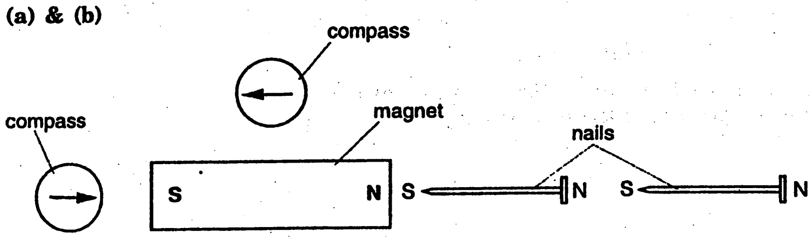
(i) Describe how to test whether the nails are still magnetised when they are away from the magnet. [1]

(ii) Describe, with the aid of a diagram, how the nails can be demagnetised. [2]

[N06/P2/Q5]

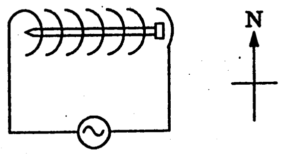
Solution

(a) & (b)



(c) (i) If the nails can continue to attract each other, the nails are still magnetised.

(ii)



Set up the circuit as shown above with the nail in the coil.With the a.c. current flowing at all times, the nail is withdrawn along an east-west direction until he nail is far away from the coil.

COMMENT on ANSWER

" (a) When a compass is placed in a magnetic field, the compass needle always points in the direction of the magnetic field. The general direction of the magnetic field is from north pole to south pole.

(b) Since the nails will be attracted to the magnet, we can deduce the poles on the nails.

(c) (i) Instead of attraction, we also can use repulsion to check if the nails are still magnetised or not.

(ii) For magnetisation, a d.c. current is required but for demagnetisation, an a.c. current is needed. "

Question 2

Fig. 7.1 shows apparatus that can be used to make an electromagnet or a permanent magnet.

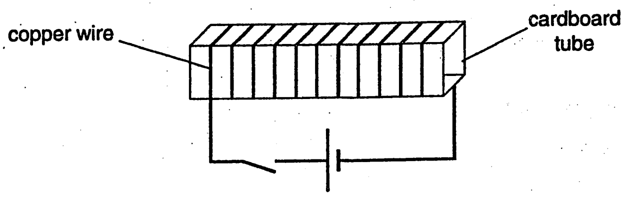


Fig. 7.1

Four rods are available. They are made of aluminium, soft iron, steel and wood.

(a) **(i)** State which rod is used to make a permanent. [1]

(ii) Describe how the apparatus is used to make a permanent magnet. [1]

(b) A computer component is screened from external magnetic fields by placing it in a box, as shown in Fig. 7.2.

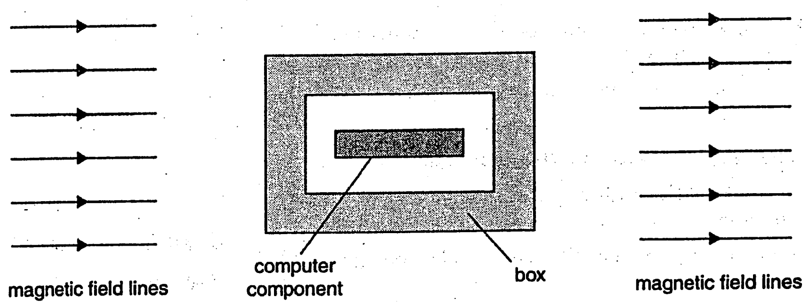


Fig. 7.2

There is a strong magnetic field outside the box. The magnetic field lines have not been drawn near the box.

(i) State the best choice for the material of the box. [1]

(ii) On Fig. 7.2, join the magnetic field lines on the left of the box to those on the right, showing the pattern of the magnetic field. [2]

[N07/P2/Q7]

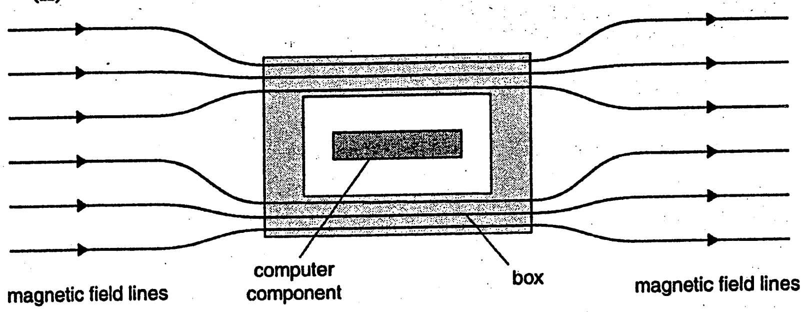
Solution

(a) (i) Steel

(ii) The steel rod is placed inside the solenoid. The current is switched on and immediately switched off. The rod is removed from the solenoid and found to be magnetised.

(b) (i) Soft iron

(ii)



COMMENT on ANSWER

"(b) (i) Alternatively, other soft magnetic materials can also be used here, such as Mumetal (which is an alloy of nickel, copper and iron).

(ii) Note that the magnetic fields lines
— do not enter inside the box.
— do not touch each other.
— do not cross each other."

Question 3

Fig. 5.1 shows part of an electric bell.

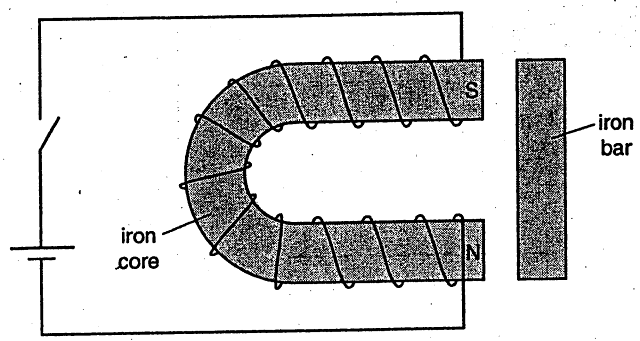


Fig. 5.1

A switch and a cell are in series with a length of wire coiled around an iron core.

The switch is closed and the current in the wire produces a south pole S and a north pole N at the ends of the core, as shown in Fig. 5.1. Magnetic poles are also produced in a small iron bar, placed near to the ends of the core.

(a) (i) On Fig. 5.1, mark with an N the position of the north pole produced in the iron bar and mark with an S the position of the south pole produced in the iron bar. [1]

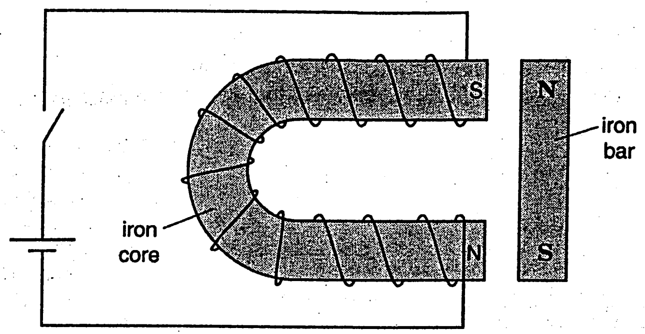
(ii) State and explain what happens to the iron bar once it is magnetised. [2]

(b) The switch is opened and there is no current in the wire. State what happens to the magnetic poles in the iron bar. [1]

[N11/P2/Q5]

Solution

(a) (i)



(ii) The iron bar moves towards the iron core as unlike poles attract each other.

(b) The iron bar loses its magnetic poles.

Question 4

Fig. 7.1 shows a compass needle near a bar magnet. Magnetic poles are shown on the compass needle and on the magnet.

A finger stops the compass needle from turning.

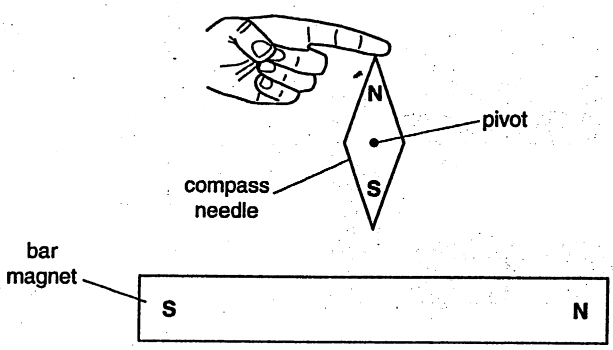


Fig. 7.1 (not to scale)

(a) (i) The magnet causes a force on the S-pole of the compass needle.

On Fig. 7.1, draw an arrow from the S-pole of the compass needle to show the direction of this force. **[1]**

(ii) Explain why the compass needle turns when the finger is removed. **[1]**

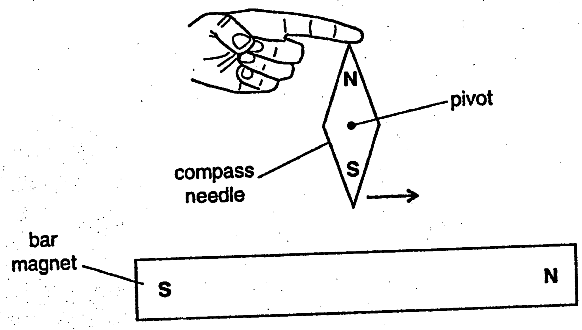
(b) A small compass is used to plot the magnetic field lines of the magnet.

Describe how the compass is used to plot magnetic field lines on a piece of paper. **[3]**

[J14/P2/Q7]

Solution

(a) (i)

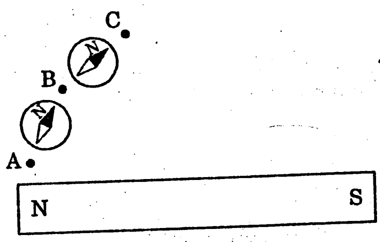


COMMENT on ANSWER

" (a) (i) Like poles of a magnet repel each other, opposite poles of a magnet attract. "

(ii) A moment is created due to a force produced by the bar magnet, which causes the compass needle to turn.

(b) Fix a sheet of paper and place the bar magnet at the centre of the paper and put a small compass near one pole of the magnet. Mark the position of the ends of the compass needle with pencil dots A and B. Then shift the compass to the next position such that one end of its needle is at B and mark the other end of the needle with a third dot C. Continue this process until the S-pole of the magnet is reached. Join the dots. The line produced represents a magnetic field line. Repeat the whole process to draw more magnetic field lines on both the sides and poles of the bar magnet.



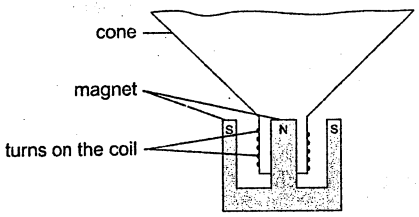
Thinking Process

MCQ Answers

Topic 22 *Magnetic Effect*

M C Q Section

1. The diagram shows parts of a loud-speaker.



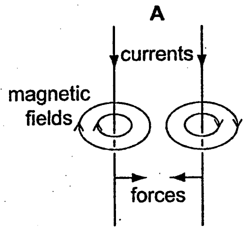
Which type of current is passed through the coil and why?

	current passed through coil	reason why
A	alternating	to keep the magnetic field constant
B	alternating	to make the coil vibrate
C	direct	to keep the magnetic field constant
D	direct	to make the coil vibrate

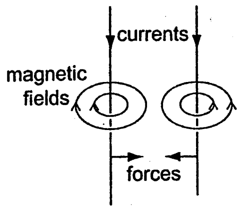
[J06/P1/Q28]

2. Two parallel wires carry currents in the same direction.
Which diagram shows the magnetic field around each wire and the direction of the force on each wire?

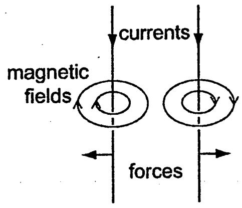
A



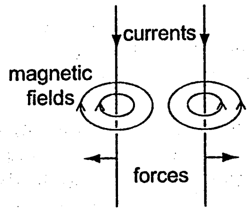
B



C

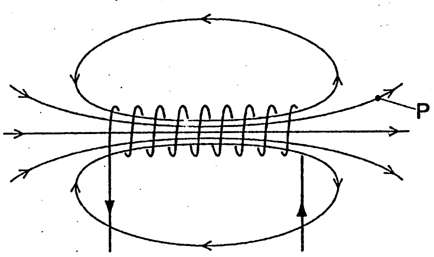


D



[J06/P1/Q34]

3. A current in a solenoid creates a magnetic field.



What is the effect on the magnetic field at the point P of using a larger current in the opposite direction?

	field strength	field direction
A	decreases	reverses
B	decreases	unchanged
C	increases	reverses
D	increases	unchanged

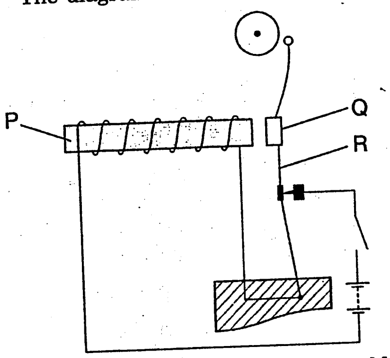
[N06/P1/Q24]

1. B An alternating current is passed through the coil placed in a magnetic field to vibrate it alongwith the cone attached to it forward and backward resulting in the cone producing compressions and rarefactions in the surrounding air that gives rise to the sound.

2. A Fact

3. C The strength of the magnetic field depends on the amount of the current in the coil. The direction of the magnetic field depends on the direction of the current in the coil.

4. The diagram shows an electric bell.

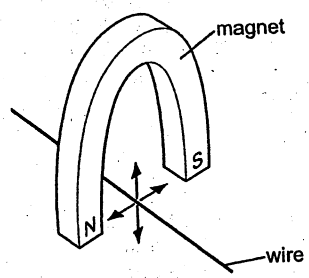


Which materials would be suitable for the parts labelled P, Q and R?

	P	Q	R
A	soft iron	brass	soft iron
B	soft iron	soft iron	spring steel
C	soft iron	brass	brass
D	spring steel	soft iron	spring steel

[N06/P1/Q25]

5. A copper wire is held between the poles of a magnet.

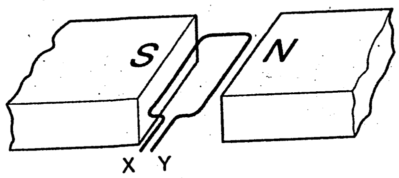


The current in the wire can be reversed. The poles of the magnet can also be changed over.
In how many of the four directions shown can the force act on the wire?

A 1 **C** 3
B 2 **D** 4

[N06/P1/Q31]

6. The diagram shows a coil in a magnetic field.

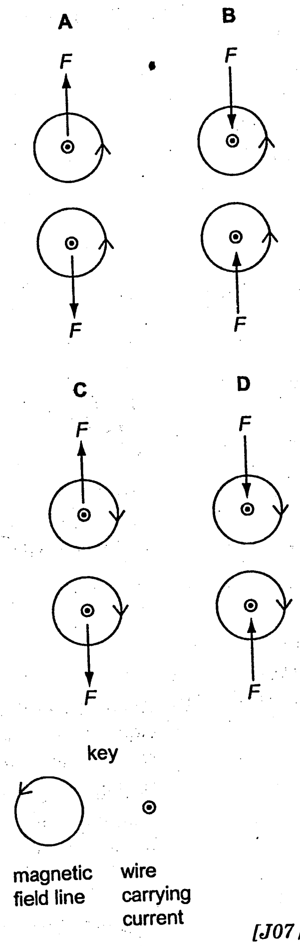


When the coil is part of a d.c. motor, what must be connected directly to X and Y?

A d.c. supply
B slip rings
C soft-iron core
D split-ring commutator

[N06/P1/Q32]

7. The diagrams show the forces F between two wires carrying currents out of the page. The magnetic fields close to the wires are also shown. Which diagram is correct?



[J07/P1/Q33]

8. In a d.c. motor, the coil is wound on a soft iron cylinder.
Why is soft iron used?

A to increase the strength of the magnetic field
B to increase the weight of the coil
C to insulate the coil from the magnet
D to prevent the coil from spinning too quickly

[J07/P1/Q34]

MCQ Answers

4. B P and Q must not retain induced magnetism and so must be "soft" type magnetic material. R must return the striker back to its original position when P and Q loses their induced magnetism.

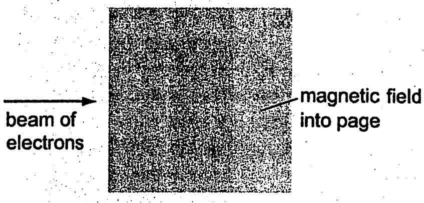
5. B Using Fleming's Left Hand Rule, we know that the force acting on the wire must be perpendicular to both the current in the wire and the magnetic field. This means that there are two possible directions for the force: upwards or downwards.

6. D Fact.

7. B Use the Right Hand grip rule to determine the direction of the magnetic field produced by the current in each wire. Since unlike magnetic flux attract each other so a force of attraction exists between the wires in B.

8. A The soft iron core helps to concentrate the magnetic flux from the field magnets on the sides of the coil.

9. The diagram shows a beam of electrons entering a magnetic field. The direction of the field is into the page.



In which direction are the electrons deflected?

A into the page
B out of the page
C towards the bottom of the page
D towards the top of page

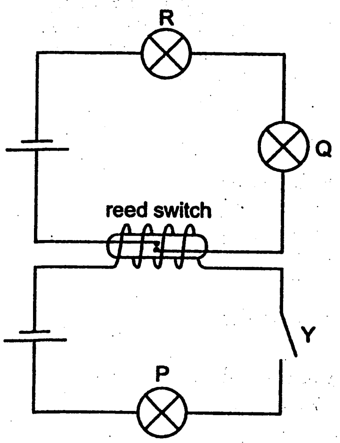
[N07/P1/Q33] & [J12/P1/Q33]

10. Which single-coil motor will have the largest turning effect?

	current in coil	number of turns in coil	iron core
A	6 A	100	no
B	10 A	200	no
C	6 A	100	yes
D	10 A	200	yes

[N07/P1/Q34]

11. In the circuit shown, all lamps are identical and all cells are identical. The resistance of the coil of the reed switch is negligible.



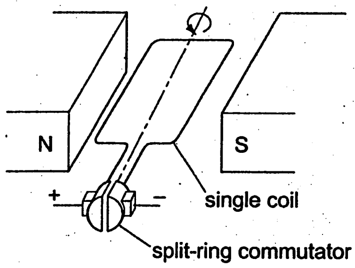
One cell lights one lamp to normal brightness.

What is the brightness of the lamps when switch Y is closed?

	P	Q	R
A	dim	dim	dim
B	normal	dim	dim
C	normal	off	off
D	off	normal	normal

[N07/P1/Q37]

12. The diagram shows a simple electric motor.



The split-ring commutator reverses the current in the coil as the coil rotates.

The coil is rotated 360° from the position shown.

How many times is the current in the coil reversed?

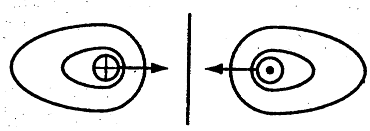
A 1 **B** 2
C 3 **D** 4

[J08/P1/Q33]

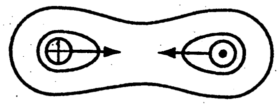
13. Each of the diagrams is a cross-section through two parallel, current-carrying conductors.

Which diagram shows correctly the magnetic field pattern and the directions of the forces on the two conductors?

A



B



Thinking Process

MCQ Answers

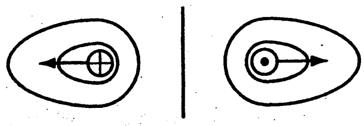
9. C The beam of electrons acts as the current in a magnetic field and it is deflected towards the bottom of the page according to the Fleming's left hand rule.

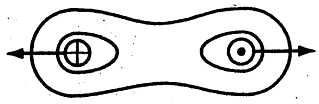
10. D Fact.

11. B When switch Y is closed, the circuit of lamp P is completed, so it lights with normal brightness because one cell lights one lamp with normal brightness. Also on closing switch Y, the coil is magnetised and in turn magnetises the reeds with opposite poles at their free ends. The reed switch is then closed which completes the circuit containing lamps Q and R. The lamps Q and R light but with less brightness because one cell in their circuit cannot light the two lamps with the normal brightness.

12. B The current in the coil reverses for every half rotation of the coil. Since one rotation of the coil consists of two half rotations, thus the current in the coil is reversed twice.

13. C The direction of the magnetic field produced by the current in the left wire is clockwise and anti-clockwise in the wire on the right according to the Right-hand grip rule. These two magnetic fields interact and a repulsive force acts on each wire, which is shown correctly in diagram C.

C 

D 

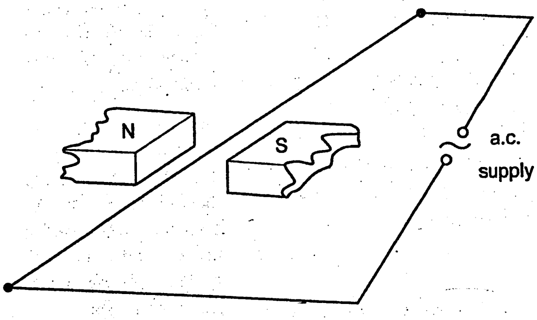
key

⊕ conductor carrying current into page

⊙ conductor carrying current out of page

[N08/P1/Q33]

14. An a.c. supply is connected to a wire stretched between the poles of a magnet.



Which way will the wire move?

A left and right

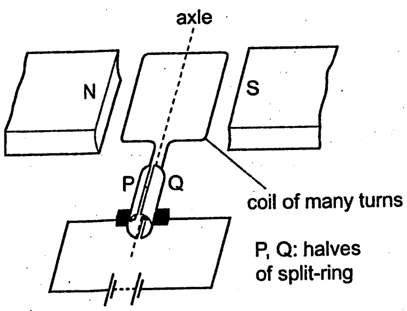
B right only

C up and down

D up only

[J09/P1/Q31]

15. A d.c. motor consists of a coil of many turns rotating in a fixed magnetic field. The coil is connected to a d.c. supply through a split-ring commutator.



Some changes are made, one at a time.

- The d.c. supply is reversed.
- The coil is turned before switching on, so that P starts on the right and Q on the left.
- The poles of the magnet are reversed.
- The turns on the coil are increased in number.

How many of these changes make the coil rotate in the opposite direction?

A 1 **B** 2

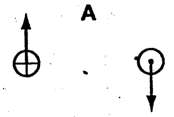
C 3 **D** 4

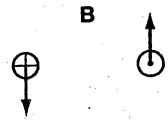
[J09/P1/Q32]

16. Each diagram shows a cross-section through two parallel conductors, each carrying an electric current.

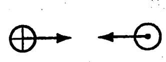
In the conductor on the left, the current is into the page; on the right, it is out of the page.

Which diagram shows the directions of the forces on the two conductors?

A 

B 

C 

D 

[N09/P1/Q31]

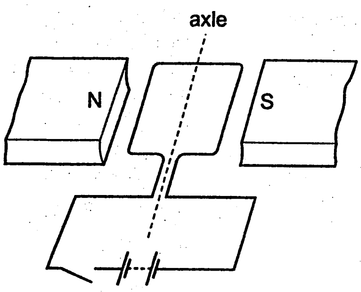
MCQ Answers

14. C The current carrying wire placed in a magnetic field experiences a force according to the Fleming's L.H.R. As the current passing through the wire is alternating so the wire moves up and down with a very small amplitude due to the high frequency of the current.

15. B By reversing the polarity of the D.C. battery, the current in the coil is reversed. As a result, the direction of the forces acting on the sides of the coil is also reversed and the coil then rotates in the opposite direction according to the Fleming's L.H.R.
Similarly by reversing the magnetic poles, reverses the direction of the magnetic field acting on the current in the sides of the coil so the coil rotates in the opposite direction.

16. C Two parallel conductors, carrying current in the opposite directions will have the magnetic field between them in the same direction. So a force of repulsion exists between them.

17. A simple model of a d.c. motor is made. By mistake, the split-ring commutator is left out. The coil can turn, but is always connected to the battery in the same way.



The coil starts in the horizontal position.

What happens to the coil when the circuit is switched on?

A It does not move at all.

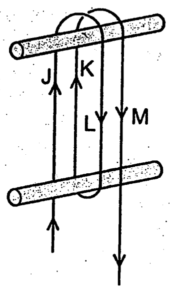
B It moves upwards, out of the magnetic field.

C It turns to the vertical position and eventually stops there.

D It turns to the vertical position then comes back to the horizontal position.

[N09/P1/Q32]

18. A long flexible wire is wrapped round two wooden pegs. A large current is passed in the direction shown.

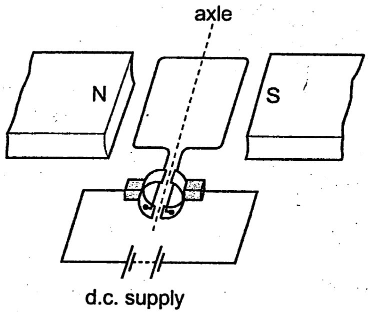


Which two pairs of lengths of wire attract each other?

	first pair	second pair
A	J and K	K and M
B	J and K	L and M
C	J and L	K and M
D	J and L	L and M

[J10/P1/Q33]

19. The diagram shows a d.c. motor.



Why is a split-ring commutator used?

A to change the current direction in the coil as the coil passes the horizontal position

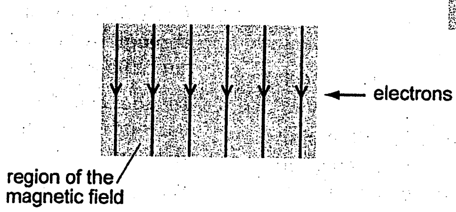
B to change the current direction in the coil as the coil passes the vertical position

C to change the current direction in the d.c. supply as the coil passes the horizontal position

D to change the current direction in the d.c. supply as the coil passes the vertical position

[J10/P1/Q36]

20. The diagram shows a beam of electrons entering a magnetic field. The direction of the magnetic field is downwards, towards the bottom of the page.



In which direction does the deflection of the electrons occur?

A into the page

B out of the page

C towards the bottom of the page

D towards the top of the page

[N10/P1/Q32]

MCQ Answers

17. C When the current passes through, the coil its front face becomes a South pole and the back face becomes a North Pole. Due to the attraction between the unlike poles of the coil and the magnets, the coil turns to the vertical position and stops there. It does not continue moving further due to the absence of the split-ring commutator.

18. B Current flowing in the same direction in two parallel wires produce opposite magnetic fields which attract each other.

19. B The split-ring commutator reverses the direction of the current in the coil when the coil passes through the vertical position and changes its contact from one carbon-brush to the other.

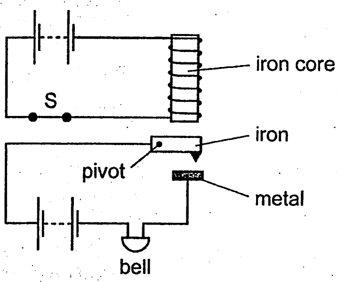
20. A According to the Fleming's LHR, the beam of electrons deflects into the page.

21. What does **not** alter the size of the turning effect on the coil of an electric motor?

A the direction of the current in the coil
B the number of turns in the coil
C the size of the current in the coil
D the strength of the magnetic field

[N10/P1/Q34]

22. The diagram shows an alarm system in which the switch S is shown closed.



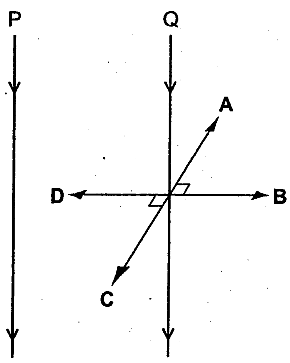
What happens when the switch S is opened?

	iron	bell
A	drops	rings
B	drops	stops ringing
C	moves up	rings
D	moves up	stops ringing

[N10/P1/Q35]

23. Two parallel vertical wires P and Q are a small distance apart in air. There is a downwards electric current in both wires. A force acts on Q owing to the current in P. This force is perpendicular to the wire Q.

What is the direction of the force on Q?



[N10/P1/Q36]

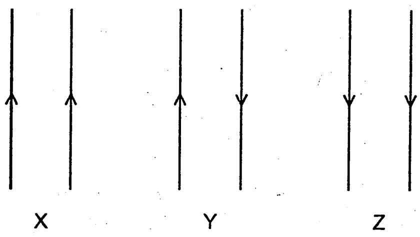
24. The coil in an electric motor is wound onto a cylinder.

Why is the cylinder made of soft iron?

A to deflect the magnetic field away from the coil
B to increase the current through the coil
C to increase the strength of the magnetic field through the coil
D to support the coil and prevent it from collapsing

[J11/P1/Q35]

25. The diagram shows three pairs of parallel wires with the currents in the directions shown.

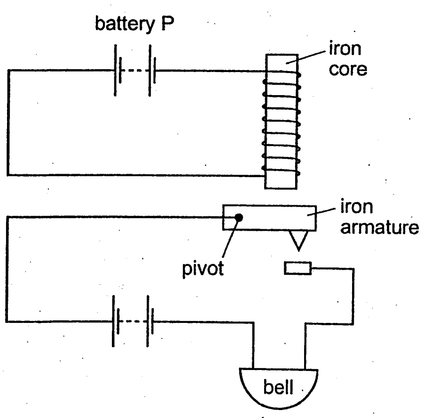


For each pair of wires, what are the forces between the wires?

	X	Y	Z
A	attraction	none	repulsion
B	attraction	repulsion	attraction
C	repulsion	attraction	repulsion
D	repulsion	repulsion	repulsion

[J11/P1/Q36]

26. The diagram shows an alarm system.



What happens when battery P is disconnected?

MCQ Answers

21. A The change in the direction of current only alters the direction of rotation of the coil.

22. A When the switch is opened, the current stops flowing in the upper circuit and the iron core is demagnetised. The iron in the lower circuit drops and comes in contact with the metal. The lower circuit is then completed and the bell rings.

23. D The current in the same direction in two parallel wires induces magnetic field around them in opposite directions. This results in a force of attraction between the wires, so the wire Q experiences a force towards the wire P.

24. C Soft iron is a magnetic material which magnetises and demagnetises quickly. On magnetising, it greatly increases the power of the motor by adding its magnetic flux to that of the coil.

25. B Like currents in two parallel wires induce opposite magnetic fields around the wires. This causes attraction between the wires. Similarly, unlike currents in two parallel wires induce magnetic fields around them in the same direction causing a repulsion between them.

26. A When the battery P is disconnected, the current in the upper circuit ceases to flow and the iron core is demagnetised. The iron armature falls, which completes the circuit and the bell rings.

	iron armature	bell
A	falls	rings
B	falls	stops ringing
C	moves up	rings
D	moves up	stops ringing

[N11/P1/Q26]

27. One component of a simple d.c. motor is a split-ring commutator.

Which metal is used to make the commutator, and why is this metal chosen?

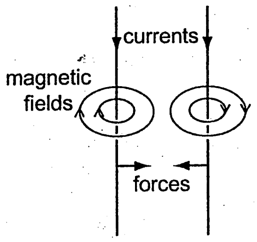
	metal	reason
A	copper	it is a good conductor of electricity
B	copper	it is a good conductor of heat
C	iron	it increases the magnetic field strength
D	iron	it is attracted to the brushes

[N11/P1/Q35]

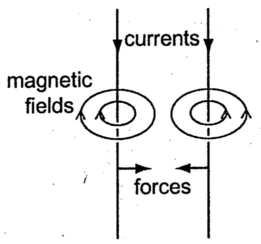
28. Two parallel wires carry currents in the same direction.

Which diagram shows the magnetic field around each wire and the direction of the force on each wire?

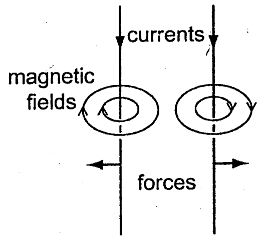
A



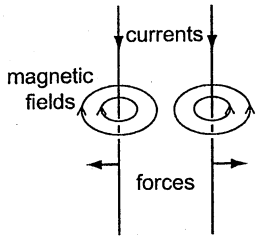
B



C



D



[N11/P1/Q36]

29. Two long, straight wires hang vertically, close to each other.

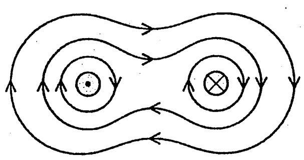
The wires carry currents in opposite directions.

⊙ current out of page

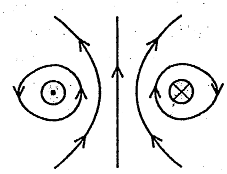
⊗ current into page

Which diagram shows the magnetic field pattern around the wires?

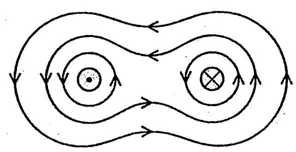
A



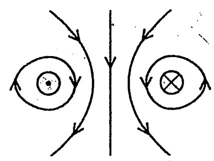
B



C



D



[J12/P1/Q26]

Thinking Process

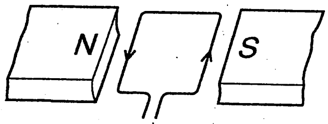
MCQ Answers

27. A Fact.

28. A Parallel wires carrying current in the same direction attract one another whereas parallel wires carrying current in opposite direction repel one another. The right hand grip rule can also be used to determine the direction of the magnetic field produced by each wire.

29. B The direction of the magnetic field produced by the current in the left wire is anti-clockwise and it is clockwise around the wire on the right, according to the Right-Hand grip rule. The magnetic flux of these two magnetic fields interact and a repulsive force acts on each wire which is correctly shown in diagram B.

30. A rectangular coil is placed between the poles of a magnet. A current passes through the coil, as shown.



What happens to the coil?

A It moves downwards.

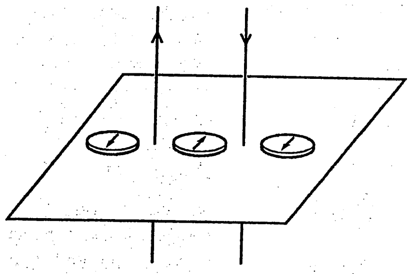
B It moves upwards.

C It rotates anticlockwise.

D It rotates clockwise.

[J12/P1/Q34]

31. Two parallel wires carry currents in opposite directions. Three plotting compasses are placed in the positions shown.



The currents in **both** wires are reversed. How many compass needles change direction?
(Ignore the effect of the Earth's magnetic field.)

A	0	**B**	1
C	2	**D**	3

[N12/P1/Q33]

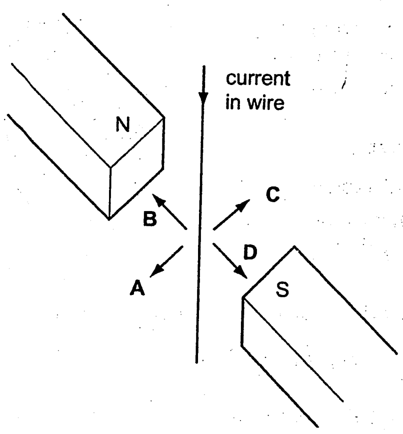
32. Which single-coil motor has the largest turning effect?

	current in coil/A	number of turns in coil	iron core
A	6	100	no
B	10	200	no
C	6	100	yes
D	10	200	yes

[N12/P1/Q34]

33. A wire hangs between the poles of a magnet.

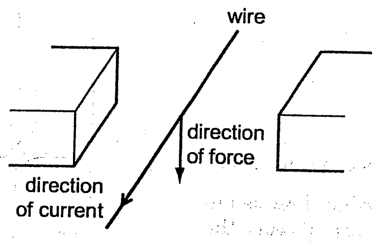
When there is a current in the wire, in which direction does the wire move?



[J13/P1/Q37]

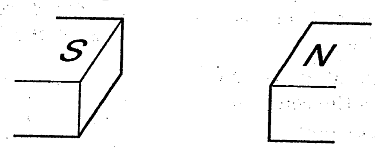
34. The diagram shows a wire placed between two magnetic poles of equal strength.

A current passes through the wire in the direction shown. The current causes a downward force on the wire.

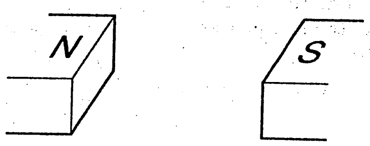


What is the arrangement of the magnetic poles?

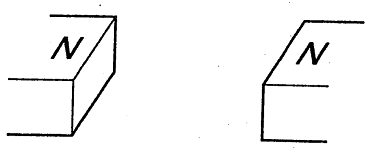
A



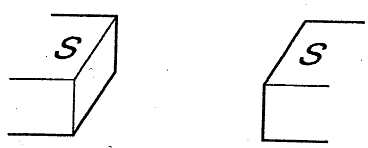
B



C



D



[N13/P1/Q32]

T h i n k i n G P r o c e s S

MCQ Answers

30. D According to the Fleming's Left-Hand rule, the left side of the coil experiences an upward force and its right side experiences a downward force. This couple of forces produce a clockwise rotation in the coil.

31. D On reversing the directions of currents through the parallel wires, the directions of the magnetic fields induced around them are also reversed. Hence all the three magnetic compasses change their directions.

32. D Fact.

33. A The wire moves in the direction of the resultant force experienced by it due to the interaction of the magnetic field of the bar magnets with the magnetic field of the current in the wire. The direction of the resultant force and hence the direction of motion of the wire can be determined by applying the Fleming's left hand rule.

34. A The current carrying wire experiences a downward force when placed in a magnetic field as shown in option **A**, according to the Fleming's LHR.

35. Two long, parallel conductors carrying current lie in a horizontal plane.

The two conductors attract one another.

The two currents **must**

A be in the same direction.

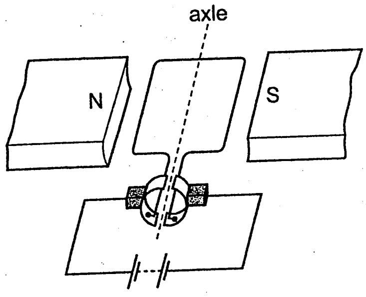
B be in opposite directions.

C be parallel to the Earth's magnetic field.

D be at 90° to the Earth's magnetic field.

[N14/P1/Q31]

36. The diagram shows a d.c. motor with its coil horizontal.



Why is a split-ring commutator used?

A to change the current direction in the coil as the coil passes the horizontal position

B to change the current direction in the coil as the coil passes the vertical position

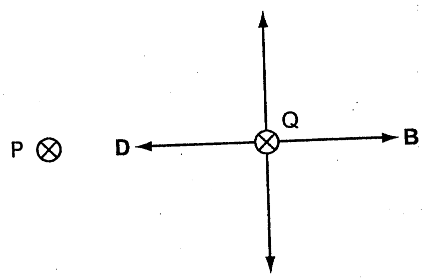
C to change the current direction in the d.c. supply as the coil passes the horizontal position

D to change the current direction in the d.c. supply as the coil passes the vertical position

[N14/P1/Q32]

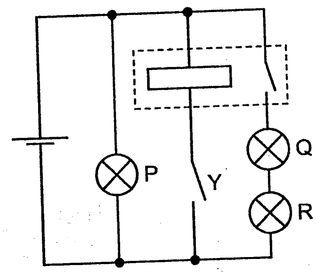
37. P and Q represent two, parallel, straight wires carrying currents into the plane of the paper. P and Q exert a force on each other.

Which arrow shows the force on Q?



[N15/P1/Q32]

38. In the circuit shown, all lamps are identical. Lamp P lights with normal brightness.



Switch Y is closed and lamps come on. Which row indicates the brightness of the lamps?

	P	Q	R
A	dim	dim	dim
B	normal	dim	dim
C	normal	off	off
D	off	normal	normal

[N15/P1/Q38]

MCQ Answers

35. A Parallel conductors with currents in opposite directions repel one another, whereas parallel conductors with currents in the same direction attract one another.

36. B Fact.

37. D The current flowing in the wires P and Q produce attracting magnetic fields between them. As a result, the two wires are attracted towards each other. Hence, the wire Q experiences a force of attraction towards the wire P along the direction D.

38. B On closing the switch Y, a current passes through the coil and magnetises it, which then closes the switch connected in series with the lamps Q and R. These two lamps light dimly with half the brightness of the lamp P, because less current passes through them due to the greater resistance in this branch, as compared to the lamp P.

Topic 22 Magnetic Effect

THEORY Section

Question 1

Fig. 6.1 shows a coil of wire wound on a cardboard tube.

There is a d.c. current in the coil. The direction of the current is shown in the key.

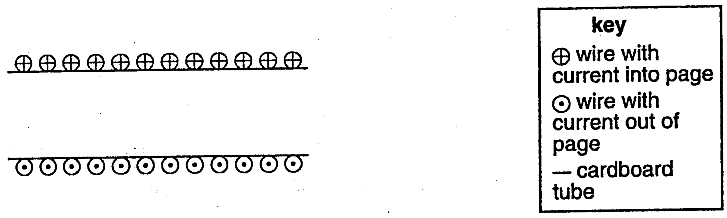


Fig. 6.1

(a) On Fig. 6.1, draw the magnetic field produced by the coil. [3]

(b) Fig. 6.2 shows a simple loudspeaker that uses the coil shown in Fig. 6.1 attached to a paper cone.

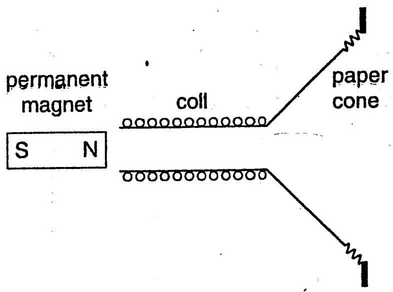


Fig. 6.2

The coil is connected to a signal generator.

There is an alternating current of frequency 100 Hz in the coil.

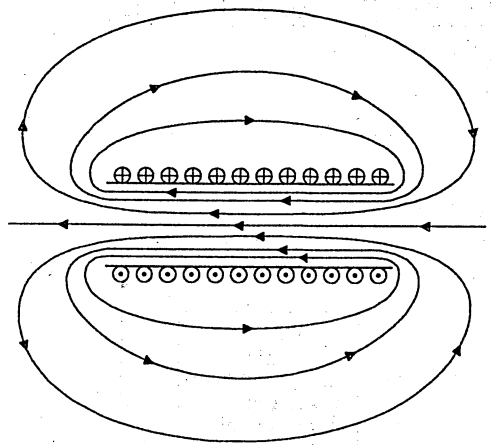
(i) State what is meant by a *frequency of 100 Hz*. [1]

(ii) Describe and explain the movement of the coil. [3]

[J07/P2/Q6]

Solution

(a)



(b) (i) It means that the current changes its direction and back again 100 times in one second.

(ii) As the current passes through the coil, the magnetic poles are produced at its ends and it acts as an electromagnet. As the a.c. in the coil verses, the poles of the electromagnet also reverse, causing the coil to vibrate left and right due to the attraction and repulsion between the magnet and the coil.

COMMENT on ANSWER

“(b) (i) Also, the current makes 100 oscillations in one second.”

Question 2

(a) Fig. 7.1 shows a straight wire between the poles of a magnet. The wire carries a current into the page.

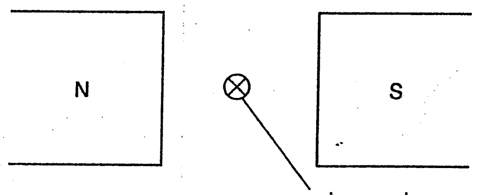


Fig. 7.1

(i) State the direction of the magnetic field between the poles of the magnet. [1]

(ii) On Fig. 7.1, draw an arrow to show the direction of the force acting on the wire. [1]

(b) Fig. 7.2 shows two wires.
Each wire carries a current into the page.

Fig. 7.2

(i) On Fig. 7.2, draw the magnetic field due to the currents in the wires. [3]

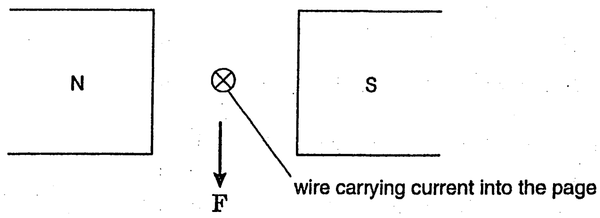
(ii) There is a force on each wire due to the current in the other wire. On Fig. 7.2, draw an arrow on each wire to show these forces. [1]

[J08/P2/Q7]

Solution

(a) **(i)** From N-pole to S-pole.

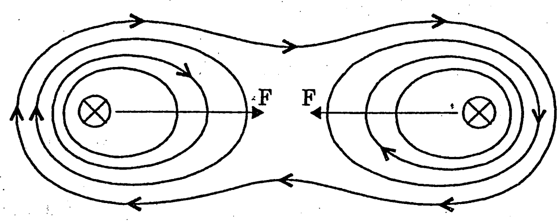
(ii)



COMMENT on ANSWER

" (a) **(ii)** The direction of the force acting on the current carrying wire is found by applying the Fleming's LHR. "

(b) **(i)** **(ii)**



Question 3

Fig. 10.1 shows a wire passing through a hole in a horizontal, plastic board.

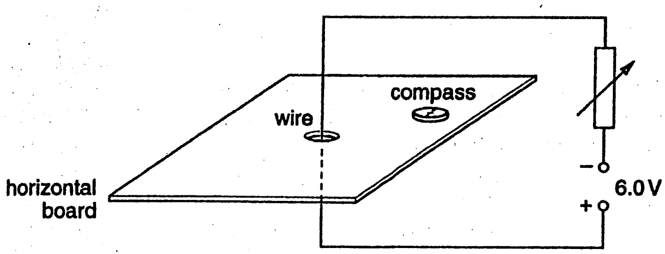


Fig. 10.1

The wire carries a current vertically upwards. A student moves a small compass around the board and plots the magnetic field lines due to the current.

(a) **(i)** Draw a diagram of the board as seen from above and mark on it the magnetic field lines due to the current. [3]

(ii) The current is increased. Describe how the magnetic field changes. [1]

(b) A 6.0 V power supply produces a current of 8.0 A in the wire. Calculate

(i) the total resistance of the circuit, [2]

(ii) the charge that flows through the wire in 2.0 minutes. [2]

(c) The north pole of a bar magnet is held on the left of the wire and the south pole of another bar magnet is held on the right, as shown in Fig. 10.2.

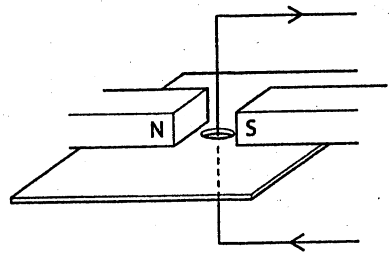


Fig. 10.2

(i) State the direction of the magnetic field at the wire due to these two poles. [1]

(ii) The wire is flexible. Describe the effect of this magnetic field on the current-carrying wire. [2]

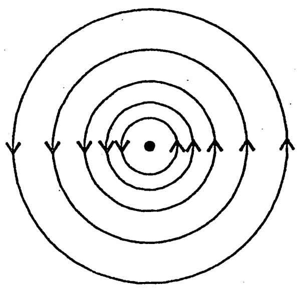
(iii) The current in the wire is now reversed. State the effect of this on the wire. [1]

(iv) Describe how this effect is put to use in a d.c. Motor. [3]

[N08/P2/Q10]

Solution

(a) (i)



(ii) The magnetic field strength around the wire increases if the current through the wire is increased, because a larger current produces a larger number of magnetic lines per unit area around the wire.

(b) (i) $R = \frac{V}{I} = \frac{6.0}{8.0} = 0.75\ \Omega$.

(ii) Charge, $Q = I \times t = 8.0 \times (2.0 \times 60) = 960\ \text{C}$

(c) (i) The direction of the magnetic field that acts on the wire is from North to South.

(ii) The direction of the magnetic field due to the bar magnets is perpendicular to the direction of current in the wire. This magnetic field interacts with the magnetic field due to the current in the wire. As a result a force is experienced by the flexible wire and it moves backwards according to the Fleming's Left-hand Rule.

(iii) The direction of the force that acts on the wire is also reversed so the wire now moves forward.

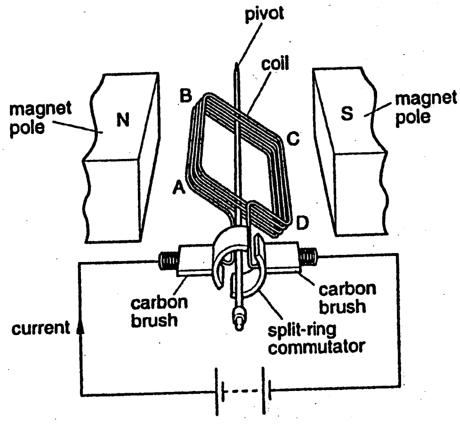
COMMENT on ANSWER

❝ (a) (i) — The magnetic field lines are closer to each other near the wire but the spacing between them increases with distance from the wire because the magnetic field is stronger near the wire but the strength of the magnetic field decreases with the distance from the wire.

— The strength of the magnetic field is determined by the number of magnetic lines per unit area, i.e. the stronger the magnetic field, the more would be the magnetic lines per unit area in it.

— The direction of the magnetic field lines is anti-clockwise according to the Right-hand Grip Rule. ❞

(iv) The D.C. Motor uses the effect of a magnetic field on a current carrying wire. The wire is shaped in the form of a rectangular coil ABCD and its ends are connected to a split-ring commutator. The coil is then placed in a magnetic field as shown below:



When a current is passed through the coil, its sides AB and CD experience a downward and upward force respectively according to the Fleming's Left Hand Rule. The coil thus rotates in anticlockwise direction.

After one half of this rotation, the sides AB and CD change their positions along with their halves of the commutator which change contact from one brush to the other. This reverses the direction of current in the sides of the coil. As a result, the direction of the forces acting on the sides of the coil is also reversed. The side AB is now on the right-hand side with an upward force on it and side CD on the left-hand side with a downward force. As a result, the coil again experiences an anticlockwise turning effect. The coil thus continuous to rotate in anticlockwise direction for so long as the current is passing in it.

Question 4

Fig. 7.1 shows two pieces of soft iron in the magnetic field of a strong permanent magnet.

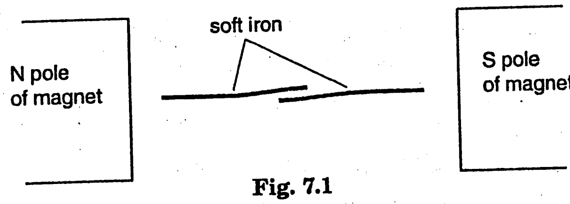


Fig. 7.1

The pieces of soft iron become magnetised.

(a) On Fig. 7.1, mark the magnetic poles produced at each end of both pieces of soft iron. [1]

(b) Fig. 7.2 shows a reed switch.

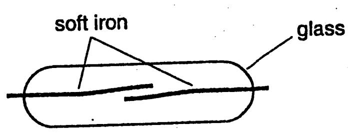


Fig. 7.2

The reed switch is placed between the poles of the strong permanent magnet. State and explain what happens. [2]

(c) Fig. 7.3 shows two separate electrical circuits.

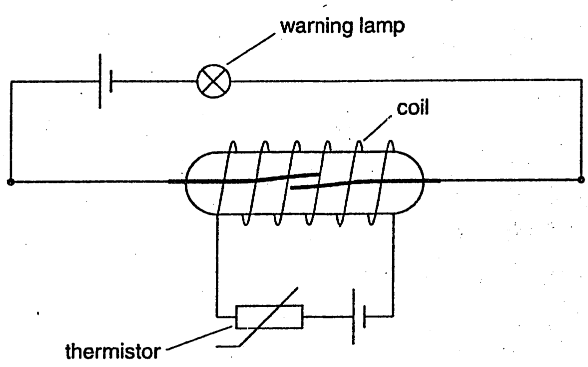


Fig. 7.3

One circuit consists of a reed switch, a cell and a warning lamp. The other circuit consists of a thermistor, another cell, and a coil wound round the reed switch. The thermistor is at the same temperature as the air around it.

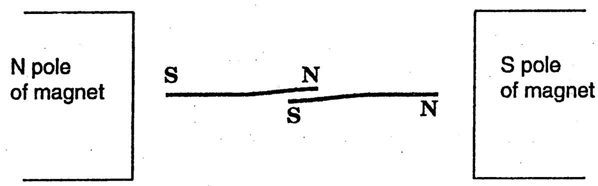
(i) State what happens to the thermistor when the temperature of the air rises. [1]

(ii) Explain why the warning lamp lights up when the air temperature rises. [2]

[J09/P2/Q7]

Solution

(a)



(b) The opposite magnetic poles at the free-ends of the reeds attract and come into contact with each other. This completes the circuit to which the reed switch is connected.

(c) **(i)** The resistance of the thermistor decreases.

(ii) The increase in temperature decreases the resistance of the thermistor. As a result, the amount of current in the coil increases which in turn increases the strength of the magnetic field in the coil. This increases the strength of the opposite magnetic poles induced at the ends of the reeds. They then attract and come into contact with each other. The second circuit is completed and the lamp lights up.

Question 5

Fig. 7.1 shows a compass.

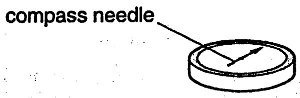


Fig. 7.1

The compass needle is a small magnet free to rotate. The head of the arrow on the compass needle is an N-pole.

(a) A bar magnet is placed between two compasses, as shown in Fig. 7.2.

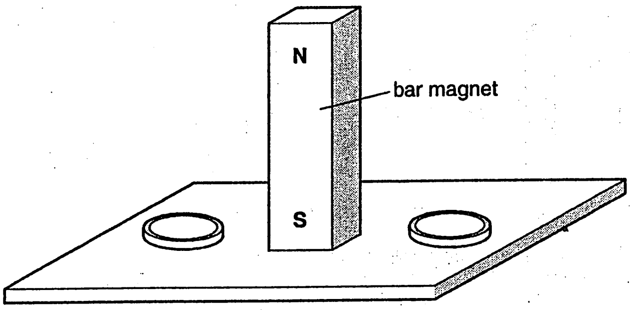


Fig. 7.2

On Fig. 7.2, draw the needles inside the two compasses and mark the N-pole of both compass needles. [2]

(b) Fig. 7.3 shows the structure of a relay.

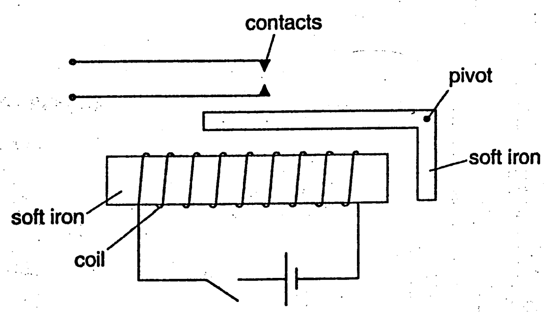


Fig. 7.3

Explain how closing the switch causes the contacts to close. [2]

(c) Fig. 7.4 is a circuit that includes a relay.

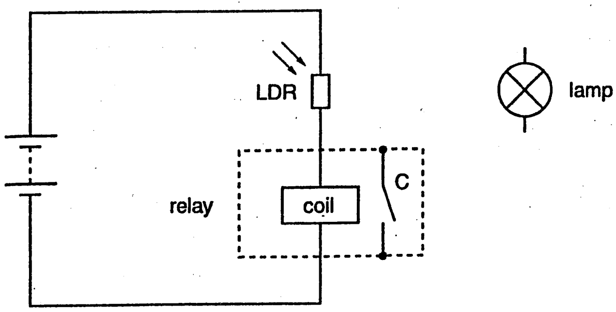


Fig. 7.4

When light shines on the light-dependent resistor (LDR), the relay contacts C close.

(i) State what happens to the resistance of the LDR when light falls on it. [1]

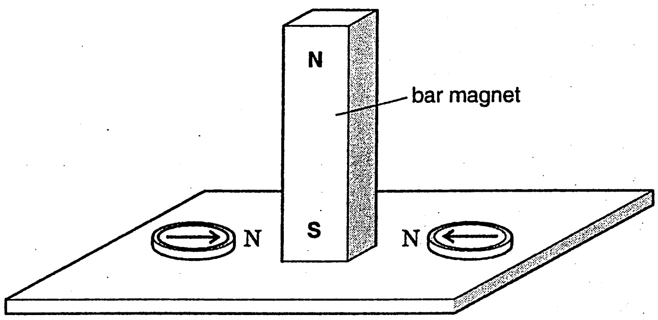
(ii) The circuit for the lamp, as shown in Fig. 7.4, is not complete.

On Fig. 7.4, draw the connections to the lamp, the contacts C and the battery that cause the lamp to switch on when light shines on the LDR. [2]

[J10/P2/Q7]

Solution

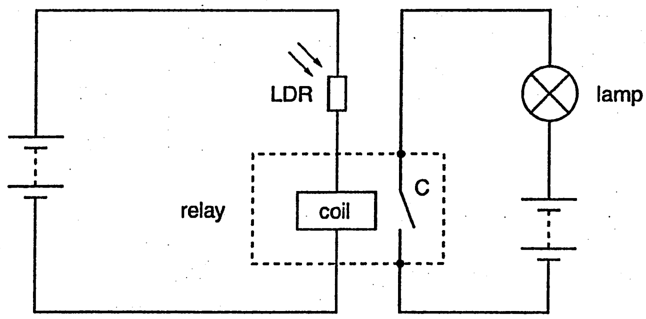
(a)



(b) The flow of current in the solenoid magnetises the soft iron core which then attracts the vertical part of the soft iron armature by magnetic induction. As a result, the horizontal part of the armature rotates upwards and causes the contacts to close.

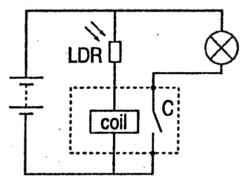
(c) (i) The resistance of the LDR decreases.

(ii)



COMMENT on ANSWER

" **(c) (ii)** Another way of completing the circuit is as follows: "



Question 6

Fig. 6.1 shows a metal bar placed inside a vertical solenoid.

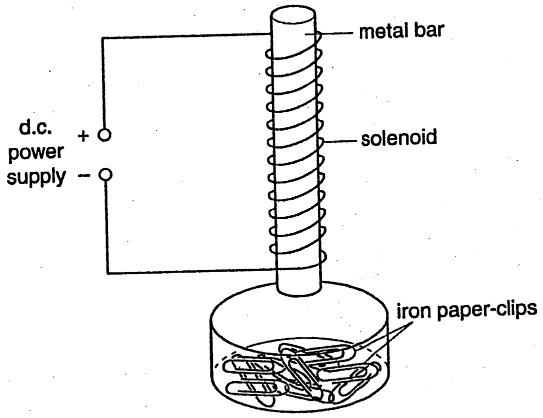


Fig. 6.1

The solenoid is a coil of several turns of insulated wire. A d.c. power supply is connected to the solenoid so that there is a current in it when the supply is switched on. The metal bar is a short distance above a small pile of iron paper-clips in a glass dish.

The power supply is

- switched on,
- left on for several seconds,
- then switched off.

Describe the behaviour of the paper-clips when this procedure is carried out using a metal bar of

(a) aluminium, [1]

(b) iron, [2]

(c) steel. [2]

[N10/P2/Q6]

Solution

(a) aluminium: No effect on the paper clips is seen on switching on or after switching off the power supply.

(b) iron: The paper clips are attracted up and stick to the iron bar when the current is switched on and fall back when the current is switched off.

(c) steel: The paper clips are attracted up and stick to the steel bar when the current is switched on and remain attracted even after the power supply is switched off.

COMMENT on ANSWER

" (a) Aluminium is a non-magnetic material. It is neither magnetised nor it attracts any magnetic material.

(b) Iron is magnetised when current is switched on but loses its magnetism when current is switched off.

(c) Steel is magnetised when the current is turned on and remain magnetised even when the switch is turned off because steel is permanently magnetised ."

Question 7

(a) A wire is wound around a soft-iron core forming a solenoid, as shown in Fig. 11.1.

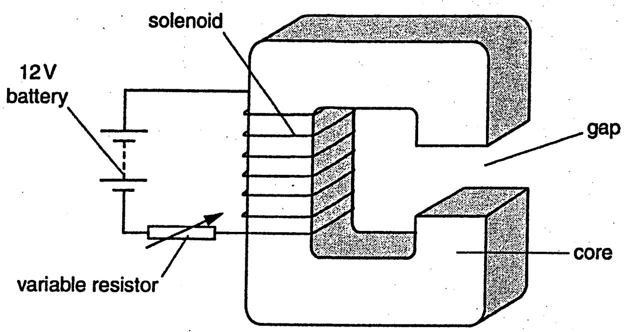


Fig. 11.1

There is a gap in the core. The solenoid is connected in series with a 12 V battery and a variable resistor (rheostat). The resistance of the solenoid is 0.30 Ω and the variable resistor is set so that it has a resistance of 4.5 Ω.

(i) Calculate the current in the solenoid. **[3]**

(ii) The current in the solenoid magnetises the soft-iron core.

Explain how the electric circuit is used to increase the strength of the magnetic field. **[2]**

(iii) Fig. 11.2 shows a horizontal, current-carrying wire PQ in the gap.

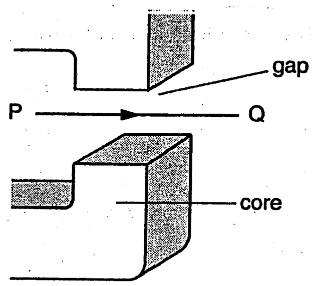


Fig. 11.2

1. The magnetic field in the gap is uniform and vertically upwards. The current in PQ is from left to right. Describe the effect of the magnetic field on PQ. **[2]**
2. State the effect on PQ of increasing the strength of the magnetic field in the gap. **[1]**

(b) The starter motor in a car is powered by a 12 V battery that is positioned next to the motor. The current in the motor is 75 A.

(i) Calculate the power supplied by the battery. **[2]**

(ii) Suggest and explain why the wires that connect the motor to the battery are very thick. **[2]**

(c) A relay is used to switch on a starter motor in a car. Describe how the relay works. You may include a diagram in your answer. **[3]**

[N12/P2/Q11]

Solution

(a) (i) $V = IR$

$12 = I \times 4.8$

$I = \frac{12}{4.8}$

$= 2.5 \text{ A}$

(ii) The strength of the magnetic field can be increased by increasing the amount of current in the solenoid which is done by decreasing the resistance of the variable resistor.

(iii) 1. A force acts on the wire PQ and it moves out of the plane of the paper.

2. A greater force acts on the wire PQ and it moves outwards with a greater speed.

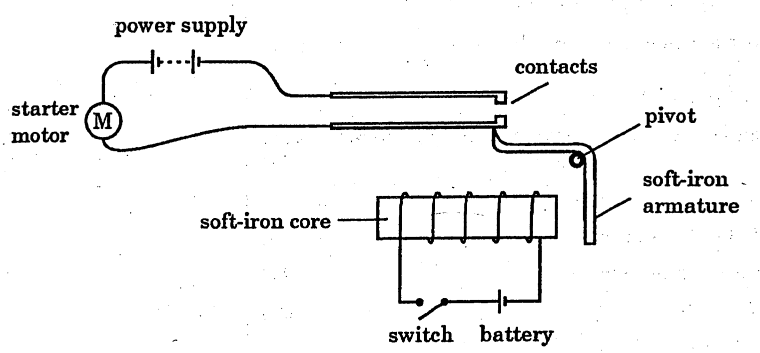
(b) (i) $P = V \times I$

$= 12 \times 75$

$= 900 \text{ W}$

(ii) The thick wires have low resistance which reduces the heating effect in the wires and decreases the power loss in the wires.

(c)



When the switch S is closed, a current flows in the solenoid and the soft-iron core is magnetised. This in turn attracts the soft-iron armature by the magnetic induction. As the vertical part of armature moves towards the soft-iron core, its horizontal part moves up and closes the contacts. This completes the circuit of the starter motor and it starts working.

COMMENT on ANSWER

" **(a) (iii)** — The direction of the force which acts on the wire PQ can be determined by applying the Fleming's LHR.
— The wire moves in the direction of this force.

(c) A relay is a circuit with a small current which is used to switch on a circuit with a large current. "

Question 8

Fig. 7.1 shows a view, from above, of two wires X and Y. These wires carry equal currents vertically downwards through a piece of card.

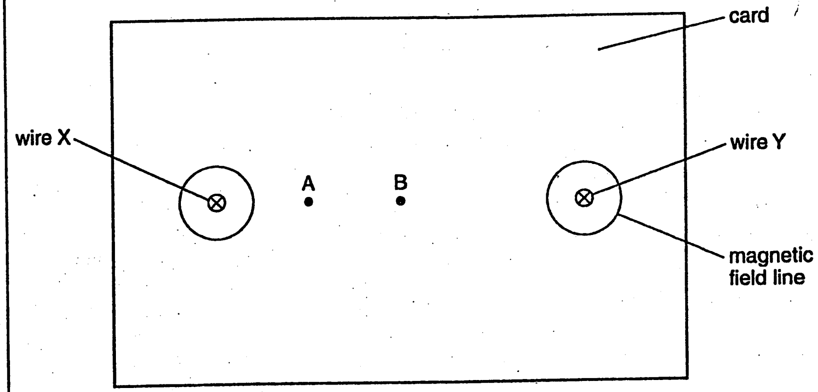


Fig. 7.1

One complete magnetic field line is drawn around each wire.
In this question, ignore the effects of the Earth's magnetic field.

(a) On Fig. 7.1, draw the complete magnetic field line due to the current in wire X that passes through point A.
Mark the direction of this field line. [2]

(b) Point B is midway between the two wires. Explain why the magnetic field at B is zero. [1]

(c) There is a force on wire Y due to the current in wire X.

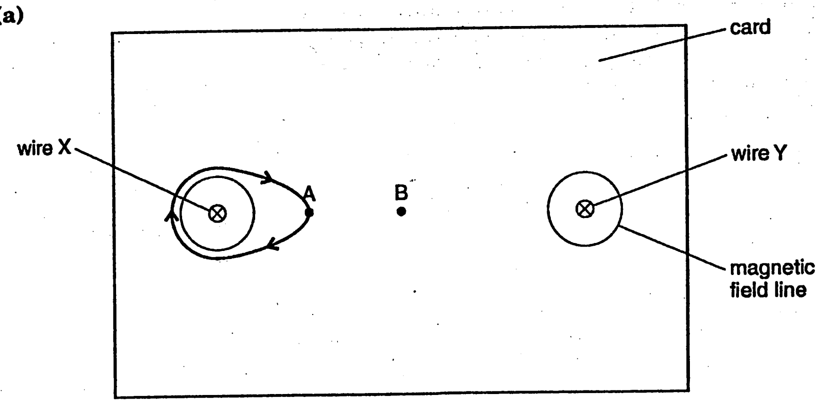
(i) State the direction of the force on wire Y. [1]

(ii) Explain why there is a force on wire Y. [1]

[J13/P2/Q7]

Solution

(a)



(b) At B, the magnetic fields due to X and Y have the same strength but opposite direction so they cancel each other.

(c) **(i)** The direction of the force on Y is towards X.

(ii) A force acts on the current carrying wire Y placed in the magnetic field caused by the wire X.

Question 9

Fig. 10.1 shows a relay connected to a cell and a switch.

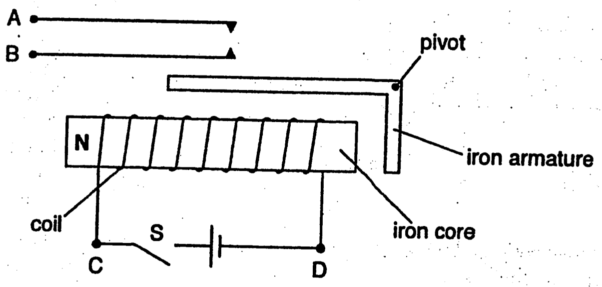


Fig. 10.1

(a) When switch S is closed, the iron core is magnetised. The left side of the core is an N-pole, as shown in Fig. 10.1. The iron armature is attracted to the core.

(i) On Fig. 10.1, mark

1. the S-pole of the iron core
2. the N-pole and the S-pole of the iron armature. [2]

(ii) The cell is reversed.
State what happens to the poles and to the armature. [2]

(iii) Explain why the core is made of iron and not steel. [2]

(b) Fig. 10.2 shows the relay connected in a circuit to a 12 V battery. The bell is not ringing.

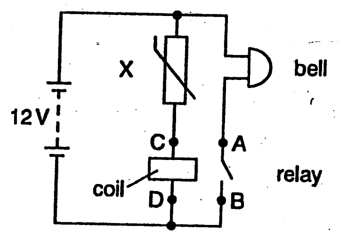


Fig. 10.2

(i) State the name of component X. [1]

(ii) Explain why the bell rings when the temperature of X rises. [2]

(iii) When the resistance of X is 2000 Ω, the current in the coil is 1.5 mA. This causes the contacts in the relay to close. The resistance of the bell is 200 Ω.

Calculate

1. the potential difference (p.d.) across X, [2]
2. the p.d. across the coil, [1]
3. the current in the battery. [2]

(iv) Component X is removed from the circuit and replaced by a different component Y.

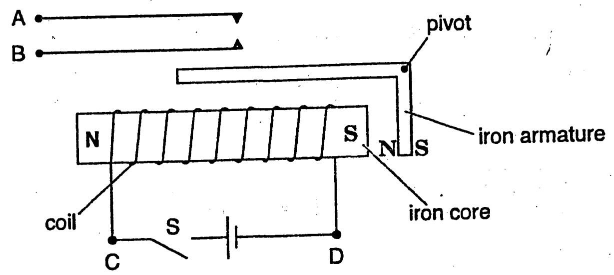
The bell now rings when bright light shines on Y.

State the name of component Y. [1]

[J15/P2/Q10]

Solution

(a) (i) 1. & 2.



(ii) Magnetic poles on the core are also reversed when the current is reversed. The armature is still attracted to the core.

(iii) Iron loses its temporary magnetism on opening the switch and allows the armature to return to its original position whereas the steel core retains its magnetism on opening the switch and armature cannot return to its original position and remains stuck to the core.

(b) (i) Thermistor

(ii) The resistance of the thermistor decreases which increases the current in the coil and the coil is strongly magnetised. The coil then attracts the armature and closes the switch of the bell circuit and the bell rings.

(iii) 1. $V = IR$

$= (1.5 \times 10^{-3}) \times 2000 = 3.0$

$\therefore$ p.d. across X $= 3.0$ V

2. $V = 12 - 3.0$

$= 9.0$ V

$\therefore$ p.d. accross the coil $= 9.0$ V

3. Current in the bell, $I = \dfrac{V}{R}$

$= \dfrac{12}{200}$

$= 0.06$ A $= 60$ mA.

Current in the battery

= current in coil branch + current in bell branch

= 1.5 mA + 60 mA

= 61.5 mA

(iv) Light dependent resistor (LDR).

COMMENT on ANSWER

“ **(a) (i)** *Alternatively,* Mark N-Pole anywhere on vertical section of armature and mark S-pole anywhere on the horizontal section of armature.

(ii) As the cell is reversed, the current in the coil is also reversed as a result a N-Pole is produced at the right and S-Pole at the left end of the core.

(b) (ii) The resistance of a thermistor decreases as its temperature increases.

(iii) 3. Do not forget to convert the value of the current in milliamperes to Amperes.

(iv) If a LDR is connected instead of the component X and a bright light shines on the LDR, the resistance of the LDR decreases and a large current then passes through the coil magnetising it strongly to attract and close the switch of the bell. ”

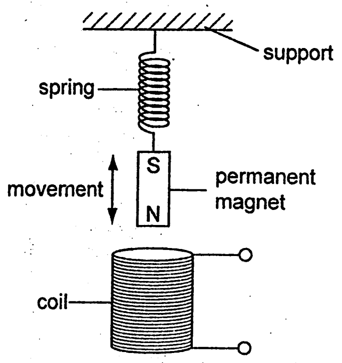
Thinking Process

MCQ Answers

Topic 23 *Electromagnetic Induction*

M C Q Section

1. A permanent magnet moving up and down on the end of a spring induces an e.m.f. in a coil.



Which factor, on its own, would **decrease** the maximum value of the induced e.m.f.?

A increasing the number of turns in the coil

B increasing the strength of the magnet

C raising the coil

D raising the support of the spring

[J06/P1/Q35]

2. Why is a transformer used to connect a generator in a power station to a long distance transmission line?

A to decrease the voltage and decrease the current

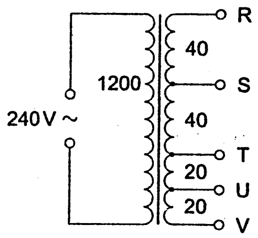
B to decrease the voltage and increase the current

C to increase the voltage and decrease the current

D to increase the voltage and increase the current

[J06/P1/Q36]

3. A transformer consists of one coil with 1200 turns and a second coil, with a total of 120 turns, which can be tapped at various places.



Which pair of terminals should be connected to a 12 V, 24 W lamp for it to be lit normally?

A RT **C** SU

B RV **D** TV

[N06/P1/Q33]

4. Why is electrical energy usually transmitted at high voltage?

A As little energy as possible is wasted in the transmission cables.

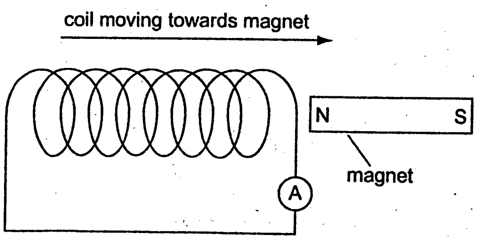
B The current in the transmission cables is as large as possible.

C The resistance of the transmission cables is as small as possible.

D The transmission system does not require transformers.

[N06/P1/Q34]

5. The diagram shows how a magnet and a coil may be used to induce an electric current.



How could the ammeter reading be increased?

A Move the coil more slowly.

B Put a resistor in series with the ammeter.

C Turn the magnet round, then move the coil.

D Use a coil with more turns.

[J07/P1/Q35]

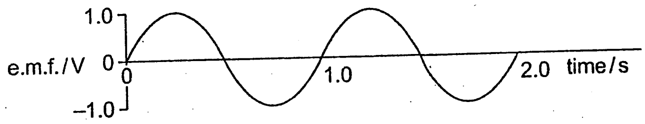
1. D The rate at which the magnetic field lines cut the coil is reduced.

2. C A step-up transformer is used at the power station to increase the voltage and decrease the current in the transmission cables to reduce the power losses.

3. C For the lamp to operate properly, the p.d. across the lamp must be 12 V. Using $\frac{V_s}{V_p} = \frac{N_s}{N_p}$ and checking for each possible output, we can find that p.d. across SU $= \frac{N_s}{N_p}V_p = \left(\frac{60}{1200}\right)240 = 12$ V.

4. B At high voltage, a lower current can be used to transmit electrical power. This reduces heating losses in the cables.

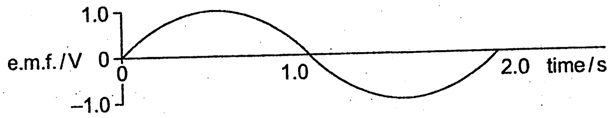
6. A simple a.c. generator produces an alternating e.m.f. as shown.



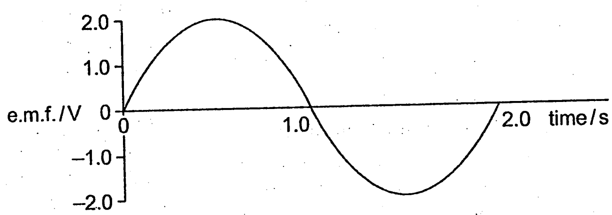
The speed of the generator is doubled.

Which graph best represents the new output?

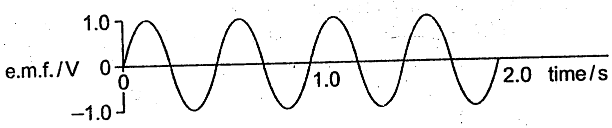
A



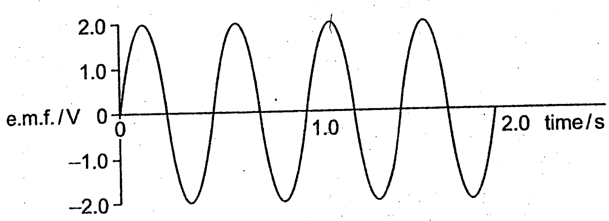
B



C

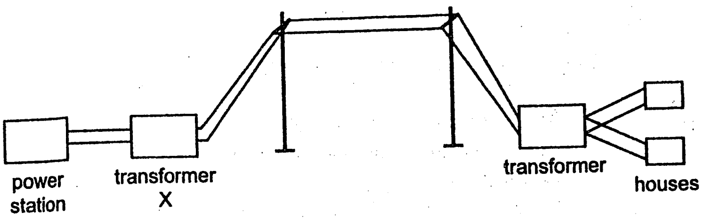


D



[J07 / P1 / Q36]

7. The diagram shows transformers and cables used to transmit electrical energy over long distances.



How does transformer X affect the voltage and the current from the power station?

5. D A coil with more turns increases the induced EMF and hence the induced current. The other ways of increasing the induced current and the reading of the ammeter are:
– use a stronger magnet
– use an iron core in the coil
– move the magnet faster

6. D The output of a generator (voltage) is directly proportional to the speed of the generator. If the speed is doubled, the value of the output a.c. voltage is also doubled. Since the period of rotation of the coil is also affected by the change in its speed as:

$$\text{period of rotation} \propto \frac{1}{\text{speed}}$$

On doubling the speed of the coil, its period of rotation is halved.

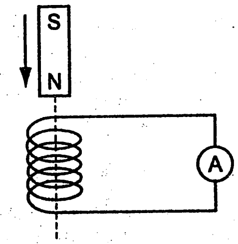
7. C The transformer X used at the power station is a step-up transformer to increase the voltage and decrease the current in the transmission cables, so that the transmission of electricity can be made at low current in the cables in order to reduce the power loss due to the heating effect of current in the cables.

	voltage	current
A	decreases it	decreases it
B	decreases it	increases it
C	increases it	decreases it
D	increases it	increases it

[N07/P1/Q36]

8. A small coil is connected to a sensitive ammeter. The ammeter needle can move to either side of the zero position.

As the magnet falls towards the coil, the ammeter needle moves quickly to the right of the zero position.



The magnet moves through the coil.

How does the ammeter needle move as the magnet falls away from the coil?

A It does not move.

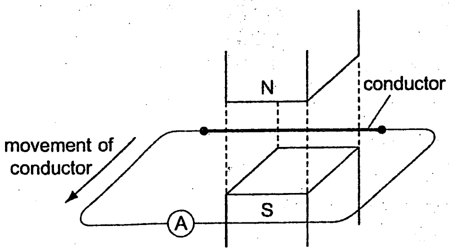
B It gives a steady reading to the right.

C It moves quickly to the left of the zero position and then returns to zero.

D It moves quickly to the right of the zero position and then returns to zero.

[N07/P1/Q35]

9. A conductor is moving horizontally across a vertical magnetic field.



An e.m.f. is induced in the conductor. No deflection is seen on the ammeter.

What is the reason for this?

A The ammeter is not between the poles.

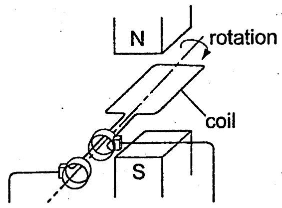
B The conductor is moving too slowly.

C The conductor is not cutting field lines.

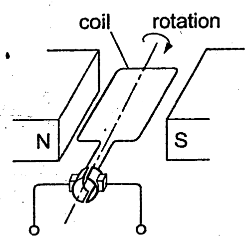
D The poles are too close together.

[J08/P1/Q34]

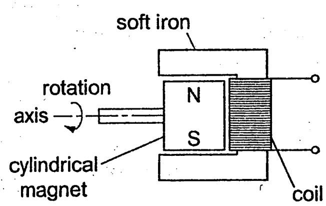
10. The diagrams show three generators.



X



Y



Z

Which are alternating current generators?

A X only

B Y only

C X and Y only

D X and Z only

[J08/P1/Q35]

MCQ Answers

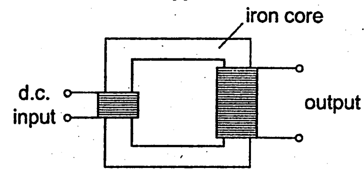
8. C As the N-pole moves into the coil, a N-pole is induced at the top end of the coil and a S-pole is induced at its bottom end. As the magnet moves out of the lower end of the coil, a N-pole is now produced at the bottom of the coil unlike the S-pole previously. Since the magnetic poles at the ends of the coil are reversed so does the deflection of the ammeter needle.

9. B The only reason for the ammeter not registering the flow of any current is that the rate of change of magnetic flux is very low and a feeble current is induced in the conductor which is not detectable by the ammeter.

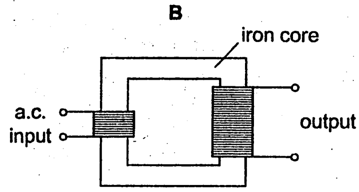
10. D The generators shown in diagrams X and Z are alternating current generators and diagram Y shows a directing current generator as it includes a commutator in its circuit.

11. Which transformer arrangement produces an output voltage that is larger than the input voltage?

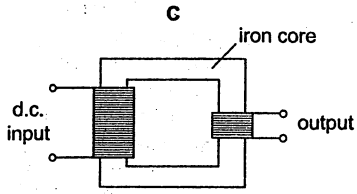
A



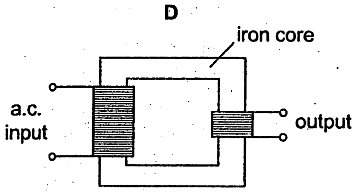
B



C



D



[J08/P1/Q36]

12. The e.m.f. induced in a conductor moving at right-angles to a magnetic field does **not** depend upon

A the length of the conductor.

B the resistance of the conductor.

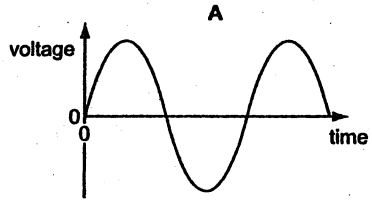
C the speed of the conductor.

D the strength of the magnetic field.

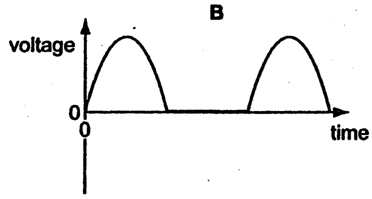
[N08/P1/Q34]

13. Which diagram shows how the voltage output of a simple a.c. generator varies with time?

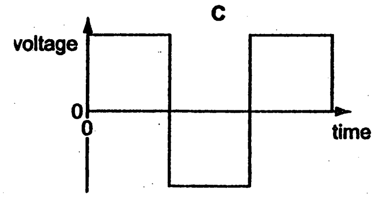
A



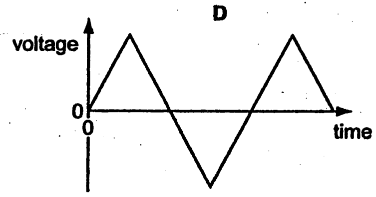
B



C

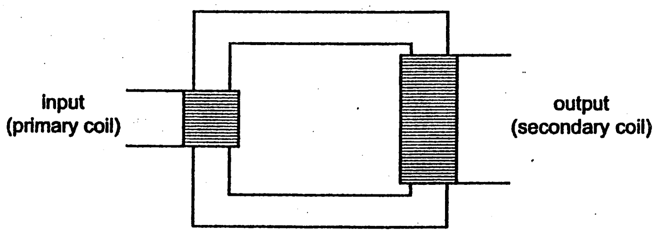


D



[N08/P1/Q35]

14. The diagram shows a working transformer.



Which statement is correct?

A The input voltage is d.c.

B The input voltage is greater than the output voltage.

C The input voltage is less than the output voltage.

D The input voltage is the same as the output voltage.

[N08/P1/Q36]

ThinkinG ProcesS

MCQ Answers

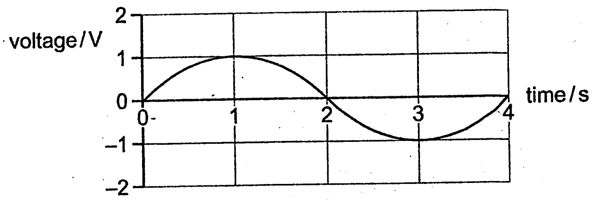
11. B A transformer works on a.c. input only and also a transformer whose output is greater than its input voltage must have a larger number of turns in its secondary coil then its primary coil. These two conditions are fulfilled by the arrangement of components in the diagram **B** only.

12. B The resistance of the conductor affects the value of the induced current but not the induced e.m.f.

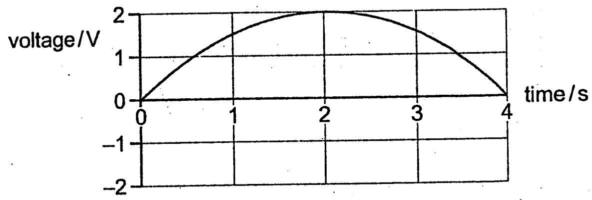
13. A Fact.

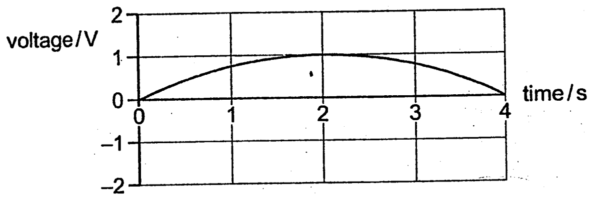
14. C A transformer works on a.c. voltage only and as the number of turns on the secondary coil is greater than the number of turns on the primary coil, so it is a step-up transformer whose output voltage is greater than the input voltage.

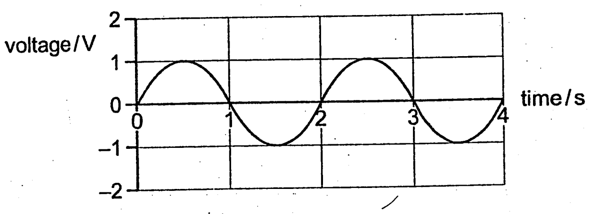
15. A simple a.c. generator produces a voltage that varies with time as shown.

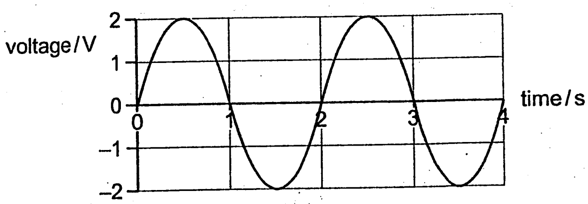


Which graph shows how the voltage varies with time when the generator rotates at twice the original speed?

A


B


C


D


[J09 / P1 / Q34]

MCQ Answers

15. D By doubling the speed of rotation of the coil doubles the rate of change of magnetic flux which doubles the output voltage of the generator according to the law of electromagnetic induction. Also, the time period reduces to half on increasing the speed of rotation to twice the original speed.

16. C The speed of the drive, the strength of the magnets and the number of turns in the coil, all the three affect the rate of change of the magnetic flux as the coil rotates and affect the e.m.f. generated but a change in the value of the resistor does not affect the value of the e.m.f. generated as it is connected as the load to the generator.

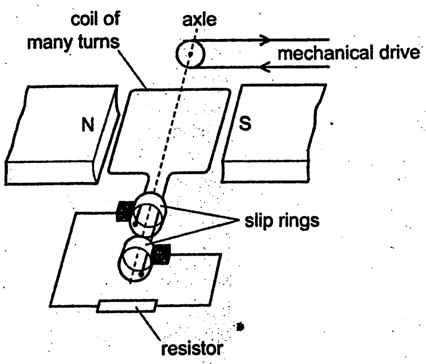
17. A The transmission of electrical energy at high voltage reduces the current in the cables which in turn reduces the loss of electrical energy due to the heating effect of current in the cables.

18. A According to the Lenz's law, whether the North pole or South pole moves towards the coil, the coil is repelled away from the magnet.

19. D As the frequency of rotation of the coil is halved, the speed of rotation of the coil is halved. This decreases the output voltage to half and the time period of rotation of the coil becomes double.

MCQ Answers

16. The diagram shows an a.c. generator connected to a resistor.



Some changes are made, one at a time.

- The speed of the drive is changed.
- The strength of the magnets is changed.
- The number of turns in the coil is changed.
- The value of the resistor is changed.

How many of these alter the value of the e.m.f. generated in the coil?

A 1 **B** 2

C 3 **D** 4

[J09/P1/Q33]

17. Why is electrical energy usually transmitted at high voltage?

A As little energy as possible is wasted in the transmission cables.

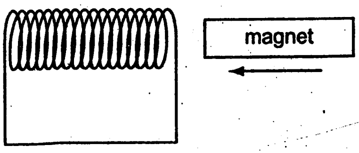
B The current in the transmission cables is as large as possible.

C The resistance of the transmission cables is as small as possible.

D The transmission system does not require transformers.

[J09/P1/Q35]

18. A magnet is pushed horizontally towards a coil of wire, inducing an e.m.f. in the coil.



In which direction does the induced e.m.f. make the coil move?

A away from the magnet

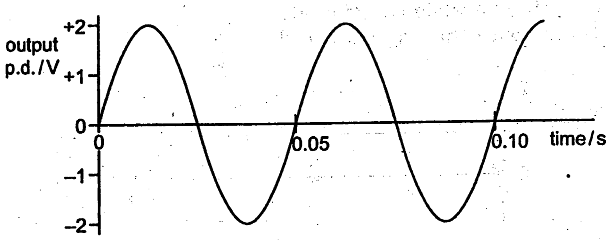
B towards the magnet

C downwards

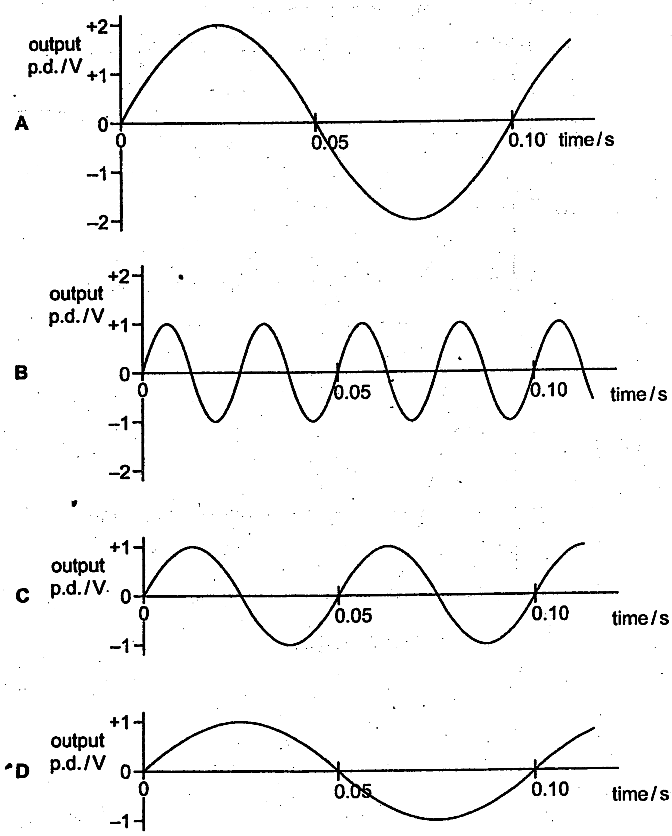
D upwards

[N09/P1/Q33]

19. The graph shows the output of an a.c. generator. The coil in the generator rotates 20 times in one second.



Which graph shows the output when the coil rotates 10 times in one second?



[N09/P1/Q34]

20. Why is a transformer used to connect a generator in a power station to a long-distance transmission line?

A to decrease the voltage and decrease the current

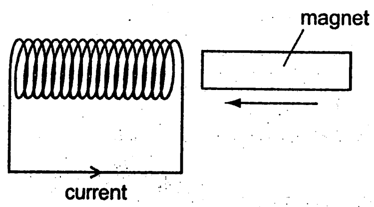
B to decrease the voltage and increase the current

C to increase the voltage and decrease the current

D to increase the voltage and increase the current

[N09/P1/Q35]

21. A magnet is pushed slowly into a coil and there is a current in the coil in the direction shown.

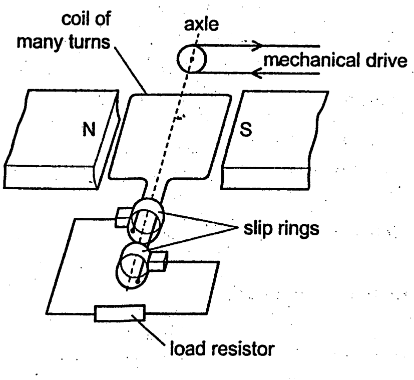


The magnet is then pulled out quickly from the same end of the coil.
What happens to the direction and the size of the current?

	direction	size
A	reversed	decreased
B	reversed	increased
C	unchanged	decreased
D	unchanged	increased

[J10/P1/Q35]

22. The diagram shows an a.c. generator connected to an electrical circuit (load resistor).



Which statement is correct?

A The direction of the potential difference across the load resistor is always the same.

B The size of the induced e.m.f. depends on the number of turns in the coil.

C The size of the induced e.m.f. does not change as the coil turns.

D Winding the coil on a soft-iron cylinder makes no difference to the induced e.m.f.

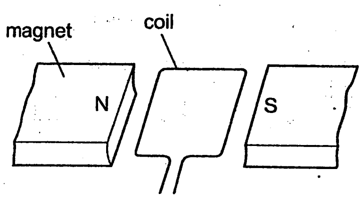
[N10/P1/Q37]

23. Electric power cables transmit electrical energy over large distances using a high voltage, alternating current.
What are the advantages of using a high voltage and of using an alternating current?

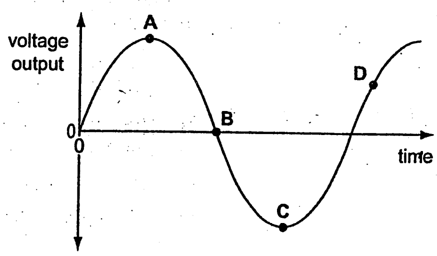
	advantage of using a high voltage	advantage of using an alternating current
A	a higher current is produced in the cable	the resistance of the cable is reduced
B	a higher current is produced in the cable	the voltage can be changed using a transformer
C	less energy is wasted in the cable	the resistance of the cable is reduced
D	less energy is wasted in the cable	the voltage can be changed using a transformer

[N10/P1/Q33]

24. The diagram shows part of an a.c. generator when its coil is in a horizontal position.



The graph shows the voltage output plotted against time.
Which point on the graph shows when the coil is in a vertical position?



[J11/P1/Q33]

T h i n k i n G P r o c e s S

MCQ Answers

20. C A step-up transformer is used at the power station to increase the voltage and decrease the current in the transmission cables. So that energy losses are minimised due to the heating effect of current in the transmission cables.

21. B The direction of the induced current is reversed because the direction of motion of the magnet is reversed.
The size of the induced current also increases because of the magnet quickly pulled out of the coil unlike its pushing slowly into the coil.

22. B It is a fact.

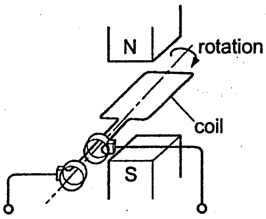
23. D With an alternating current, the value of voltage can be made high or low using a transformer and with high voltage, the current in the cables and hence the energy loss is reduced.

25. The electromotive force (e.m.f.) induced in a conductor moving at right-angles to a magnetic field does **not** depend upon

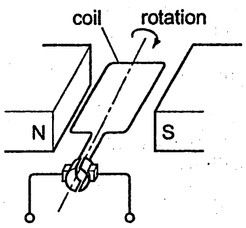
A the length of the conductor.
B the resistance of the conductor.
C the speed of the conductor.
D the strength of the magnetic field.

[J11/P1/Q34]

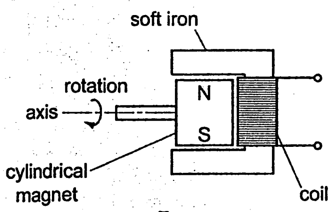
26. The diagrams show three electrical devices, X, Y and Z.



X



Y



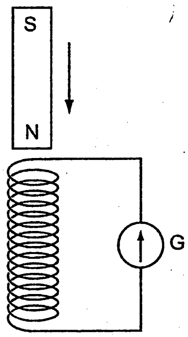
Z

Which devices provide an alternating current (a.c.) output?

A X only
B Y only
C X and Y
D X and Z

[N11/P1/Q34]

27. A small coil is connected to a galvanometer G, as shown.



When a magnet is allowed to fall towards the coil, the galvanometer pointer gives a momentary deflection to the right of the zero position.

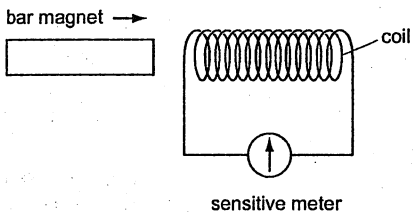
The magnet moves through the coil.

What happens to the galvanometer pointer as the magnet falls away from the coil?

A It gives a continuous reading to the left.
B It gives a momentary deflection to the left.
C It gives a continuous reading to the right.
D It gives a momentary deflection to the right.

[N11/P1/Q37]

28. A bar magnet is pushed into one end of a long coil connected to a sensitive meter.



Which of the following affects the **magnitude** of the deflection of the meter?

A the direction in which the coil is wound
B the speed with which the magnet enters the coil
C which end of the coil is used
D which pole of the magnet enters first

[J12/P1/Q35]

Thinking Process

MCQ Answers

24. B When the coil passes through its vertical position, its longer sides are moving parallel to the magnetic flux between the magnetic poles, so no cutting of the flux occurs. Hence, no e.m.f. is induced in the coil and the output of the generator is zero.

25. B The resistance of the conductor affects the value of the induced current but not the induced e.m.f.

26. D The generator shown in diagrams X and Z are alternating current (a.c.) generators. Diagram Y shows a direct current (d.c.) generator as it includes a split ring commutator component.

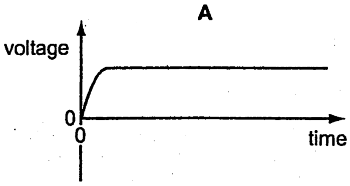
27. B As the N-pole moves into the coil, a N-pole is induced at the upper end of the coil and a S-pole is induced at its lower end. As the magnet falls away from the coil, a N-pole is now induced at the lower end unlike the S-pole induced previously. Since the magnetic poles at the ends of the coil are reversed so does the deflection of the galvanometer pointer.

28. B The following factors only affect the EMF produced in the coil and the magnitude of the deflection of the meter?

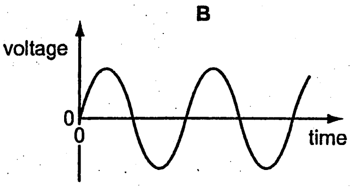
- the no. of turns in the coil.
- the strength of the magnet.
- the speed of motion of the magnet.
- the soft iron core in the coil.

29. Which graph represents the voltage output of a simple a.c. generator?

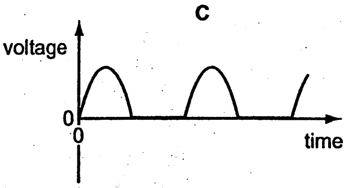
A



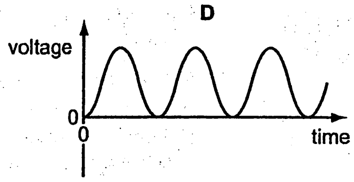
B



C



D



[J12/P1/Q36]

30. A magnet is moved towards a coil of insulated wire. A voltmeter connected across the coil shows a positive reading.

What produces a higher reading on the voltmeter?

A moving the magnet away from the coil at the same speed

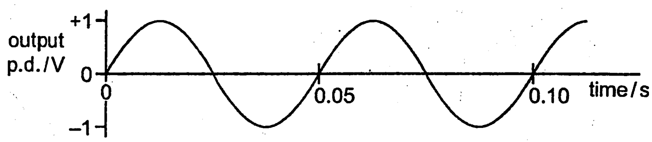
B moving the magnet away from the coil at a slower speed

C moving the magnet towards the coil at a faster speed

D moving the magnet towards the coil at a slower speed

[N12/P1/Q35]

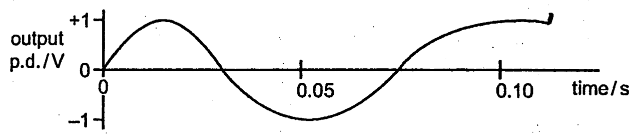
31. The graph shows the output of an a.c. generator. The coil in the generator rotates 20 times in one second.



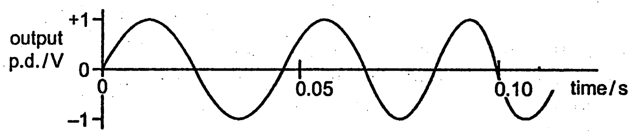
The speed of rotation of the coil steadily increases.

Which graph best shows how the output changes?

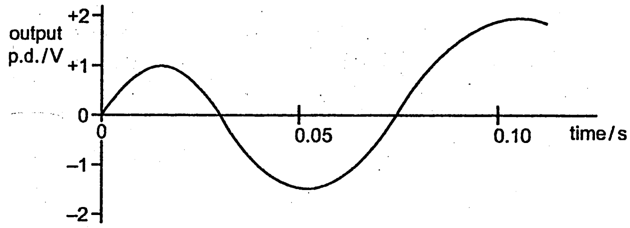
A



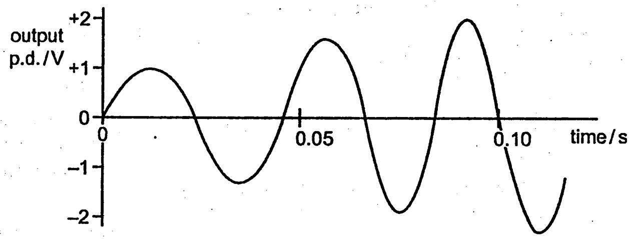
B



C



D



[N13/P1/Q33]

32. Which device uses the force experienced by a current in a magnetic field when in normal use?

A cathode-ray oscilloscope

B electrostatic precipitator

C loudspeaker

D transformer

[J14/P1/Q34]

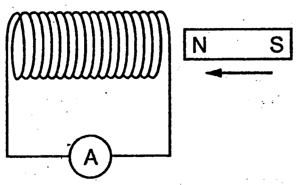
MCQ Answers

29. B Fact

30. C The magnitude of the EMF induced in the coil depends on:
— the no. of turns in the coil.
— the strength of the bar magnet.
— the speed of the magnet.

MCQ Answers

33. As a magnet is moved into the coil of wire as shown, there is a small reading on the sensitive ammeter.



Which change increases the size of the reading?

A moving the opposite pole into the coil

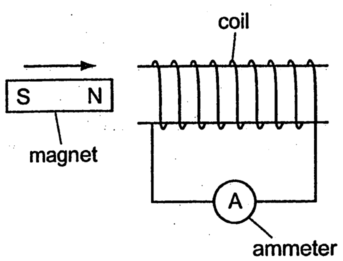
B pulling the magnet out of the coil

C pushing the magnet in faster

D unwinding some of the turns of wire

[J14/P1/Q36]

34. A student moves a magnet into a coil of wire as shown in the diagram. The coil of wire is connected to a sensitive ammeter.



Which change does **not** produce an increase in the reading?

A increasing the number of turns on the coil

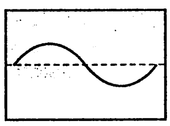
B increasing the resistance of the ammeter

C increasing the speed of the magnet

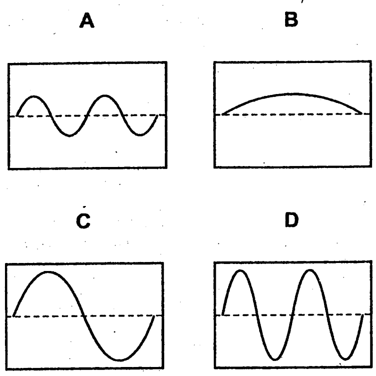
D increasing the strength of the magnet

[N14/P1/Q33]

35. The coil of an a.c. generator is rotated and the output is displayed on the screen of a cathode-ray oscilloscope (c.r.o.).
The diagram shows the trace on the screen.

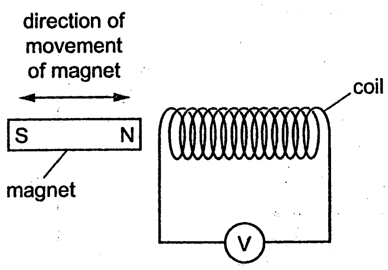


Which trace appears on the screen when the speed of rotation of the coil is doubled but the settings on the c.r.o. are unaltered?



[N14/P1/Q34]

36. A teacher moves a magnet into and out of a coil of wire, as shown, in order to demonstrate electromagnetic induction.



Which statement is correct?

A As the magnet is moved into the coil the left-hand end of the coil becomes a S-pole.

B As the magnet is taken out of the coil the left-hand end of the coil becomes a N-pole.

C Increasing the speed at which the magnet enters the coil, increases the induced voltage.

D Increasing the speed at which the magnet leaves the coil decreases the induced voltage.

[J15/P1/Q36]

37. A transformer consists of two coils which are wound on to a metallic core.

Which type of voltage is supplied to the transformer and which metal is used to make the core?

31. D A steadily increasing speed of rotations of the coil of the generator will result in the steadily increasing output voltage of the generator and decreasing its time period.

32. C The diaphragm in the loudspeaker vibrates as a result of changing current in a fixed magnetic field.

33. C Fact. If the magnet moves faster, a larger current will flow into the coil.

34. B Increasing the resistance of the ammeter would decrease the current in the coil and hence the ammeter reading.

35. D Doubling the speed of rotation of the generator's coil doubles the output voltage produced by the generator, as well as the number of waves produced on the screen. Therefore, the amplitude and the frequency of the waves both double.

36. C Fact.

	supply voltage	metal
A	alternating	iron
B	alternating	steel
C	direct	iron
D	direct	steel

[J15/P1/Q37]

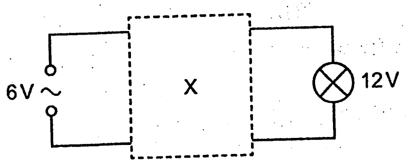
38. Electric power cables transmit electrical energy over large distances using high-voltage, alternating current.

What are the advantages of using a high voltage and of using an alternating current?

	advantage of using a high voltage	advantage of using an alternating current
A	high current is produced in the cable	the resistance of the cable is reduced
B	high current is produced in the cable	the voltage can be changed using a transformer
C	less energy is wasted in the cable	the resistance of the cable is reduced
D	less energy is wasted in the cable	the voltage can be changed using a transformer

[N15/P1/Q35]

39. The diagram shows an electrical device X connected between a 6 V a.c. supply and a 12 V lamp



The lamp is seen to glow with normal brightness.

What is X?

A a capacitor

B a potential divider

C a relay

D a transformer

[N15/P1/Q37]

MCQ Answers

37. A A transformer can only work on alternating voltage supply and its two coils are wound on a soft-iron core.

38. D The value of the voltage can be easily changed by a transformer. Also, by transmitting electrical power at high voltage, a smaller current flows through transmission cables which in turn reduces energy losses produced due to heating.

39. D A step-up transformer is used to change 6 V a.c. supply to 12 V a.c. to let the lamp glow with normal brightness.

Topic 23 Electromagnetic Induction

THEORY Section

Question 1

Fig. 3.1 shows the construction of a simple a.c. generator. When the coil is rotated an e.m.f. is induced in the coil.

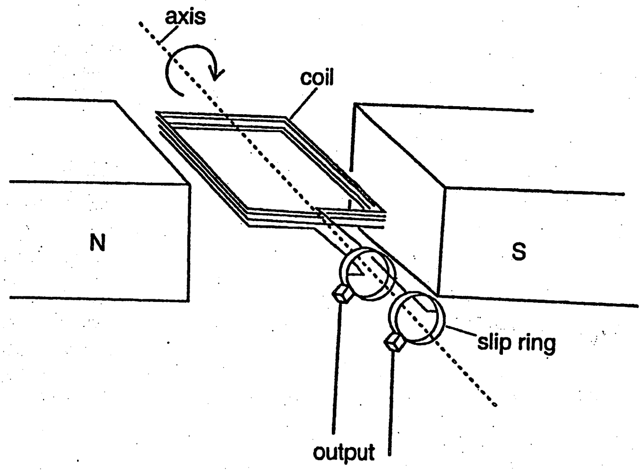


Fig.3.1

(a) Explain why an e.m.f. is induced. [2]

(b) State the purpose of the slip rings. [1]

(c) The direction of the current in the coil can be found from Lenz's law. State Lenz's law. [1]

(d) The induced e.m.f. can be increased by rotating the coil faster. State one other way in which the e.m.f. can be increased [1]

[J06/P2/Q3]

Solution

(a) As the coil rotates, it cuts the magnetic field lines between the N-S magnetic poles of the field magnets. A change in the magnetic flux takes place and as a result an e.m.f. is induced in the coil according to the law of electromagnetic induction.

(b) The slip rings are used to pass the induced current in the coil into the output circuit where it is to be used.

(c) The direction of the induced e.m.f and hence the induced current is always such as to oppose the change producing it.

(d) The value of the induced e.m.f. can be increased also by using stronger magnets.

COMMENT on **ANSWER**

“ **(d)** The induced e.m.f can be increased also by:
- using a coil of longer sides.
- using a soft iron core in the coil.
- increasing the number of turns on the coil. ”

Question 2

Fig. 7.1 shows one way to demonstrate an electrical effect.

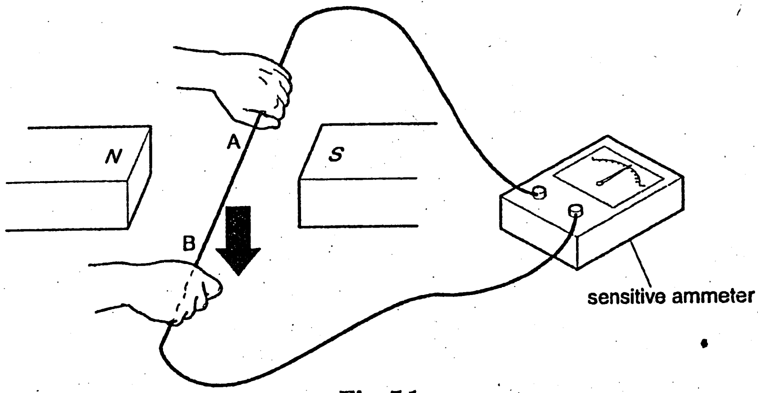


Fig. 7.1

As the wire is moved downwards between the magnetic poles, the needle of the ammeter deflects to the right.

(a) State the name of this electrical effect. [1]

(b) State what happens to the needle of the ammeter when the wire is moved upwards between the magnetic poles. [1]

(c) State and explain what happens to the needle of the ammeter when the wire is held stationary between the magnetic poles. [2]

(d) Explain why, in Fig. 7.1, the direction of the current in the wire is from A to B when the wire is moved downwards. [2]

[N06/P2/Q7]

Solution

(a) Electromagnetic Induction.

(b) The needle will deflect in one direction.

(c) The needle will show no deflection since there is no rate of change of magnetic flux linkage.

(d) Using Fleming's Right Hand Rule, the induced current is perpendicular to both the motion of the wire and the direction of the magnetic field.

COMMENT on ANSWER

" **(b)** The needle deflects due to an induced current flowing in the circuit.

(c) When the wire is stationary, the wire does not cut the magnetic field lines between the poles.

(d) Fleming's Right Hand Rule states that the thumb, first finger and second finger of the right hand gives the direction of the motion, magnetic field and induced current respectively. "

Question 3

A farmer connects a house to the mains electricity. The house is a long way from the nearest 230 V mains electricity supply.
Fig. 10.1 shows the mains supply connected to the house.

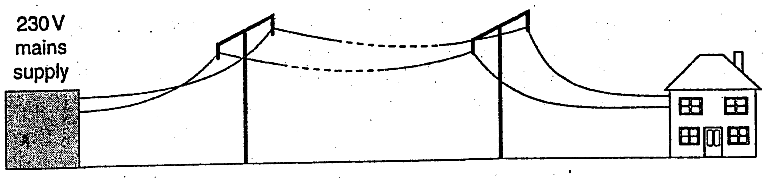


Fig. 10.1

(a) The farmer uses 230 V lamps in the house but they do not light up at full brightness. Explain why the lamps are dim. [2]

(b) The farmer adds transformers, as shown in Fig. 10.2.

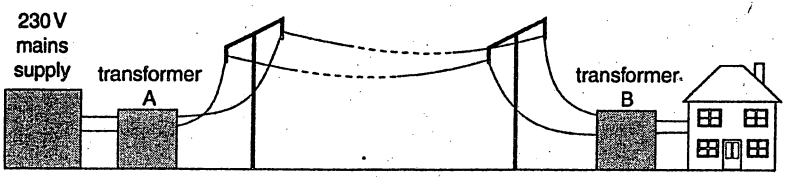


Fig. 10.2

The lamps in the distant house light up at full brightness.
Explain why the lamps are now bright. [3]

(c) (i) Describe the structure of a transformer. You may draw a diagram to help your explanation. [3]

(ii) Explain in detail how a transformer produces an output voltage. [3]

(d) The 230 V mains supply provides 690 W of power to transformer A in Fig. 10.2.

(i) Calculate the current supplied to the transformer. [2]

(ii) Calculate the energy supplied to the transformer in 10 minutes. Give your answer in joules. [2]

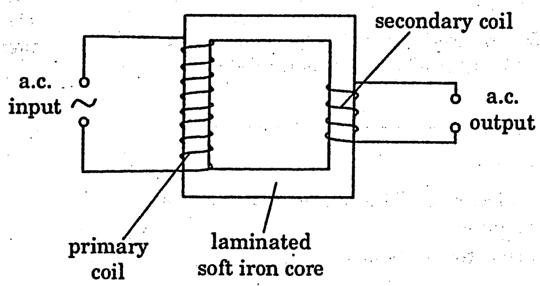
[J07/P2/Q10]

Solution

(a) The long length of the line produced a high resistance which causes the power loss in the transmission line.

(b) The transformer A steps up the voltage and reduces the current in the transmission line. The low current in the transmission cables reduces the power loss. The transformer B steps the voltage down to 230 V and increases the amount of current so the lamps light up at full brightness.

(c) (i) A transformer has a primary coil and a secondary coil wound round a soft iron core which is made of laminations of soft iron insulated from each other.



(ii) An a.c. input is applied to the primary coil which produces a changing magnetic field in the primary coil. The soft iron core links this changing magnetic field with the secondary coil. This changing magnetic field then induces an alternating e.m.f. in the secondary coil.

(d) (i) $I = \frac{P}{V} = \frac{690}{230} = 3.0\text{ A}$

(ii) $\text{Energy} = VIt = 230 \times 3 \times (10 \times 60) = 414000\text{ J}$

COMMENT on ANSWER

“ (d) (ii) *Alternatively:*

$\text{Energy} = Pt$
$= 690 \times 600$
$= 414000\text{ J}$

Note: Convert minutes into seconds. ”

Question 4

Fig. 11.1 shows a workman using a cordless electric drill.

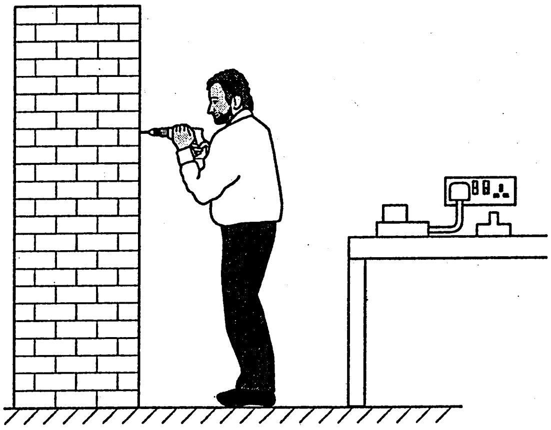


Fig. 11.1

The motor of the drill is powered by a rechargeable battery with an electromotive force (e.m.f.) of 18 V. When the drill is used, the power supplied to the motor is 450 W.

(a) Explain what is meant by an *e.m.f. of 18 V.* [2]

(b) The workman uses the drill for 90 minutes.

Calculate

(i) the electrical energy supplied to the motor, [3]

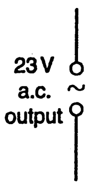
(ii) the charge that the battery supplies. [2]

(c) After 90 minutes of use, the battery is flat. It is connected to a charger and is recharged. The charger includes a transformer that produces a 23V a.c. output from a 230 V a.c. mains supply.

(i) Draw a labelled diagram to show the structure of the transformer. [2]

(ii) State how the transformer ensures that the a.c. output has a value of 23 V when the input is the 230 V a.c. mains supply. [1]

(iii) The 23 V a.c. output of the transformer is used in a rectifying circuit to produce a direct current that recharges the battery. Complete the circuit diagram of the circuit.



[2]

(d) State and explain **one** advantage of using an alternating current (a.c.) for long-distance transmission of electrical power. [3]

[N10/P2/Q11]

Solution

(a) It means that 18 J of energy is released to move 1 C charge through the complete circuit of the electric drill.

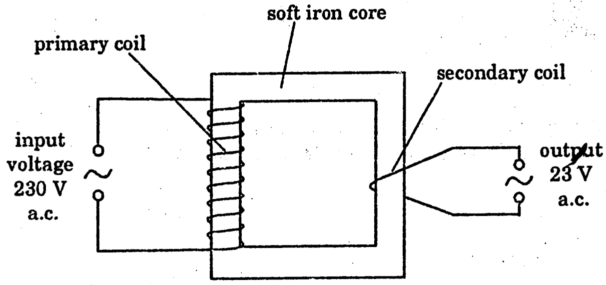
(b) (i) Electrical energy, $E = Pt$

$$= 450 \times (90 \times 60)$$
$$= 2430000 \text{ J} = 2.43 \times 10^6 \text{ J}$$

(ii) $\text{e.m.f.} = \dfrac{E}{\text{charge}}$

$$\Rightarrow \text{charge} = \frac{E}{\text{e.m.f.}}$$
$$= \frac{2.43 \times 10^6}{18} = 135000 = 1.35 \times 10^5 \text{ C}$$

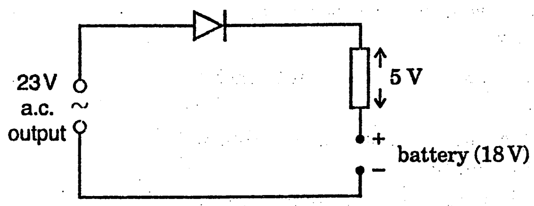
(c) (i)



Turn ratio 10:1

(ii) It can be ensured by having the turns ratio of 10:1 between its primary coil and the secondary coil.

(iii)



(d) One of the main advantages of a.c. is that it can be easily and cheaply changed from one voltage to another using a transformer. This makes it possible to transmit electric power at a very high voltage and low current over long distances with minimum power loss.

Question 5

Fig. 9.1 shows two coils of insulated wire wound on an iron ring. Coil A is connected to a battery and a switch. The switch is open. Coil B is connected to a sensitive centre-zero voltmeter.

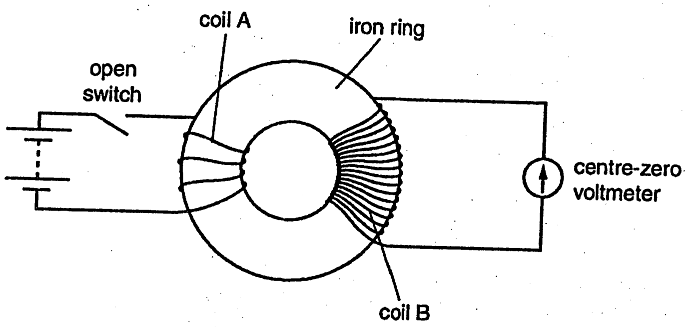


Fig. 9.1

The switch is closed. There is a current in coil A.

(a) On Fig. 9.1,

(i) mark the direction of the current in coil A, [1]

(ii) draw the magnetic field lines produced in the iron ring. [3]

(b) As the switch is closed, the voltmeter deflects to the right and then returns to zero.

(i) Explain why there is a deflection on the voltmeter. [2]

(ii) The switch is opened. State and explain what happens to the deflection on the voltmeter. [2]

(iii) Without changing coil A, state two changes to the apparatus that cause a greater deflection of the voltmeter. [2]

(c) The battery in Fig. 9.1 is replaced by an alternating current (a.c.) supply. The output from coil B is used to power a lamp that is a long distance away. Each lead from coil B to the lamp has a resistance of 2.5Ω. These leads are represented by the two resistors shown in Fig. 9.2.

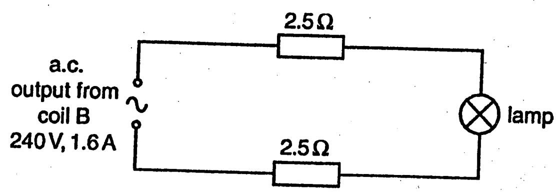


Fig. 9.2

The output voltage of coil B is 240 V and the current in the circuit is 1.6 A.

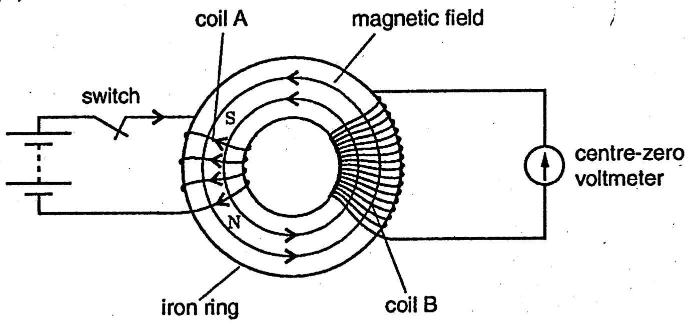
(i) Calculate the electrical power produced by coil B. [2]

(ii) Calculate the total power loss in the leads to the lamp. [3]

[J12/P2/Q9]

Solution

(a) (i) & (ii)



(b) (i) On closing the switch the current in coil A changes from zero to maximum which produces a change in the magnetic field in coil A. This changing magnetic field is linked to the coil B by the iron ring and induces an EMF in coil B. Which produces a momentary deflection in the voltmeter.

(ii) The current and hence the magnetic field in coil A now changes from maximum to zero. This changing field acts on coil B through the iron ring and induces an EMF in it. The voltmeter then shows a momentary deflection in the opposite direction to the previous one.

(iii) 1. Increase the amount of current in coil A.

2. Increase the number of turns in coil B.

(c) (i) Electrical poweer, $P = VI$

$= 240 \times 1.6 = 384$ W.

(ii) Total power loss, $P = I^2R$

$= (1.6)^2 \times 5.0 = 12.8$ W.

COMMENT on ANSWER

"(b) (iii) *Alternatively:*
- use a battery of small (internal) resistance.
- use wires of smaller resistance, e.g. thicker wires or shorter wires.
- coil A and coil B should be closer on the iron ring.
- use a more sensitive voltmeter."

Question 6

Fig. 8.1 shows a simple a.c. generator. The coil is turning and an e.m.f. is induced in the coil.

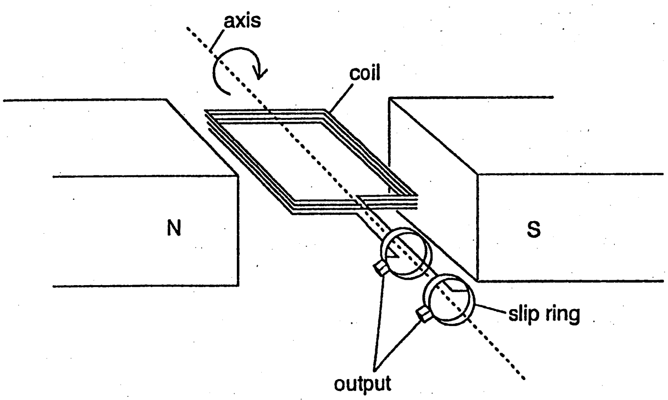


Fig. 8.1

(a) The generator contains a permanent magnet. State the name of a metal used in a permanent magnet. [1]

(b) At the instant shown in Fig. 8.1, the induced e.m.f. is a maximum.

(i) Explain why the induced e.m.f. is a maximum. [2]

(ii) State the position of the coil where there is no induced e.m.f. [1]

[J13/P2/Q8 Either]

Solution

(a) Steel

(b) (i) At the instant shown, the rate of cutting of magnetic flux is maximum as the coil is passing through the horizontal position, so a maximum e.m.f is induced in the coil.

(ii) Vertical position

COMMENT on ANSWER

❝ (a) Alternative answers:
— magnetite
— alnico
— magnadur

(b) (i) According to the law of electromagnetic induction
" The magnitude of the emf induced is directly proportional to the rate of change of magnetic flux."

(ii) When the coil is passing through the vertical position, its sides do not cut any magnetic flux, hence no e.m.f. is induced. ❞

Question 7

Fig. 8.1 shows the structure of a simple alternating current (a.c.) generator.

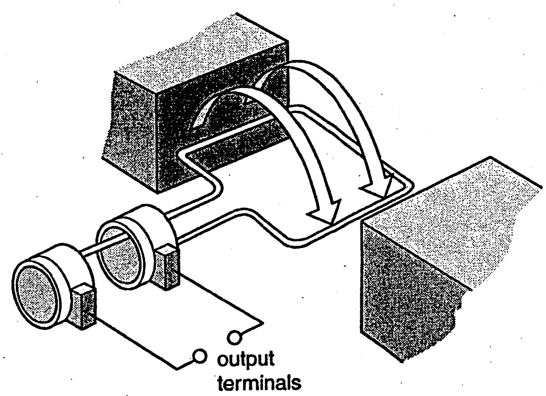


Fig. 8.1

(a) On Fig. 8.1, label
- the coil of the generator with the letter C,
- a slip ring with the letter S,
- a carbon brush with the letter B. [2]

(b) The a.c. generator is operating and the arrows on Fig. 8.1 show the direction of rotation.
Explain why there is an electromotive force (e.m.f.) between the two output terminals. [3]

(c) The output terminals of the a.c. generator are connected to a cathode-ray oscilloscope (c.r.o.). Fig. 8.2 shows the trace on the screen of the c.r.o.

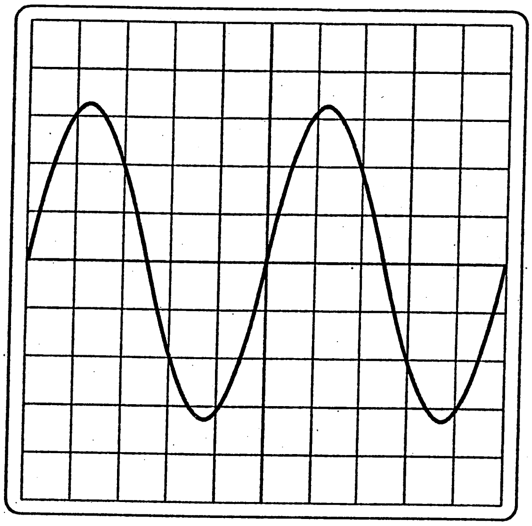


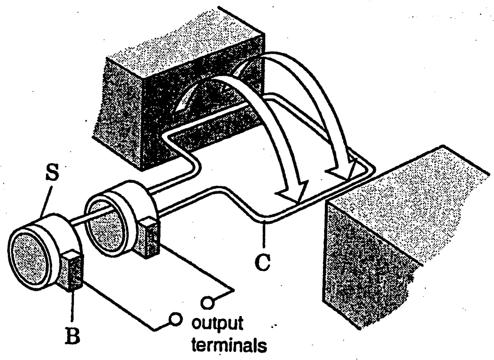
Fig. 8.2

Describe how the trace and a setting on the c.r.o. are used to find the time for one revolution of the coil of the a.c. generator. You may draw on Fig. 8.2 if you wish. [2]

[N14/P2/Q8]

Solution

(a)



(b) As the coil rotates, it cuts the magnetic field between the magnetic poles of the field magnets. A change in the magnetic flux takes place, and as a result an e.m.f. is induced in the coil according to the law of electromagnetic induction.

(c) One wavelength corresponds to one revolution of the coil. To find the time for one revolution, count the number of horizontal divisions occupied by one complete wavelength and multiply it with the time-base setting.

Question 8

Fig. 6.1 shows a simple a.c. generator.

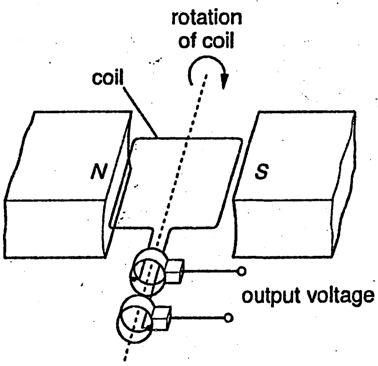


Fig. 6.1

(a) The coil rotates and an alternating electromotive force (e.m.f.) is induced in the coil.

Fig. 6.2 shows how the alternating e.m.f. varies with time as the coil rotates.

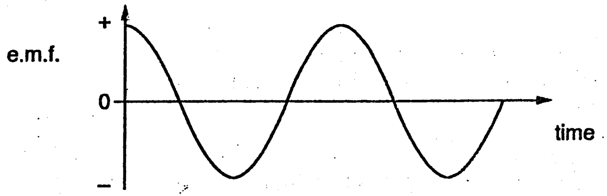


Fig. 6.2

Explain

(i) why an e.m.f. is induced, [2]

(ii) why the e.m.f. is sometimes positive and sometimes negative. [1]

(b) Changes are made to the a.c. generator, one at a time:

- stronger magnets are used
- more turns are wound on the coil
- the coil is turned faster.

Complete the table in Fig. 6.3 to show what happens to the maximum value of the e.m.f. and to the frequency of the alternating e.m.f.

changes made	what happens to the maximum value of the e.m.f.	what happens to the frequency of the e.m.f.
stronger magnets		
more turns on the coil		
the coil is turned faster		

Fig. 6.3

[3]

[J15/P2/Q6]

Solution

(a) (i) As the coil rotates, its sides cut the magnetic flux between the N-poles and S-poles of the field magnets. Due to this change in the magnetic field, an e.m.f. is induced in the coil.

(ii) When the coil rotates, its one side cuts the field line in one direction and then the same side cuts the field line in the reverse direction which causes the reversal in the output e.m.f. from positive to negative or negative to positive.

(b)

changes made	what happens to the maximum value of the e.m.f.	what happens to the frequency of the e.m.f.
stronger magnets	**Increases**	**No change**
more turns on the coil	**Increases**	**No change**
the coil is turned faster	**Increases**	**Increases**

COMMENT on ANSWER

" (a) (ii) The e.m.f is sometimes positive and sometimes negative because each one side moves one way and then the other. OR because the flux increases and then decreases. "

Question 9

Thin wire, covered in plastic insulation, is used to make a solenoid (long coil). The solenoid is connected to a sensitive ammeter. Fig. 10.1 shows the N-pole of a steel magnet placed next to the solenoid.

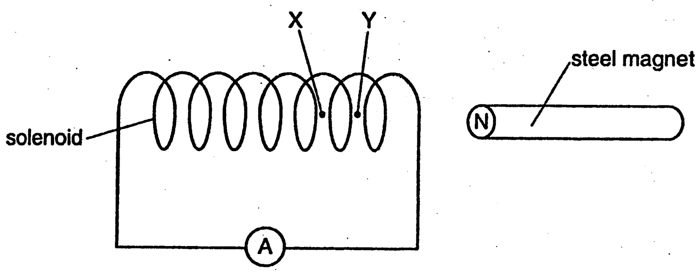


Fig. 10.1

Point X and point Y are on the axis of the solenoid.

(a) (i) Explain why plastic is an electrical insulator. [1]

(ii) Explain why the magnet is **not** made from

1. aluminium, [1]
2. iron. [1]

(b) In one experiment, the magnet in Fig. 10.1 is moved to the left and passes into the solenoid. The N-pole of the magnet travels from Y to X at a constant speed. As it moves, the ammeter shows a small current.

(i) Explain why there is a current in the solenoid when the magnet is moving. [3]

(ii) The N-pole travels from Y to X in 0.14 s. As it moves, the current shown on the ammeter is 0.045 mA. The resistance of the solenoid is 1.2 Ω.
Calculate

1. the potential difference (p.d.) across the solenoid, [2]
2. the charge that passes through the solenoid as the N-pole moves from Y to X. [2]

(c) In a second experiment, the speed of the N-pole is greater than its speed in the first experiment. It now takes only 0.070 s to travel from Y to X. A current in the same direction is shown on the ammeter.

(i) State and explain how the size of this current compares with the size of the current in the first experiment. [2]

(ii) The same quantity of charge passes through the coil in both the first and second experiments.

Explain why this is the case. [1]

(d) State two ways in which the equipment shown in Fig. 10.1 can be used to produce a current in the solenoid that is in the opposite direction. [2]

[N15/P2/Q10]

Solution

(a) (i) Plastic is an electrical insulator because it does not contain free electrons and thus cannot conduct electricity.

(ii) 1. Aluminium is not a magnetic material.

2. Iron is a soft magnetic material and can be magnetised only temporarily.

(b) (i) When the N-Pole enters into the solenoid and moves from Y to X, its magnetic flux is cut by the coil. Due to this change in the magnetic flux, a brief EMF and hence a small current is induced in the solenoid and the ammeter shows a small momentary deflection.

(ii) 1. Potential difference, $V = IR$

$$= \frac{0.045}{1000} \times 1.2$$
$$= 5.4 \times 10^{-5}\ \text{V}$$

2. Charge, $Q = It$

$$= \frac{0.045}{1000} \times 0.14$$
$$= 6.3 \times 10^{-6}\ \text{C.}$$

(c) (i) As the magnet moves faster and takes half of the previous time to move from Y to X, the rate of change of magnetic flux is doubled. Hence, the current induced is doubled.

(ii) Since in the second experiment, the current is doubled and the time is halved, the product of I and t gives the same result i.e. the same charge Q, as in the first experiment.

(d) 1. Insert S-Pole at the same end of the solenoid.

2. Insert N-Pole at the other end of the solenoid.

COMMENT on ANSWER

"(a) (ii) *Alternatively,*

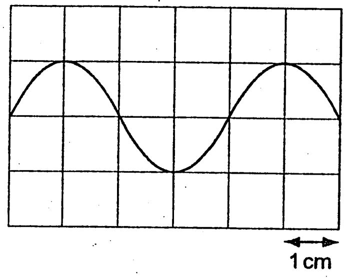
Iron cannot be made a permanent magnet.

(b) (ii) Do not forget to change the value of current in milliamperes to amperes."

Topic 24 *Electronics, CRO*

M C Q Section

1. The diagram shows the output waveform of an a.c. generator as displayed on a cathode-ray oscilloscope. The horizontal scale is 5 ms/cm.

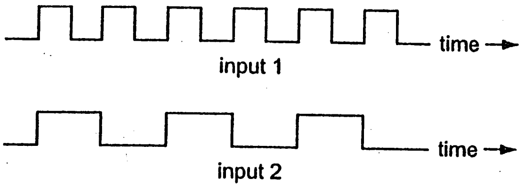


What is the time for one complete rotation of the generator?

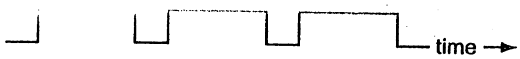
A 5 ms **C** 20 ms
B 10 ms **D** 30 ms

[N06/P1/Q35]

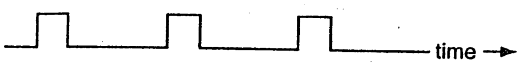
2. The variation with time of the two inputs to a NAND gate are shown.

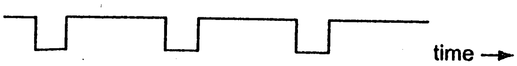


What is the correct variation with time of the output of the NAND gate?

A


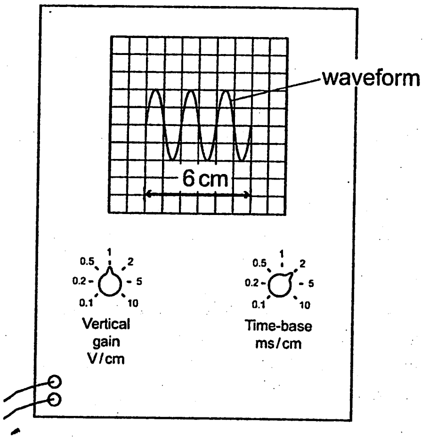
B


C


D


[N06/P1/Q36]

3. A waveform is displayed on a cathode-ray oscilloscope. The length of three cycles of the waveform is 6 cm. The vertical gain and the time-base settings are shown on the diagram.



What is the time taken for one cycle of the waveform?

A 1 ms
B 2 ms
C 4 ms
D 6 ms

[J07/P1/Q37]

MCQ Answers

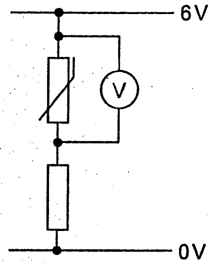
1. C The period of the generator is the same as the period of the waveform displayed by the CRO. Hence time for one complete rotation = period = 4 × 5 ms = 20 ms. Note that one complete waveform occupies four squares horizontally on the display.

2. D The output is based on the truth table for the NAND gate.

Input 1	Input 2	output
0	0	1
0	1	1
1	0	1
1	1	0

3. C One cycle of the waveform is formed in 2cm of the screen and the time-base is set at 2 ms/cm.
Time taken for one cycle = 2×2 = 4ms.

4. The diagram shows a thermistor connected in a potential divider circuit.



The resistance of the thermistor decreases when its temperature rises. The thermistor is heated.

What happens to the potential difference across the thermistor as it is heated?

A It decreases but not to zero.

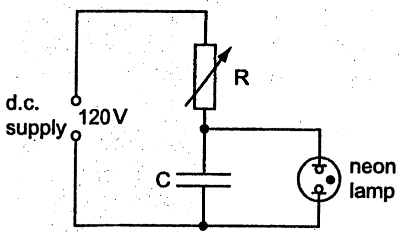
B It decreases to zero.

C It increases.

D It stays the same.

[J08/P1/Q37]

5. The electric circuit shown is used to study the charging of capacitor C.



The neon lamp lights when the p.d. across the capacitor C reaches 110V. C then discharges through the neon lamp. When C has discharged, the lamp goes out and the p.d. across C slowly increases once more.

What is the effect of increasing the resistance of R?

A The lamp lights up and goes out at the same rate.

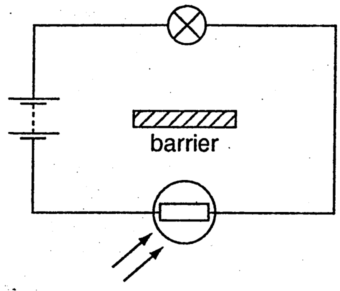
B The lamp lights up and goes out less frequently.

C The lamp lights up and goes out more frequently.

D The lamp will not go out at all.

[N08/P1/Q37]

6. A lamp is connected in series with a light-dependent resistor (LDR) and a battery. The barrier shields the LDR from the lamp.



When low intensity light falls on the LDR, the lamp glows dimly.

If the light intensity on the LDR increases, what happens to the lamp?

A It gets brighter.

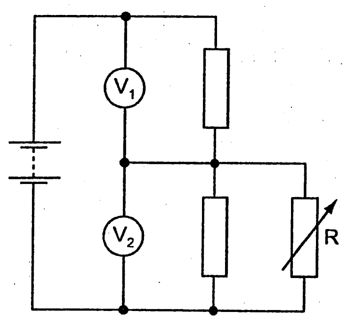
B It gets dimmer but does not go out.

C It goes out.

D It stays the same.

[J09/P1/Q36]

7. The circuit diagram shows a variable resistor R connected in parallel to the lower half of a potential divider.



The resistance of R increases.

What happens to the two voltmeter readings?

	reading on V_1	reading on V_2
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

[J09/P1/Q37]

Thinking Process

MCQ Answers

4. A The resistance of a thermistor decreases with the increase in its temperature but not to zero. Since the thermistor is a part of a series circuit, so the potential difference across it is proportional to its resistance ($V \propto R$). Thus, on heating the thermistor, its resistance decreases and so does the P.D. across it but not to zero.

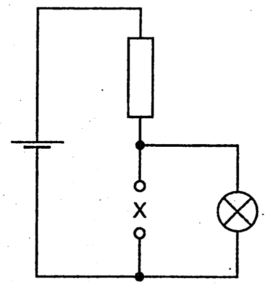
5. B On increasing the resistance of the variable resistor, the amount of current in the circuit decreases and the capacitor takes a longer time to charge and then discharge its charge through the neon lamp. The neon lamp therefore flashes less frequently.

6. A The resistance of the LDR decreases on increasing the intensity of light falling on it. As a result, a larger amount of current passes through the circuit and the lamp gets brighter.

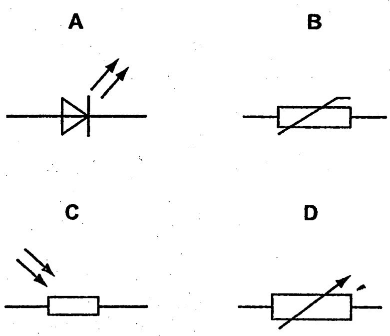
7. B As the value of the current in the single resistor in series and the combined current in the parallel circuit is the same. So, the potential difference across the resistor in series (V_1) and across the parallel circuit (V_2) is determined by $V \propto R$.

On increasing the value of the variable resistor, the potential difference (V_2) across the parallel circuit increases and the potential difference across the resistance in series (V_1) decreases.

8. The diagram is a circuit designed to switch on a lamp when it gets dark.

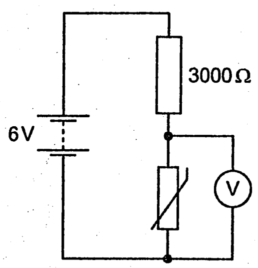


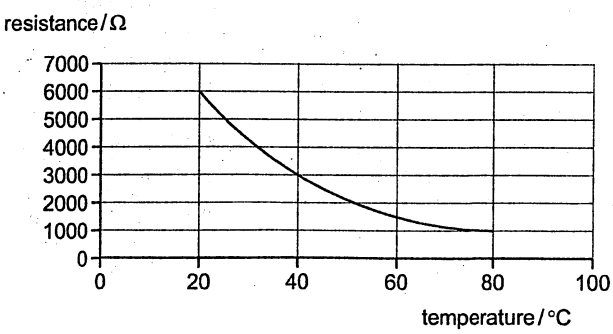
Which component is used as the sensor at X?



[N09/P1/Q36]

9. A thermistor is connected in a circuit with a 6 V battery, a 3000 Ω resistor and a voltmeter, as shown. The graph shows how the resistance of the thermistor varies with temperature.





What is the temperature of the thermistor when the voltmeter reads 2V?

A 20 °C

B 40 °C

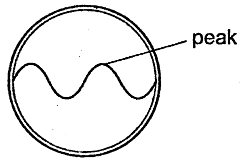
C 60 °C

D 80 °C

[N09/P1/Q37]

10. A cathode-ray oscilloscope is connected to an a.c. generator.

A wave is seen on the screen of the oscilloscope.



The speed of rotation of the generator is doubled.

What is the effect on the wave?

	number of peaks on the screen	amplitude of wave on the screen
A	doubled	doubled
B	doubled	same
C	same	doubled
D	same	same

[J10/P1/Q32]

MCQ Answers

8. C A Light Dependent Resistor (LDR) is used at X. When it gets dark, its resistance becomes high and a greater proportion of P.D. across its ends makes the lamp to light.

9. C Since the P.D. across the thermistor is 2V, the P.D. across the 3000 Ω resistor is 4V. The current in 3000 Ω resistor

$=\frac{V}{R}=\frac{4}{3000}=0.00133\text{A}.$

As the thermistor and the 3000Ω resistor are in series, the current in them is the same.

Hence, Resistance of thermistor

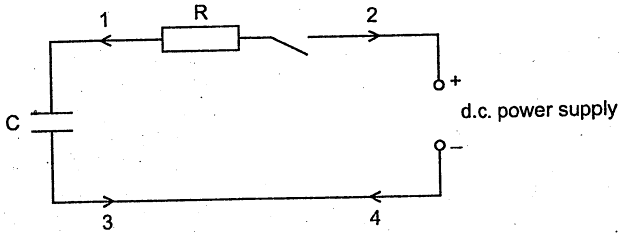
$=\frac{V}{I}=\frac{2}{0.00133}=1500\ \Omega$

From the graph, the temperature of the thermistor when its resistance is 1500 Ω = 60 °C.

10. A Doubling the speed of rotation of the generator's coil doubles the number of waves produced on the screen. So, the no. of peaks on the screen becomes doubled. Also, as the output voltage produced by the generator is doubled by doubling its speed, so, the amplitude of the wave also becomes doubled.

MCQ Answers

11. A capacitor C charges when it is connected to a d.c. power supply.



Which arrows show the direction of the conventional current when the capacitor is charging?

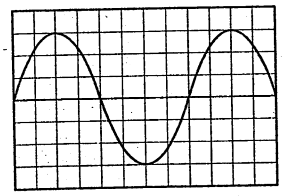
A 1 and 3 **B** 1 and 4

C 2 and 3 **D** 2 and 4

[J10/P1/Q34]

12. An alternating voltage of frequency 0.5 Hz is applied to the Y-plates of a cathode-ray oscilloscope (c.r.o.).

The diagram shows the screen of the c.r.o.



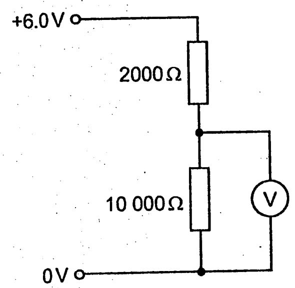
What is the time taken for the spot to cross the screen?

A 3 s **B** 6 s

C 15 s **D** 30 s

[J11/P1/Q37]

13. The diagram shows a potential divider system of two resistors connected to a 6.0 V power supply.



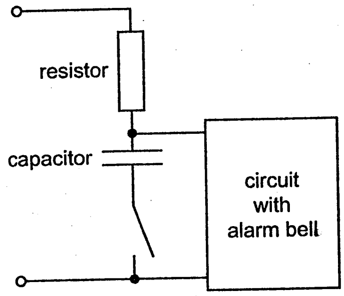
What is the reading on the voltmeter?

A 1.0 V **B** 1.2 V

C 3.0 V **D** 5.0 V

[N11/P1/Q28]

14. In the circuit shown, the alarm bell will only start ringing some time after the switch is closed.



What causes the time delay?

A the capacitor charging

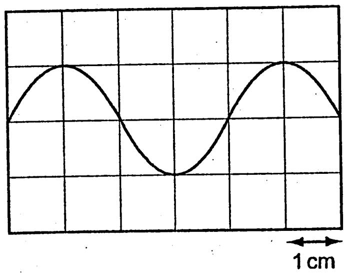
B the capacitor discharging

C the resistor cooling down

D the resistor heating up

[N11/P1/Q29]

15. The diagram shows the output of an a.c. generator as displayed on a cathode-ray oscilloscope. The horizontal scale is 5 ms / cm.



What is the time for one complete rotation of the coil of the generator?

A 5 ms **B** 10 ms

C 20 ms **D** 30 ms

[N12/P1/Q36]

11. A The conventional current flows from the positive terminal to the negative terminal of the battery.

12. A The time taken by one wave is given by:

$T = \frac{1}{f} = \frac{1}{0.5} = 2$ sec.

Since the screen shows one and a half waves across its length, so the total time taken by a spot to cross the screen is 3 seconds.

13. D Current flowing in a series circuit is equal throughout.

$I = \frac{V}{R} = \frac{6}{12000}$ A and

$V = IR$

$= \frac{6}{12000} \times 10000$

$= 5$ V

14. A The delay is due to the time needed to charge the capacitor until the voltage across the capacitor is equal to the operating voltage of the alarm bell.

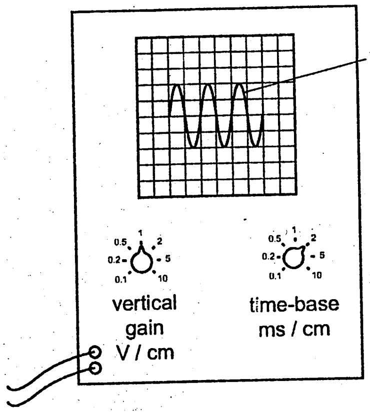
15. C One complete rotation of the coil of the generator is represented by one complete wave on the graph which is formed on the four squares of the graph.

Hence, the time for one rotation

= 4 cm × scale used

= 4 × 5 = 20 ms.

16. The trace of a waveform is seen on the screen of a cathode-ray oscilloscope.



Which statement about the controls is correct?

A The amplitude of the trace is changed by adjusting the time-base.

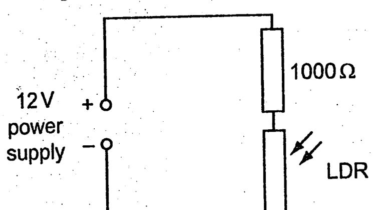
B The amplitude of the trace is changed by adjusting the vertical gain.

C The whole trace is moved to the right by adjusting the time-base.

D The whole trace is moved upwards by adjusting the vertical gain.

[N12/P1/Q37]

17. In a darkened room, a 1000 Ω resistor and a light-dependent resistor (LDR) are connected in series with a 12 V power supply.



The curtains are opened and light falls on the LDR.

What happens to the voltage across the LDR?

A It decreases.

B It increases.

C It remains at 0 V.

D It remains at 12 V.

[J13/P1/Q38]

18. There is a bright spot on the screen of a cathode-ray oscilloscope (c.r.o.). This is caused by fastmoving particles.

What are these particles?

A alpha-particles

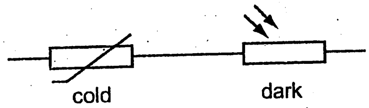
B electrons

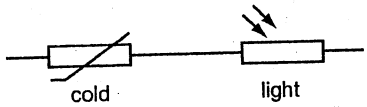
C neutrons

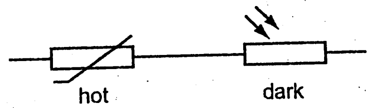
D protons

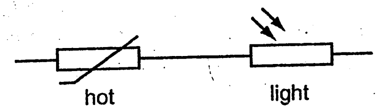
[N13/P1/Q34]

19. A thermistor and a light-dependent resistor are connected in series. Which conditions give the largest resistance?

A


B


C


D


[N13/P1/Q35]

20. What are emitted by the hot filament inside a cathode-ray tube?

A alpha-particles

B atoms

C electrons

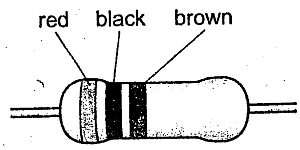
D protons

[J14/P1/Q37]

21. The table contains part of the colour code for resistors.

black	brown	red
0	1	2

What is the resistance of the resistor with the colour bands shown?



MCQ Answers

16. B The amplitude of a trace on a CRO screen is changed by adjusting the Y-gain. Whereas, the trace can be shifted to the right or to the left by adjusting the X-shift. Similarly, the trace can be shifted upwards or downwards by adjusting the Y-shift.

17. A As the current in the series circuit is constant. So, the P.D across the LDR is directly proportional to its resistance i.e. $V \propto R$.

As the resistance of the LDR decreases when light falls on it. So the voltage across it also decreases.

18. B Fact.

19. A A thermistor is a temperature dependent resistor whose resistance is high when it is cold but it decreases with the increase in its temperature. A light dependant resistor has a very high resistance in the dark but it decreases with the amount of light shining on it.

20. C Electrons are emitted inside a cathode-ray tube due to the phenomenon of thermionic emission.

21. B The first band denotes tens, the second band denotes units. The third band is the multiplier. Note that brown denotes a multiplier of 10.

Therefore, resistance

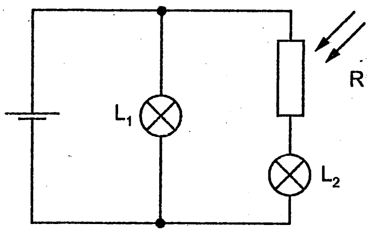
$= [(2 \times 10) + 0] \times 10$

$= 20 \times 10 = 200\ \Omega$

A 102 Ω **B** 200 Ω
C 201 Ω **D** 1000 Ω

[J14/P1/Q38]

22. In the circuit shown, R is a light-dependent resistor. Its resistance decreases when the intensity of the light shining on it increases.

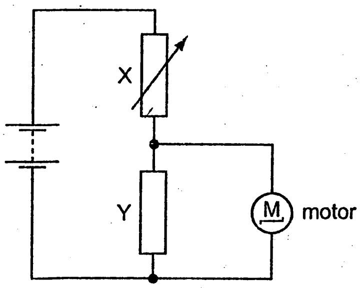


The light intensity on R increases.
What happens to the brightness of the two lamps L_1 and L_2?

	L_1	L_2
A	decreases	decreases
B	decreases	increases
C	stays the same	decreases
D	stays the same	increases

[N14/P1/Q35]

23. In the circuit shown, resistors X and Y act as a potential divider to control the speed of a motor.



What is the reason for the potential divider?

A to vary the direction of the current in X

B to vary the e.m.f. of the battery

C to vary the potential difference across the motor

D to vary the resistance of the motor

[N14/P1/Q36]

24. Which particles are emitted by the hot filament of a cathode-ray oscilloscope (c.r.o.) and which type of field is used to accelerate them?

	particles	type of field
A	electrons	electric
B	electrons	magnetic
C	protons	electric
D	protons	magnetic

[N15/P1/Q36]

MCQ Answers

22. D The resistance of the LDR decreases on increasing the intensity of light falling on it. As a result, a larger amount of current passes through L_2 and the LDR, which increases the brightness of L_2. Since, L_1 is in parallel with L_2 and the LDR, the current going through L_1 will not be affected by the resistance of the LDR.

23. C The motor is connected in parallel to Y. Therefore, the voltage drop across Y and the motor is the same. By varying the resistance of resistor X, the p.d. across Y changes and, thus, the speed of the motor can be controlled.

24. A Electrons are emitted from the hot filament by the process of thermionic emission and they are accelerated by the electric field set up between the cathode (filament) and the anode.

Topic 24 Electronics, CRO

THEORY Section

Question 1

Fig. 7.1 shows an electrical circuit and a cathode-ray oscilloscope (C.R.O.).

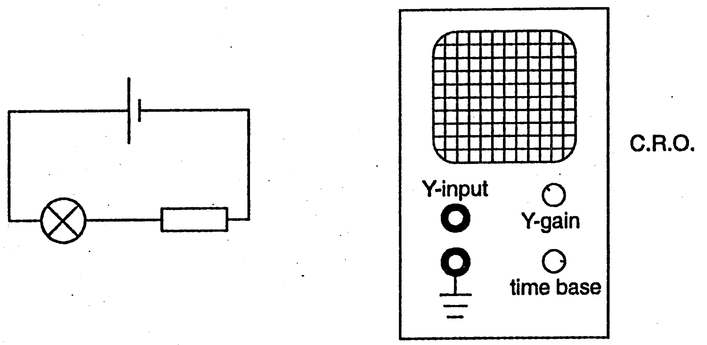


Fig. 7.1

(a) On Fig. 7.1, draw the connections you would make to enable the C.R.O. to measure the potential difference (p.d.) across the resistor. [1]

(b) Fig. 7.2 shows the trace on the screen before and after the connections are made.

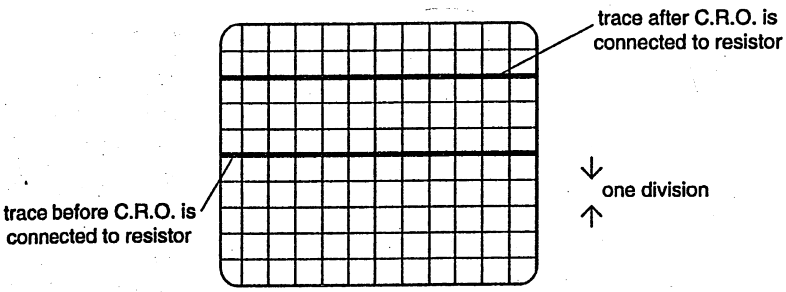


Fig. 7.2

The Y-gain control is set at 2 V for each division on the screen.

(i) State the value of the p.d. across the resistor.

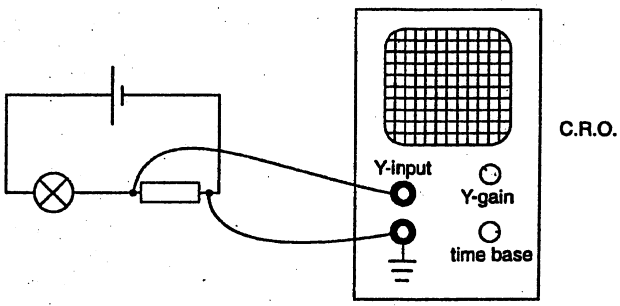
p.d. = ... [2]

(ii) The Y-gain control is altered to 4 V for each division.
On Fig. 7.2, draw the new trace seen on the screen. [1]

[J06/P2/Q7]

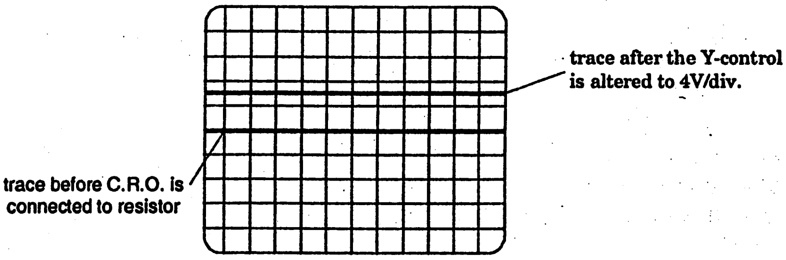
Solution

(a)



(b) (i) p.d. across the resistor $= 3 \text{ div.} \times 2 = 6 \text{ V}$

(ii)



COMMENT on ANSWER

"(a) The left end of the resistor being connected to the positive terminal of the battery is at a high voltage. So it is connected to the high potential terminal of the Y-input of the CRO.

Similarly, the right end of the resistor is at a low (zero) voltage so it is connected to the zero voltage terminal of the Y-input of the CRO.

(b) (ii) The p.d. across the resistor is 6V, so when the Y-gain of the CRO is set at 4V per division, the trace is formed at 1.5 division from the zero position on the screen."

Question 2

Fig. 11.1 shows an electronic circuit.

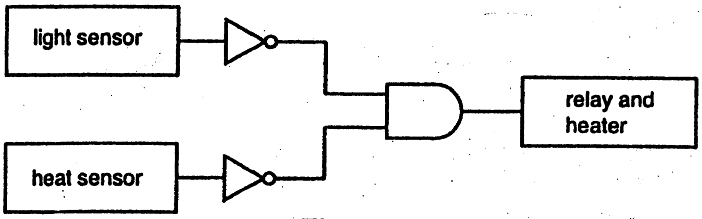


Fig. 11.1

(a) State the names of the two types of logic gate used in Fig. 11.1. [1]

(b) The heat sensor consists of a thermistor, a resistor and a power supply that are connected as a potential divider. The output voltage of the heat sensor is high when the sensor is hot, and is low when the sensor is cold.

(i) Draw a circuit diagram of the heat sensor, showing how the components are connected. [2]

(ii) Explain how the heat sensor produces a high output voltage when the sensor is hot. [2]

(c) The output voltage of the light sensor in Fig. 11.1 is high when it is in bright light, and is low when it is in the dark.
Explain what happens to the outputs of the three logic gates when

(i) it is cold and dark, [2]

(ii) it is cold and bright. [2]

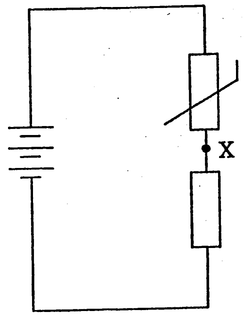
(d) State a practical use for this circuit. [1]

[N06/P2/Q11 OR]

Solution

(a) NOT and AND gates.

(b) (i)



(ii) When the sensor is hot, the thermistor has a very low resistance compared to the fixed resistor. Since the sum of p.d. across thermistor and p.d. across the fixed resistor is a constant, the p.d. across the thermistor decreases. So the potential at X is at a high value.

(c) (i) When its cold, NOT gate connected to heat sensor produces a "1" output. When its dark, NOT gate connected to light sensor produces a "1" output. Since both inputs to the AND gate are "1"s, the output from the AND gate is "1".

(ii) When its cold, NOT gate connected to heat sensor produces a "1" output. When its bright, NOT gate connected to light sensor produces a "0" output. The output from the AND gate is "0".

(d) To keep the soil warm in a greenhouse at night.

COMMENT on ANSWER

"(a) There are two NOT gates and one AND gate in Fig 11.1.

(b) The point X is connect to input of the NOT gate. The fixed resistor and thermistor must be connected in series. The order in which the two are connected to the power supply is important and affects the potential produced at X.

(c) Truth table for NOT gate –

Input	Output
0	1
1	0

Truth table for AND gate –

Input 1	Input 2	Output
0	0	0
0	1	0
1	0	0
1	1	1

"

Question 3

EITHER

The Y-plates of a cathode-ray oscilloscope (CRO) are connected to an alternating voltage of amplitude 4.0 V and frequency 25 Hz.

The Y-gain of the CRO is set at 2.0 V/division and the time-base is set at 0.01 s/division.

On the grid below, draw the trace on the screen of the CRO. Show your calculations beside the grid.