Registration Number

Candidate Name ____________________

NATIONAL JUNIOR COLLEGE
JC 2 COMMON TEST 2

PHYSICS 9248

Wednesday 26 Jun 2002 2h 05 min

INSTRUCTIONS TO CANDIDATES

Do not open this booklet until you are told to do so.
Write your name and registration number in the spaces at the top of this answer sheet.

Section B [60 marks]
Write your answers in the spaces provided on the question paper.

Section C [35 marks]
Write your answers on the writing paper provided.

INFORMATION FOR CANDIDATES
For numerical answers, all working should be shown.
The number of marks is given in brackets [ ] at the end pf each question or part question.
You are advised to spend 70 minutes on Section B.

FOR EXAMINER'S USE			
Section B		Section C	
Question	Marks	Question	Marks
26	9	Part 1- 32	
27		Part 2- 33	
28		Part 2 -34	
29			
30			
31			

Total: /95

This question paper consists of 19 printed pages including this cover page.

Section B- Answer all the questions
(You are advised to spend not more than 70 minutes in this section)

26(a) Is an explosion an elastic or inelastic situation? Explain. [2]

Inelastic. Momentum not conserved.
No conservation of energy

(b) Two blocks of masses M and $3M$ are placed on a horizontal, frictionless surface. A light spring is attached to one of them. A cord initially holding the blocks together is burned (see **Figure. 26.1**); after this, the block of mass $3M$ moves to the right with a speed of 2.00 ms^{-1}.

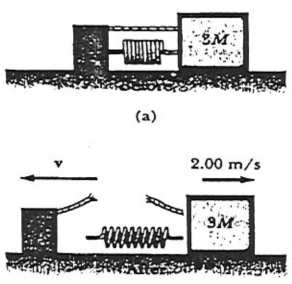


Figure. 26.1

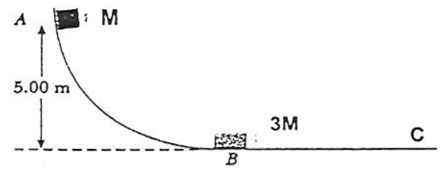
(i) What is the speed of the block of mass M? [2]

$M_1V_1 = M_2V_2$
$3M(2) = MV_2$
$V_2 = -6.00\ ms^{-1}$

4

(ii) Find the original elastic energy in the spring if M = 0.350 kg. [2]

(c) The spring is then detached from the block. Consider a frictionless track ABC.



The block of mass M is released from A. It makes a head-on elastic collision at B with the block of mass $3M$ that is initially at rest. Calculate the maximum height to which M rises after the collision if the $3M$ block moves at 4.5 ms^{-1} after the collision. [4]

By conservation of energy
Initial energy of $M_{block} = mgh$
$= 49.05M\ J$
Kinetic Energy of $3M$ block $= \frac{1}{2}mv^2$
$= \frac{1}{2}(3M)(4.5)^2$
$= 30.375J$
Final energy of $M_{block} = 49.05 - 30.375$
$= 18.675J$
$mgh_2 = 18.675$
$h_2 = \frac{18.675}{9.81}$
$= 1.90\ m$ (3sf)

9

27. A pilot was assigned to navigate the space shuttle, sent to repair a faulty communication satellite which is in a *geostationary* orbit.
Mass of Earth = 6.00×10^{24} kg.
Radius of Earth = 6.38×10^{6} m
1 day = 8.64×10^{4} s

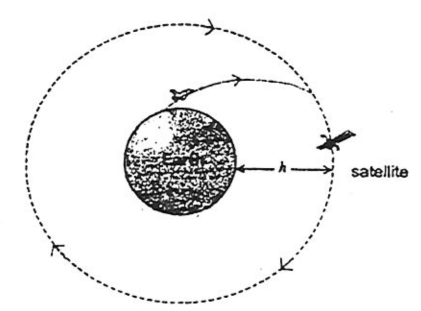


Figure 27.1 (not drawn to scale)

(a) Explain why the *geostationary* orbit must be on the same plane as the Earth's equator. [1]

(b) Determine the height *h* of the *geostationary* satellite from the Earth's surface. (Assume the Earth is spherical.) [3]

$\frac{GMm}{r^2} = mr\left(\frac{2\pi}{T}\right)^2$ $\quad h = r - R_E$

$r = \frac{GMm}{\left(\frac{2\pi}{T}\right)^2}$

$=$

(c) Calculate the orbital speed of the satellite. [1]

$V = r\omega$

(d) Determine the *gravitational potential difference* that the space shuttle experienced in its journey from the Earth's surface to the satellite's orbit. [2]

$\Delta\phi = \phi_r - \phi_{RE}$

$= -\frac{GM}{r} - \frac{G}{r}$

(e) Assuming the space shuttle is launched from Earth's equator, determine the minimum initial speed which the space shuttle must possess in order to reach the satellite's orbit. You may ignore the effects of air resistance. [3]

(f) In practice, the required speed with which the space shuttle is launched, relative to the Earth's surface, is less than that calculated in **(e)**. Explain. [1]

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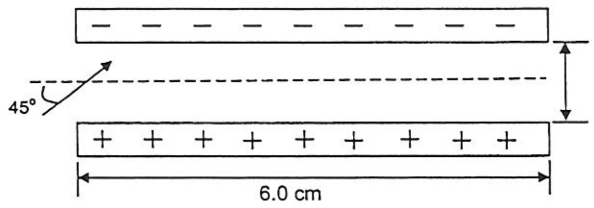
28. Suppose electrons enter the uniform field midway between two plates, moving at an upward 45° angle as shown below. The electric field strength in the region between the two plates is 5.0×10^{3} NC^{-1}.



(i) Find the potential difference between the two plates. [1]

(ii) For an electron which just enters the field as shown in the figure, draw a diagram to show the electrostatic force acting on the electron and the direction of the electric field. Determine the magnitude of this force. Hence find the acceleration of this electron. [3]

(iii) What maximum speed can this electron have to avoid striking the upper plate? Ignore fringing of the field. [3]

(iv) Determine the kinetic energy lost by the electron from the point of entry to the highest position between the two plates reached by the electron. [2]

29 (a) Explain why it is usual to transmit energy along overhead power lines as a.c. [2]

(b) A transformer, to be used in a low voltage power supply, is connected to the 240 V r.m.s., 50 Hz, sinusoidal a.c. mains supply and gives an r.m.s. output voltage of 12 V. There are 1800 turns on the primary coil.

(i) Calculate the number of turns on the secondary coil. [1]

(ii) Assuming that there are no energy losses, calculate the current in the primary coil when the current in the secondary coil is 9.0 A. [1]

(iii) A 2.5 Ω, resistor is connected across the secondary coil. Calculate the rate at which electrical energy is transformed into internal energy in the resistor. [1]

(iv) Calculate the peak value of the output voltage of the transformer. [1]

(v) The output from the transformer is rectified by the use of a diode in series with the load. Sketch the output waveform, showing clearly how the value of the voltage across the load changes with time. Your graph should include suitable voltage and time scales. [2]

(vi) State and explain briefly how the output can be smoothed. [2]

30 (a) A side view of a simple electron gun is shown in **figure 30.1**. Show that the speed with which electrons emerge from the anode of this gun will be about 2×10^7 ms^{-1} when the potential difference between the cathode and the anode is 1200V. [2]

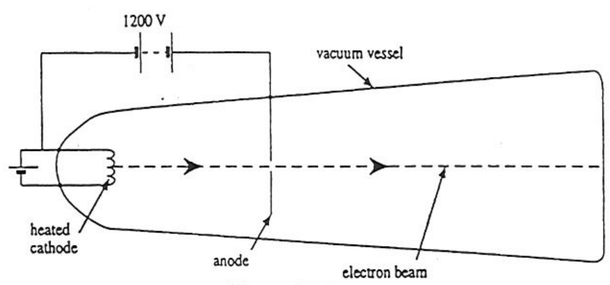


Figure 30.1

(b) Electrons emerging horizontally from the electron gun in part **(a)** then enter a uniform magnetic field which is directed upwards in the plane of the diagram (see **figure 30.1**). Calculate the magnitude of the force on an electron in this magnetic field of flux density 0.080 T. [2]

(c) Draw the path of an electron passing through the field described in part **(b)** on each of the two diagrams shown in the figure below. No further calculations are expected. [2]

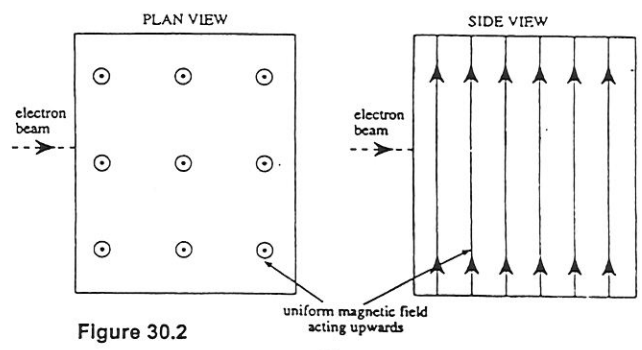


Figure 30.2

(d)(i) State whether the speed of an electron changes while it is in the magnetic field. Explain you answer. [2]

(ii) State, with a reason, whether the force on the electron alters while it is in the magnetic field. [2]

31 (a) An operational amplifier of open-loop gain 10^5 operates with supply voltage $\pm$ 14 V. What is the voltage across its input terminals when it has just been saturated? [1]

(b) The circuit below shows how an operational amplifier is set up.

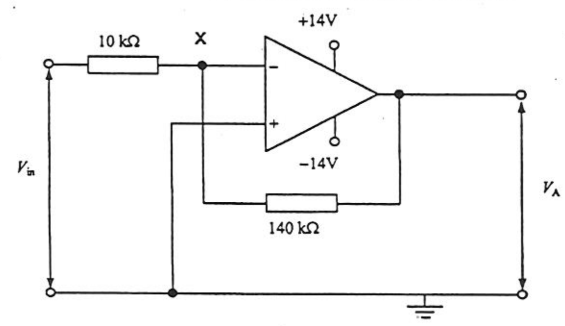


Figure 31.1

(i) State the potential at point **X**. [1]

(ii) Determine the gain of the circuit shown in **figure 31.1**. [2]

(iii) An alternating voltage as shown in **figure 31.2** is now applied across the inputs of the circuit. Copy **figure 31.2** and, on the same axes, sketch the output voltage and label it as **A**. Include appropriate values of voltage in your sketch. [2]

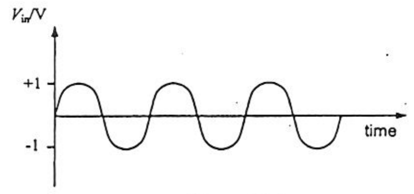


Figure 31.2

(iv) Determine the gain of the circuit shown in **figure 31.3**. [2]

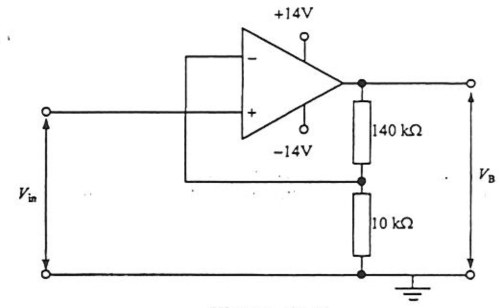


Figure 31.3

(v) The same input signal V_{in}, is applied to the input leads of circuit shown in **figure 31.3** Sketch the output voltage on the same axes and label it as **B.** Also, include appropriate values of voltage in your sketch. [2]

Section C- Part 1: Compulsory Question
(You are advised to spend not more than 20 minutes on question 32)

32. (a) A student attempts to make a 1.5 mm-thick copper coin resting on one of its faces on a table to jump up by blowing over the top face of the coin as shown schematically in **figure 32.1.**

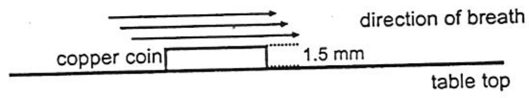


Figure 32.1

(i) Explain, using Bernoulli's principle, why the coin will jump up if the student blows over its top face hard enough. [3]

(ii) Assuming the student's breath is fairly streamline, estimate the minimum speed of his breath required to make the coin jump up. [3]

[density of air = 1.2 kgm^{-3}; density of copper = 6400 kgm^{-3}]

(iii) Hence determine the pressure difference between the air immediately above and below the coin. [1]

(b)(i) **Figure 32.2** shows a cross section through an aircraft wing which is mounted in a wind tunnel. A stream of air moves from left to right and carries with it lines of dense smoke.

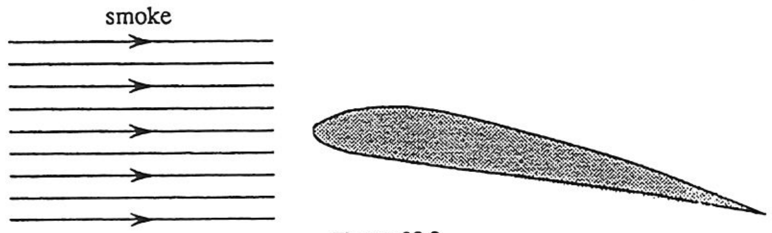


Figure 32.2

1. Continue the smoke lines in **Figure 32.2** to show a streamline air flow around the wing. [1]
2. Mark the region of maximum air **speed** around the wing with an **X**, and the region of minimum air **pressure** with a Y. [1]
3. Explain, with reference to Newton's laws of motion, why a lift force is exerted on the wing. [3]

(ii) If the inclination of the wing to the horizontal is gradually increased, the air flow over the wing becomes increasingly turbulent. At the inclination shown in **figure 32.3**, there is **no** streamline flow over the top surface of the wing.

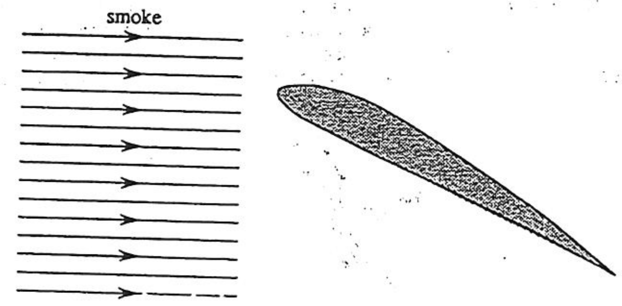


figure 32.3

1. Continue the smoke streams in **figure 32.3** to show the air flow around the wing. [1]
2. Explain why this situation may be undesirable during aircraft flight. [2]

Section C- Part 2: Answer any one of the two questions.
(You are advised to spend not more than 25 minutes on a question)

33(a) **Figure 33.1** shows the structure of a **silicon solar cell.** It consists of two layers of silicon. The upper layer (an N-type semiconductor) is rich in loosely bound electrons. When sunlight falls on its top surface, some loosely bound electrons are liberated, provided charge-carriers that can flow between the upper and the lower layers.

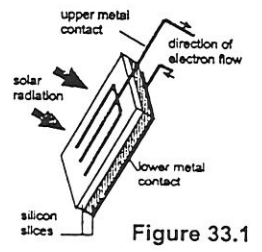


Figure 33.1

Figure 33.2 shows data obtained from one such solar cell. Graphs of the p.d. across and the current through the cell are plotted for the two different levels of illumination.

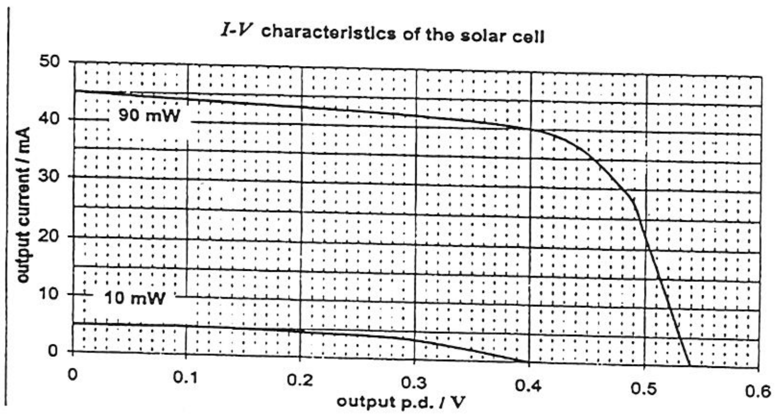


Figure 33.2

(i) For the incident power of 90 mW, deduce
(1) E, the e.m.f. of the solar cell,
(2) R, the load resistance when the output current is 30 mA.
(3) r, the internal resistance of the cell when the output current is 30 mA.

Show clearly how you obtained these values. [5]

(ii) For the incident power of 10 mW, deduce the efficiency of the solar cell when the output p.d. is 0.1 V. [2]

(b) (i) For the circuit shown in **Figure 33.3**, when the 10μF capacitor is fully charged, determine

(1) I_1, I_2 and I_3 [6]

(2) the charge stored in the capacitor. [2]

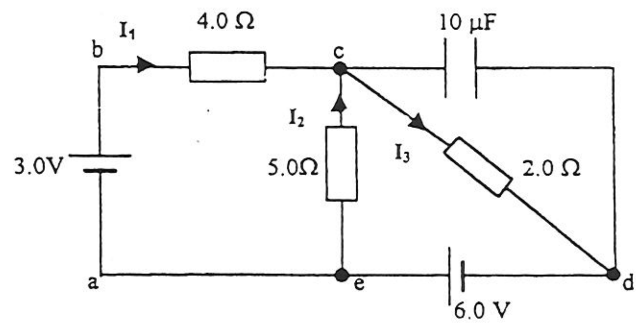


Figure 33.3

(ii) (1) If the fully charged 10μF capacitor is removed from the circuit and then connected to a 5μF capacitor which is charged to 6 V. If the two positive plates are connected together and the two negative plates are connected together, calculate the energy stored in the 10μF capacitor. [3]

(2) Describe qualitatively what happens when the capacitors are connected as given in (b)(ii)(1). [2]

34 Parts **(a)** and **(b)** of this question are about the design of a new propulsion system for driving a boat at sea.

(a) In one proposal, shown in **figure 34.1**, a copper bar is fixed under the boat and a large current is passed through it. A large electromagnet produces a vertical magnetic field.

(i) State the direction of the force on the bar when the current is flowing as shown in the diagram. [1]

(ii) Give two ways of increasing the force on the bar. [2]

(iii) Explain briefly why this system will not work. [3]

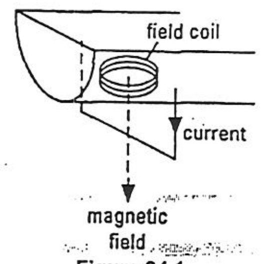


Figure 34.1

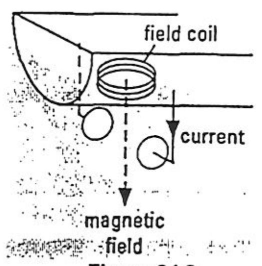


Figure 34.2

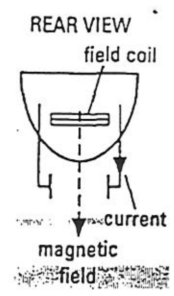


Figure 34.3

(b) A second proposal suggests passing a current through the water instead of through the copper bar using an electrode system as shown in **figures 34.2** and **figure 34.3.** Each electrode face has a surface area of 0.75 m^2 and they are 1.5 m apart. The drag force on the boat, which has a mass of 150 000 kg, is 12 000 N when it moves at 8.0 ms^{-1}. The current used is to be 1000 A.

(i) Explain what is meant by ionisation and how this enables a current to flow in sea water. [2]

(ii) Explain why the boat moves when a current is passed through the water. [2]

(iii) What is the magnetic flux density required so that the thrust is sufficient to maintain a constant speed of 8.0 ms^{-1}? [2]

(c) A long solenoid P, carrying a current, is shown in section in **figure 34.4.** A small coil Q, which is connected to a sensitive voltmeter (not shown), is placed in the centre of the solenoid.

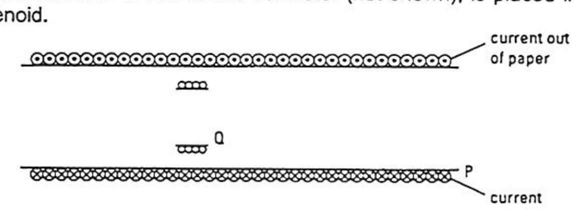


Figure 34.4

(i) Copy **figure 34.4** and sketch on it the flux pattern inside and outside the solenoid P due to the current in it. [2]

(ii) Explain why an induced e.m.f. is recorded on the voltmeter when the current in the solenoid changes. [3]

(iii) In further experiments, the current in solenoid P is changed at the same rate as in **(ii).** Compare qualitatively the induced e.m.f. with that obtained in **(ii)** when, separately,

(1) the coil Q is placed at the end of P,

(2) a ferrous core is placed in P. [3]

Candidate Name ____________________

Registration Number: 01

NATIONAL JUNIOR COLLEGE
JC 2 Term III COMMON TEST

PHYSICS
PAPER 1 Multiple Choice **9248/1**

Wednesday 26 June 2002 50 min

INSTRUCTIONS TO CANDIDATES

Do not open this booklet until you are told to do so.
Write your name and registration number in the spaces at the top of this page.
There are **25** questions in this paper. Answer **ALL** questions.

For each question there are four possible answers, **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in soft pencil on the separate answer sheet.

INFORMATION FOR CANDIDATES

Each correct answer will score one mark. No mark will be deducted for a wrong answer.
Any rough working should be done in this booklet.

Answers :-

1 A	6 B	11 D	16 C	21 D
2 A	7 A	12 C	17 A	22 B
3 D	8 D	13 C	18 D	23 B
4 B	9 D	14 A	19 C	24 B
5 B	10 A	15 B	20 C	25 B

1 If power is dissipated when a steady current I flows between two points in a circuit, the potential difference V between the points is defined by P/I. The emf E induced in a coil by a changing magnetic flux Φ is given by

$$E = -\frac{d\Phi}{dt}$$

It follows that magnetic flux can be written in base units of

A $kgm^2s^{-2}A^{-1}$
B $kgm^2s^{-2}A$
C $ms^{-2}A^{-1}$
D $ms^{-1}A$

2 The resistance R of a uniform conducting wire is calculated using measurements of its length L and radius r. The instrument for measuring L has an error of 2% and that for measuring r has an error of 1%. If there is no error in the value of the resistivity, the calculated value of R will have an error of

A 4 %
B 3 %
C 2 %
D 1 %

3 A particle is projected horizontally from the edge of a table with an initial speed u and attains a speed v just before hitting the ground. What is the time of flight of the particle? (Neglect air resistance.)

A $\frac{v}{g}$ B $\frac{v-u}{g}$ C $\frac{\sqrt{v^2-u^2}}{2g}$ D $\frac{\sqrt{v^2-u^2}}{g}$

4 A ball is projected vertically upwards from ground level at the surface of a planet where the acceleration due to gravity is 5.0 ms^{-2}. If the ball reaches a maximum height of 40 m, what is its velocity 6 s after it was thrown?

A 10 ms^{-1} upwards
B 10 ms^{-1} downwards
C 20 ms^{-1} upwards
D 20 ms^{-1} downwards

5 A man stands on a balance inside the lift. If the reading of the balance is less than his true weight, which of the following statements concerning the motion of the lift is correct?

A ascending with constant velocity
B descending with acceleration
C descending with deceleration
D ascending with acceleration

6 A pendulum bob of mass m is attached to a string of length l. It is acted upon by a force until its angle with the vertical becomes 60°. Find the minimum work required to move the mass to this position.

A mgl
B $\frac{1}{2}mgl$
C 0
D $\frac{\sqrt{3}}{2}mgl$

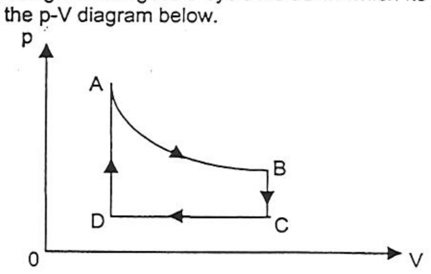
7 A newly discovered planet has a mass equal to one eighth of the earth's mass and a radius equal to one half of the earth's radius. If the gravitational field strength at the earth's surface is g_0, on the new planet's surface, it is

A $\frac{g_0}{2}$ B $\frac{g_0}{8}$ C $\frac{g_0}{4}$ D $\frac{g_0}{16}$

8 The root-mean-square speed of a sample of helium gas molecules, each of mass m, is c. Which of the following deductions is correct?

A The percentage of molecules traveling at speed c is greater than at other speeds.
B All molecules travel randomly with speed c.
C The average speed of the molecules is c.
D The average kinetic energy of the molecules is $\frac{1}{2}mc^2$.

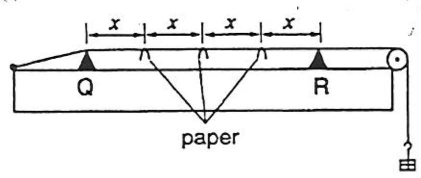
9 A fixed mass of an ideal gas undergoes a cycle ABCD in which its pressure p and volume V change as shown in the p-V diagram below.



Which of the following statements is correct?

A From A to B, work is done on the gas.
B From B to C, heat is taken in by the gas
C From C to D, the internal energy of the gas increases.
D From D to A, the internal energy of the gas increases.

10 A wire is stretched over two supports, Q and R, a distance $4x$ apart. Three light pieces of paper rest on the wire, as shown.



When the wire is made to vibrate at one particular wavelength $2x$, which of the following best describes the subsequent behaviour of the three pieces of paper.

A All three pieces of paper stay on the wire.

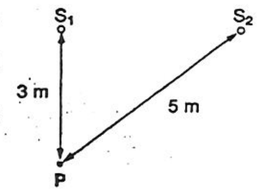
B The middle piece of paper stays on, but the others fall off the wire.

C The middle piece of paper falls off, but the others stay on the wire.

D All three pieces of paper fall off the wire.

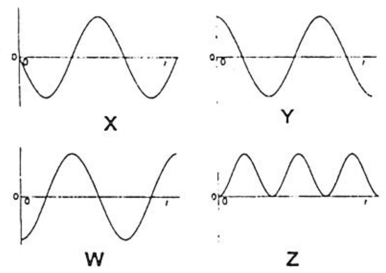
11 Water waves of wavelength 2 m are produced by two generators, S_1 and S_2, as shown.
Each generator, when operated by itself, produces waves which have an intensity I at P, which is 3 m from S_1 and 5 m from S_2.

When the generators are operated in phase, what is the intensity of oscillation at P?



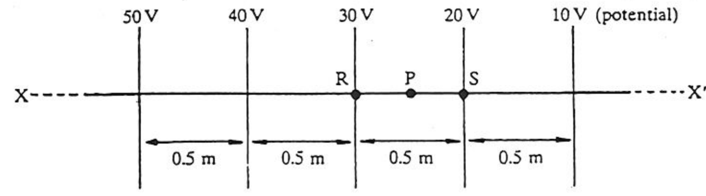
A 0 B $\sqrt{2}I$ C $2I$ D $4I$

12 The following graphs relate to a mass oscillating in simple harmonic motion. The displacement of the mass from its equilibrium position is a maximum at t = 0s.
Which of the following pairs of graphs X to Z shows the graph of velocity of the mass against time and the acceleration of the mass against time respectively?



A X and Y B Y and Z C X and W D Y and W

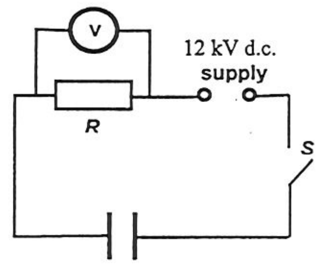
13

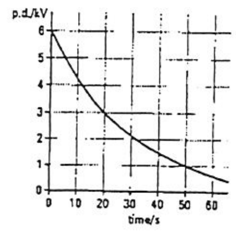


The diagram above shows how the electric potential varies along a line XX' in an electric field. What will be the electric field strength, in Vm^{-1}, at the point P on XX', which is midway between R and S?

A 5 B 10 C 20 D 30

14 When switch S is closed in the circuit below, the potential difference across the fixed resistor R varies with time as shown in the graph.





What fraction of the final energy is stored in the capacitor after 20 s? (Assuming the voltmeter is ideal and the capacitor is uncharged initially.)

A 9/16 B 3/4 C 9/25 D 1/16

15 Fig 1.15 shows an 8-pin package consisting of ten identical resistors, each of resistance 1.0 Ω, connected together. What is the effective resistance between pins 4 and 7, assuming that all other pins left unused?

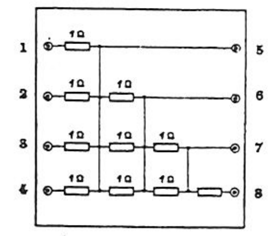


Fig.1.15

A 1.08 Ω B 1.83 Ω C 2.50 Ω D 3.00 Ω

16 A simple form of temperature sensor is shown in **Fig 1.16(a)**. It consists of a thermistor T, a resistor R, a 24-V power supply of negligible internal resistance and a 10 V, 0.2 A bulb. The resistance of the thermistor depends on its temperature as shown in **Fig 1.16(b)**.

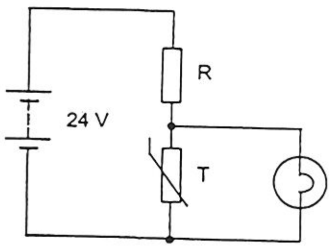


Fig. 1.16(a)

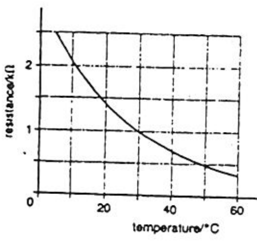


Fig. 1.16(b)

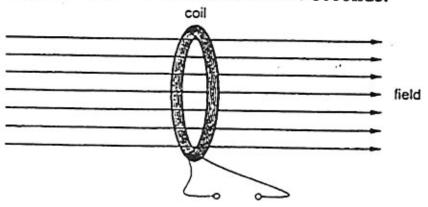
If the temperature of the room is 30.0°C, which one of the following is the correct value of the resistor R for the lamp to work at its specified voltage and current?

A 1.4 Ω B 34 Ω C 67 Ω D 1400 Ω

17 In a Millikan oil drop experiment, a potential difference between the parallel plates is varied until a negatively charged oil drop is stationary. Which of the adjustments, will cause the oil drop to fall?

A decrease the potential of the upper plate
B increase the potential difference between the plates
C decrease the separation of the plates
D apply a B-field into the plane containing the plates

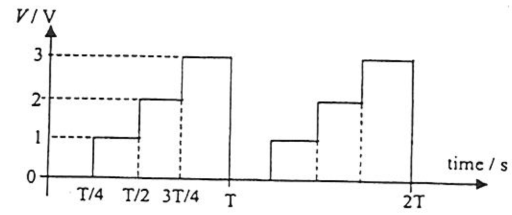
18 A 100-turn thin coil of cross-sectional area 2.0×10^{-3} m^2 is perpendicular to a magnetic field which increases uniformly from zero to 1.5×10^{-2} T in a time of five seconds.



Which one of **A** to **D** below correctly describes the e.m.f. which is induced in the coil?

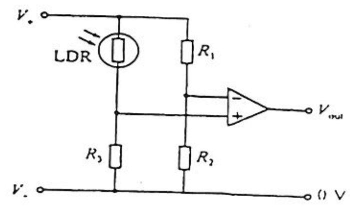
A The e.m.f increases uniformly from zero to 0.6 mV in the five seconds.
B The e.m.f. decreases uniformly from 0.6 mV to zero in the five seconds.
C The e.m.f. decreases uniformly from 6 mV to zero in the five seconds.
D The e.m.f. is constant and equal to 0.6 mV in the five seconds.

19 A periodic voltage, as shown below, is applied across a 5.0 Ω resistor. What is the average rate of heat production in the resistor?



A 0.45 W B 70 W C 0.70 W D 7.5 W

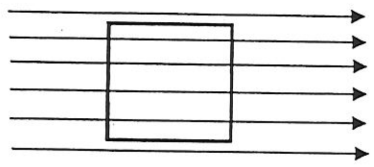
20



In the above circuit, the output voltage from the operational amplifier is positive. Which of the following changes could cause the output voltage to change to negative?

A Increasing the value of R_1.
B Increasing the value of R_3.
C Decreasing the light intensity on the LDR.
D Decreasing the value of R_2.

21 A square coil of side 8.0 mm containing 20 turns is suspended at the centre of a long horizontal solenoid so that two sides of the coil are vertical and the other two sides are parallel to the B-field of 0.01 T as shown in the figure below:



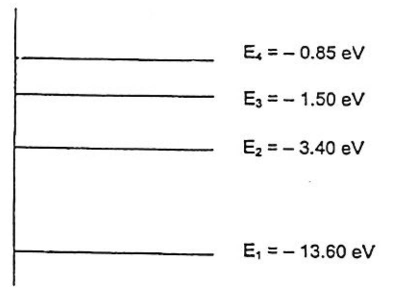
If the current in the square coil is 5.0 mA, what is the moment of the couple acting on the coil?

A 0 Nm
B 3.2×10^{-9} Nm
C 3.2×10^{-8} Nm
D 6.4×10^{-8} Nm

22 In the photoelectric effect, a light of photon energy 3.5 eV is incident on the emitter plate. A stopping potential of 1.0 V is required to prevent the electrons from reaching the collector plate. The threshold frequency of the metal, in hertz, is

A 2.4×10^{14}
B 6.1×10^{14}
C 8.5×10^{14}
D 1.1×10^{15}

23 The diagram below represents the energy levels of the four lowest states of the hydrogen atom. The energies are in units of electron volts. [1 eV = 1.60×10^{-19} J]



What is the value of the longest wavelength which might be emitted by a spectral transition between any pair of these four levels?

A 3.83×10^{-6} m
B 1.90×10^{-6} m
C 9.75×10^{-6} m
D 4.33×10^{-6} m

24 In a nuclear reactor a nucleus of ${}^{235}_{92}U$ absorbs a neutron and undergoes fission in which the products are a nucleus of ${}^{144}_{56}Ba$, a nucleus of Kr and two neutrons.
Which one of A to D below is the number of protons in the nucleus of Kr?

A 35
B 36
C 53
D 90

25 A radioactive source has a half-life of 10 hours. In the absence of this source an average count rate of 5 s^{-1} is recorded. When the source is placed in a fixed position near the counter, the average count rate is 85 s^{-1}. What is the reading on the counter with the source still in place 20 hours later?

A 15 s^{-1}
B 25 s^{-1}
C 40 s^{-1}
D 45 s^{-1}