# 3220/201

SCOTTISH CERTIFICATE OF EDUCATION 1997

THURSDAY, 15 MAY 9.30 AM – 11.00 AM

# PHYSICS
## HIGHER GRADE
Paper I

**Read Carefully**

1 All questions should be attempted.

2 The following data should be used when required unless otherwise stated.

| | | | |
|---|---|---|---|
| Speed of light in vacuum $c$ | $3{\cdot}00 \times 10^{8}$ m s$^{-1}$ | Planck's constant $h$ | $6{\cdot}63 \times 10^{-34}$ J s |
| Charge on electron $e$ | $-1{\cdot}60 \times 10^{-19}$ C | Mass of electron $m_e$ | $9{\cdot}11 \times 10^{-31}$ kg |
| Acceleration due to gravity $g$ | 9·8 m s$^{-2}$ | Mass of proton $m_p$ | $1{\cdot}67 \times 10^{-27}$ kg |

**Section A (questions 1 to 30)**

3 Check that the answer sheet is for Physics Higher I (Section A).

4 Answer the questions numbered 1 to 30 on the answer sheet provided.

5 Fill in the details required on the answer sheet.

6 Rough working, if required, should be done only on this question paper, or on the first two pages of the answer book provided—**not** on the answer sheet.

7 For each of the questions 1 to 30 there is only **one** correct answer and each is worth 1 mark.

8 Instructions as to how to record your answers to questions 1–30 are given on page two.

**Section B (questions 31 to 38)**

9 Answer questions numbered 31 to 38 in the answer book provided.

10 Fill in the details on the front of the answer book.

11 Enter the question number clearly in the margin of the answer book beside each of your answers to questions 31 to 38.

12 Care should be taken **not** to give an unreasonable number of significant figures in the final answers to calculations.

SCOTTISH QUALIFICATIONS AUTHORITY

## SECTION A

**For questions 1 to 30 in this section of the paper, an answer is recorded on the answer sheet by indicating the choice A, B, C, D or E by a stroke made in ink in the appropriate box of the answer sheet—see the example below.**

**EXAMPLE**

The energy unit measured by the electricity meter in your home is the

A ampere

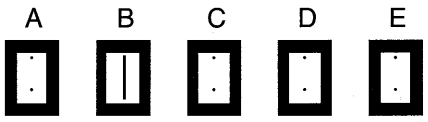
B kilowatt-hour

C watt

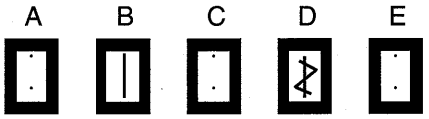
D coulomb

E volt.

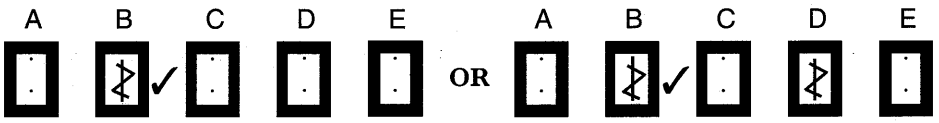
The correct answer to the question is B—kilowatt-hour. Record your answer by drawing a heavy vertical line joining the two dots in the appropriate box on your answer sheet in the column of boxes headed B. The entry on your answer sheet would now look like this:




If after you have recorded your answer you decide that you have made an error and wish to make a change, you should cancel the original answer and put a vertical stroke in the box you now consider to be correct. Thus, if you want to change an answer D to an answer B, your answer sheet would look like this:




If you want to change back to an answer which has already been scored out, you should enter a tick (✓) to the RIGHT of the box of your choice, thus:



## SECTION A

**Answer questions 1–30 on the answer sheet.**

**1.** Which of the following groups contains two vector quantities and one scalar quantity?

A Time, distance and force

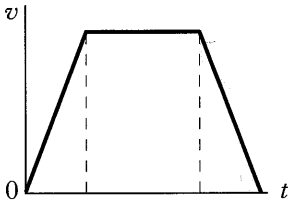
B Acceleration, mass and momentum

C Velocity, force and momentum

D Displacement, velocity and acceleration

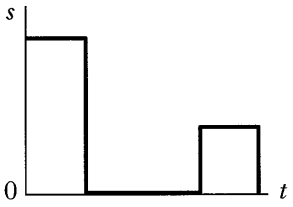
E Speed, distance and momentum

**2.** The diagram below is the velocity-time graph for a model train moving along a straight track.

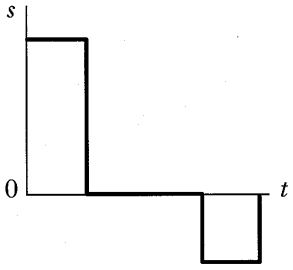



Which of the following could represent the displacement-time graph for the same motion?

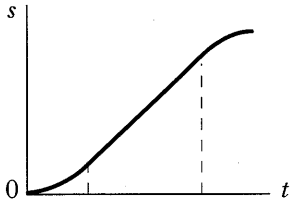
A



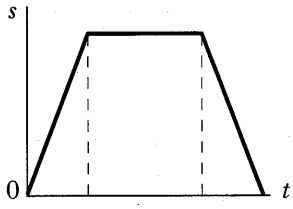

B



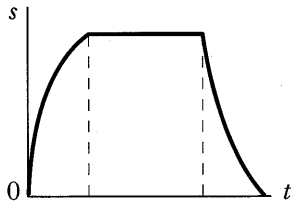

C




D




E



3. A train decelerates uniformly from 12·0 m s$^{-1}$ to 5·0 m s$^{-1}$ while travelling a distance of 119·0 m along a straight track. The deceleration of the train is

A 0·5 m s$^{-2}$

B 0·7 m s$^{-2}$

C 1·2 m s$^{-2}$

D 7·0 m s$^{-2}$

E 14·0 m s$^{-2}$.

4. A ball is projected vertically upwards with an initial speed of 40 m s$^{-1}$. The acceleration due to gravity can be taken to be 10 m s$^{-2}$.

What total time will the ball take to rise to its highest point and then return to its starting point?

A 2 s

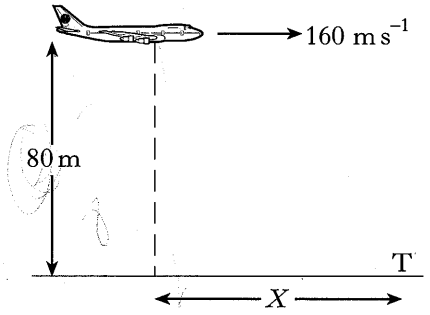
B 4 s

C 6 s

D 8 s

E 16 s

5. An aeroplane is flying at 160 m s$^{-1}$ in level flight 80 m above the ground. It releases a package at a horizontal distance $X$ from the target T.




The effect of air resistance can be neglected and the acceleration due to gravity can be taken as 10 m s$^{-2}$.

The package will score a direct hit on the target T if $X$ is

A 40 m

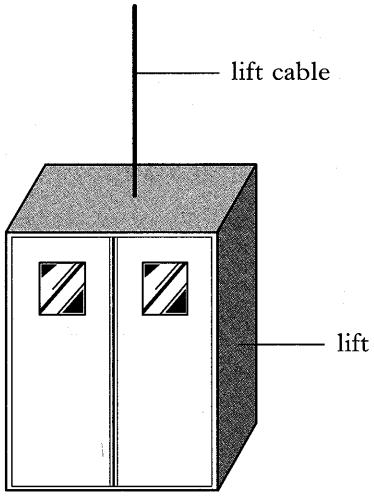
B 160 m

C 320 m

D 640 m

E 2560 m.

6. The lift in a department store has a mass of 1100 kg.




The lift is descending with a uniform downwards acceleration of 2 m s$^{-2}$. The acceleration due to gravity can be taken as 10 m s$^{-2}$.

What is the force applied to the lift by the lift cable?

A 1100 N

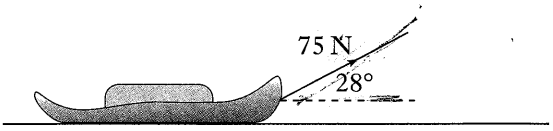
B 2200 N

C 8800 N

D 11 000 N

E 13 200 N

**7.** A sledge is pulled a distance of 8 m in a straight line along a horizontal surface.

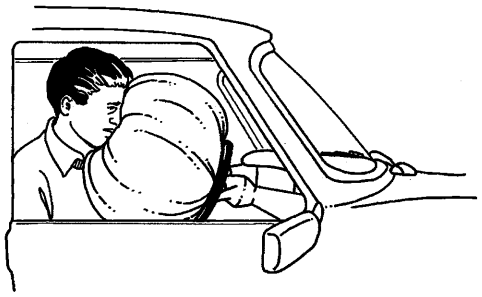



The tension in the rope is 75 N and the angle between the rope and the horizontal surface is 28°.

Which row in the following table is correct?

| | *Horizontal component of tension*/N | *Vertical component of tension*/N | *Work done by rope*/J |
|---|---|---|---|
| A | 75 sin 28° | 75 sin 62° | 600 |
| B | 75 cos 28° | 75 sin 28° | 530 |
| C | 75 sin 62° | 75 sin 28° | 600 |
| D | 75 cos 28° | 75 sin 62° | 600 |
| E | 75 sin 28° | 75 cos 28° | 35 |

**8.** Many car manufacturers are now fitting airbags which inflate automatically during an accident, as shown below.



The purpose of the airbag is to protect the driver by

A reducing his change of momentum per second

B increasing his change of momentum per second

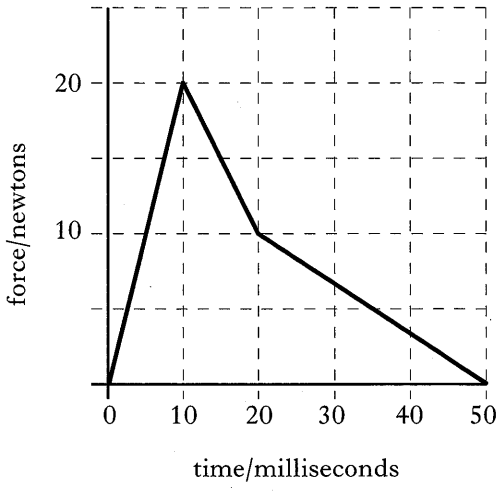
C reducing his final velocity

D reducing his total change in momentum

E increasing his total change in momentum.

**9.** The force acting on an object is measured and the results are stored in a computer.

The force-time graph obtained from the computer is shown below.




What is the average force acting on the object during the 50 milliseconds?

A 15 N

B 10 N

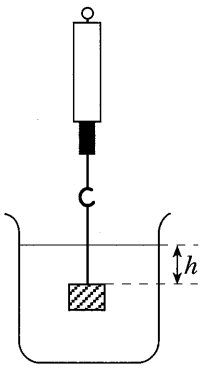
C 8 N

D 2·5 N

E 1 N

**[Turn over**

**10.** A small metal block is suspended from a spring balance at a depth $h$ below the surface of a liquid in a large beaker.




Which of the following statements is/are true?

I The reading on the spring balance depends on the density of the liquid in the beaker.

II The reading on the spring balance is equal to the upthrust of the liquid on the metal block.

III The reading on the spring balance will increase as the depth $h$ is increased.

A I only

B II only

C III only

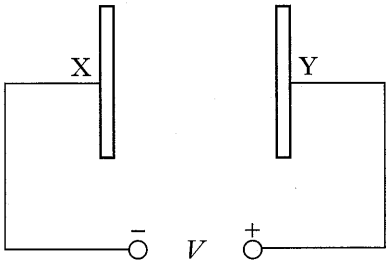
D I and II only

E I and III only

**11.** Which of the following gives the approximate relative spacings of molecules in ice, water and water vapour?

| | *Molecular spacing in ice/units* | *Molecular spacing in water/units* | *Molecular spacing in water vapour/units* |
|---|---|---|---|
| A | 1 | 1 | 10 |
| B | 1 | 3 | 1 |
| C | 1 | 3 | 3 |
| D | 1 | 10 | 10 |
| E | 3 | 1 | 10 |

**12.** Two parallel metal plates X and Y in a vacuum have a potential difference $V$ across them.




An electron of charge $e$ and mass $m$, initially at rest, is released from plate X.

The speed of the electron when it reaches plate Y is given by

A $\dfrac{2eV}{m}$

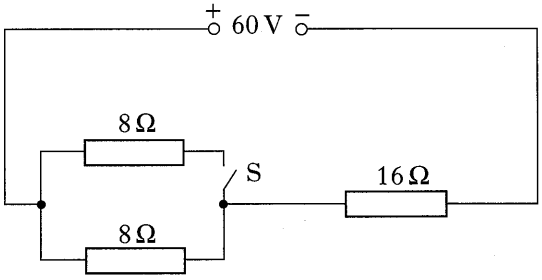
B $\sqrt{\dfrac{2eV}{m}}$

C $\sqrt{\dfrac{2V}{em}}$

D $\dfrac{2V}{em}$

E $\dfrac{2mV}{e}$.

**13.** In the following circuit, the p.d. across the 16 Ω resistor is 40 V when switch S is **open**.




The p.d. across the 16 Ω resistor when switch S is **closed** is

A 12 V

B 15 V

C 30 V

D 45 V

E 48 V.

**18.** A capacitor is to be connected across a 230 V r.m.s. a.c. supply. To prevent damage to the capacitor, its minimum voltage rating must be

A 163 V

B 230 V

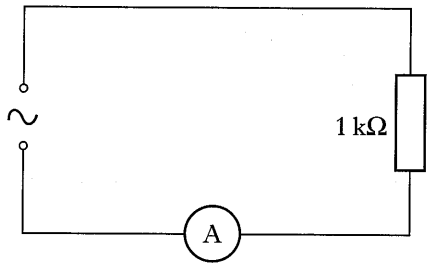
C 325 V

D 460 V

E 650 V.

**19.** A resistor is connected in a circuit as shown below.

The output from the a.c. supply can be varied in frequency but has a constant r.m.s. voltage.




a.c. meter

The frequency of the output from the supply is increased steadily from 50 Hz to 5 kHz.

The reading on the a.c. ammeter

A remains constant

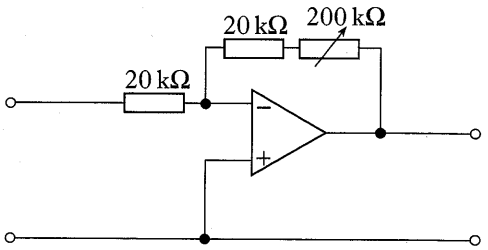
B falls steadily

C rises steadily

D rises then falls

E falls then rises.

**20.** A physicist designs the amplifier circuit shown below.




In this circuit, adjustment of the resistance of the variable resistor from zero to 200 kΩ allows the voltage gain to be altered over the range

A zero to one

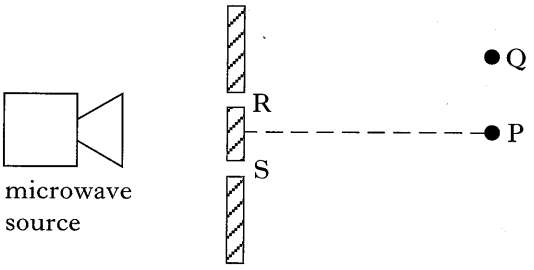
B zero to ten

C zero to eleven

D one to ten

E one to eleven.

**21.** A source of microwaves of wavelength $\lambda$ is placed behind two slits, R and S. A microwave detector records the maximum response when it is placed at P, where RP = SP.




The microwave detector is moved and the **next** maximum is recorded at Q.

The path difference (SQ–RQ) must be

A 0

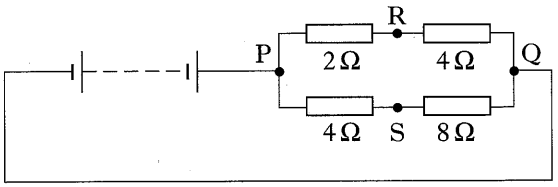
B $\frac{\lambda}{2}$

C $\lambda$

D (any odd number) $\times \frac{\lambda}{2}$

E (any whole number) $\times \lambda$.

**14.** In the circuit shown, the p.d. between points P and Q is 12 V.




The reading on a voltmeter connected across points R and S is

A 0 V

B 2 V

C 4 V

D 6 V

E 8 V.

**15.** When there is a potential difference of $V$ volts across a resistor, the power dissipated in the resistor is $P$ watts.

The current in the resistor, in amperes, is given by

A $\frac{P}{V}$

B $\frac{P}{V^2}$

C $\frac{V}{P}$

D $\frac{V^2}{P}$

E $\sqrt{\frac{P}{V}}$.

**16.** The unit for capacitance can be written as

A $\mathrm{V\,C^{-1}}$

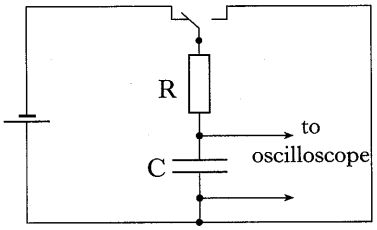
B $\mathrm{C\,V^{-1}}$

C $\mathrm{J\,s^{-1}}$

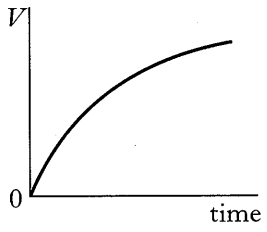
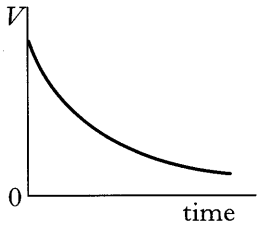
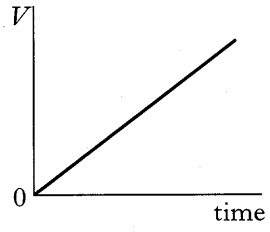
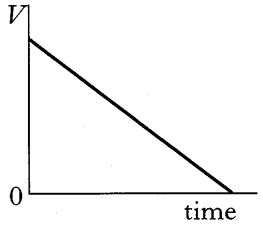
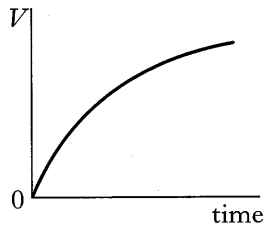
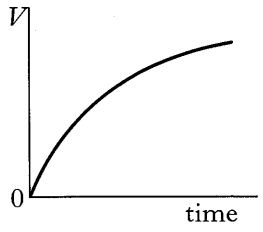
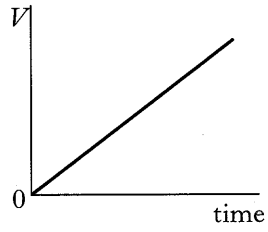
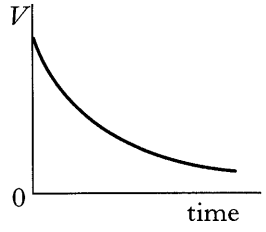
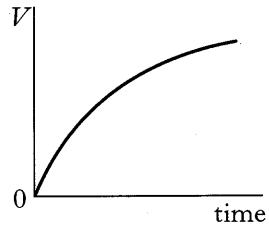
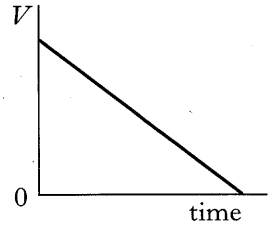
D $\mathrm{C\,J^{-1}}$

E $\mathrm{J\,C^{-1}}$.

**17.** The following circuit is used to charge and then discharge a capacitor C.




Which of the following pairs of graphs correctly shows how the voltage $V$ across the capacitor varies with time during charging and discharging?

| | **Charging** | **Discharging** |
|---|---|---|
| A |  |  |
| B |  |  |
| C |  |  |
| D |  |  |
| E |  |  |

**22.** A liquid and a solid have the same refractive index.

What would happen to the speed and the wavelength of light waves passing from the liquid into the solid?

| | *Speed* | *Wavelength* |
|---|---|---|
| A | decreases | decreases |
| B | decreases | increases |
| C | increases | increases |
| D | increases | decreases |
| E | stays the same | stays the same |

**23.** The intensity of light can be measured in

A $W$

B $W\,m^{-1}$

C $W\,m$

D $W\,m^{-2}$

E $W\,m^{2}$.

**24.** The light intensity is 160 units at a distance of 0·50 m from a point source of light in a darkened room.

At 2·0 m from this source, the light intensity is

A 160 units

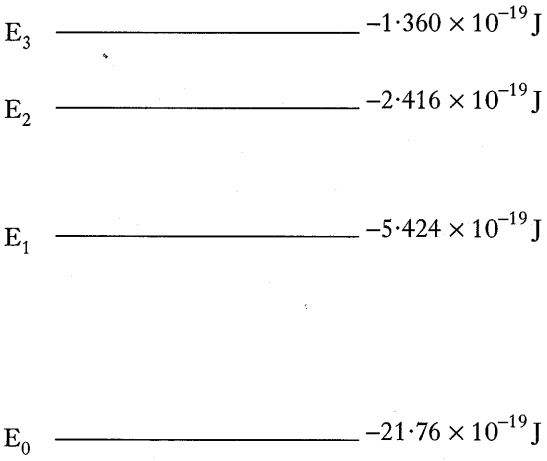
B 80 units

C 40 units

D 10 units

E 5 units.

**25.** The diagram below shows some of the energy levels for the hydrogen atom.




The highest frequency of radiation emitted due to a transition between two of these energy levels is

A $2{\cdot}04 \times 10^{20}$ Hz

B $1{\cdot}63 \times 10^{20}$ Hz

C $3{\cdot}08 \times 10^{15}$ Hz

D $2{\cdot}46 \times 10^{15}$ Hz

E $1{\cdot}59 \times 10^{14}$ Hz.

**26.** A light emitting diode produces light of wavelength $\lambda$.

The energy of a photon of light emitted by this diode is given by

A $h\lambda$

B $\frac{h}{\lambda}$

C $\frac{h\lambda}{c}$

D $\frac{hc}{\lambda}$

E $hc\lambda$.

**[Turn over**

**27.** Which of the following statements could explain the faint dark lines observed in the spectrum of sunlight when viewed through a high quality spectroscope?

I Gases in the outer layers of the Sun absorb certain frequencies of light.

II Gases in the inner layers of the Sun emit only certain frequencies of light.

III Gases within the Sun produce only a line emission spectrum.

A I only

B II only

C III only

D I and II only

E I and III only

**28.** A physicist varied the distance between a radioactive source and a detector. She obtained the following results which have been corrected for background radiation.

| *Distance from source to detector*/cm | 10 | 20 | 30 | 40 | 50 |
|---|---|---|---|---|---|
| *Corrected count-rate*/$s^{-1}$ | 127 | 31 | 14 | 8 | 5 |

From these results, what is the relationship between the corrected count-rate $R$ and the distance $d$ from the source to the detector?

A $R \propto d^2$

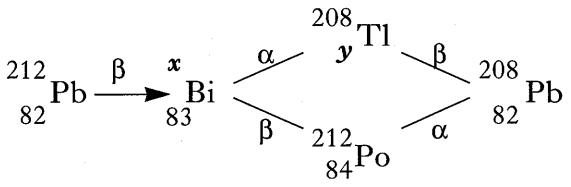
B $R \propto d$

C $R \propto \sqrt{d}$

D $R \propto \frac{1}{d}$

E $R \propto \frac{1}{d^2}$

**29.** Part of a radioactive decay series is shown below.




The numbers $x$ and $y$ in the series have been omitted.
What are the correct values for $x$ and $y$?

| | $x$ | $y$ |
|---|---|---|
| A | 212 | 84 |
| B | 211 | 81 |
| C | 213 | 84 |
| D | 212 | 81 |
| E | 211 | 83 |

**30.** The process of nuclear fission occurs in the core of a nuclear reactor.

Which of the following statements about this process is/are true?

I Two nuclei are produced when an unstable nucleus fissions.

II Two unstable nuclei combine.

III Neutrons are released when an unstable nucleus fissions.

A I only

B II only

C III only

D I and II only

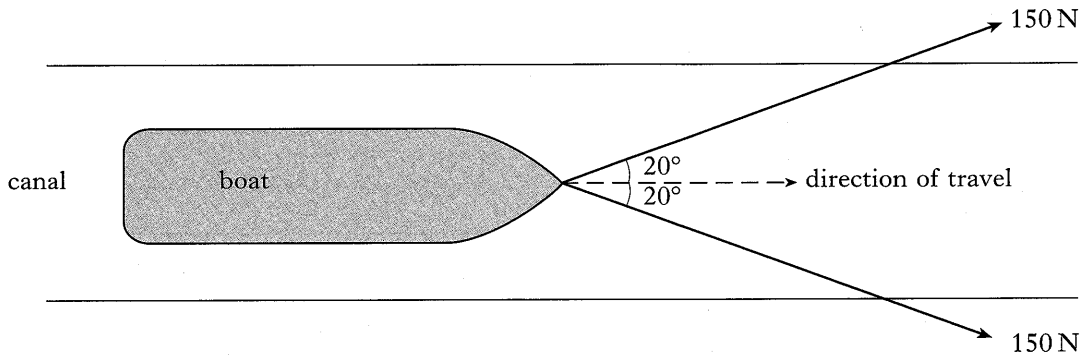
E I and III only

## SECTION B

**Write your answers to questions 31 to 38 in the answer book.**

*Marks*

**31.** Two ropes are used to pull a boat at constant speed along a canal.

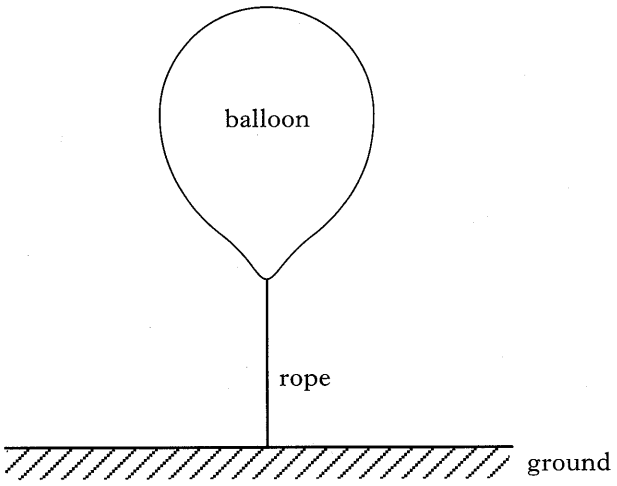



Each rope exerts a force of 150 N at 20° to the direction of travel of the boat as shown.

(*a*) Calculate the magnitude of the resultant force exerted by the ropes.

(*b*) What is the magnitude of the frictional force acting on the boat? **3**

**32.** The diagram shows a weather balloon of mass $m$ tethered by a rope to the ground.




(*a*) Draw a sketch of the balloon. Mark and name all the forces acting vertically on the balloon.

(*b*) What is the resultant force acting on the balloon? **2**

**[Turn over**

**33.** A pupil carries out an experiment on a linear air track with two vehicles X and Y. Vehicle X is propelled towards vehicle Y which is initially at rest and the vehicles are allowed to collide.

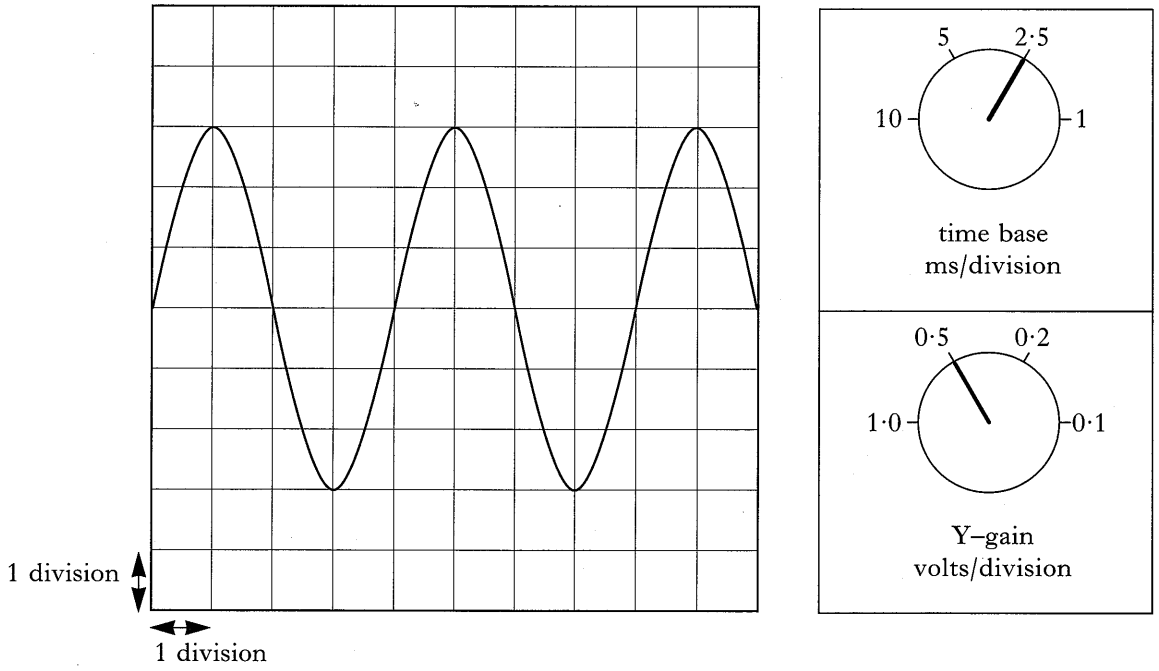
The results obtained are shown in the tables below.

| *Before Collision* | | | |
|---|---|---|---|
| *Momentum of X*/ kg m s$^{-1}$ | *Momentum of Y*/ kg m s$^{-1}$ | *Kinetic energy of X*/J | *Kinetic energy of Y*/J |
| 0·12 | 0 | 0·036 | 0 |

| *After Collision* | | | |
|---|---|---|---|
| *Momentum of X*/ kg m s$^{-1}$ | *Momentum of Y*/ kg m s$^{-1}$ | *Kinetic energy of X*/J | *Kinetic energy of Y*/J |
| 0·06 | 0·06 | 0·009 | 0·018 |

Explain whether the collision between the vehicles is elastic or inelastic. **2**

**34.** The output from a signal generator is connected to the input terminals of an oscilloscope. A trace is obtained on the oscilloscope screen. The oscilloscope control settings and the trace on the oscilloscope screen are shown in the diagram below.

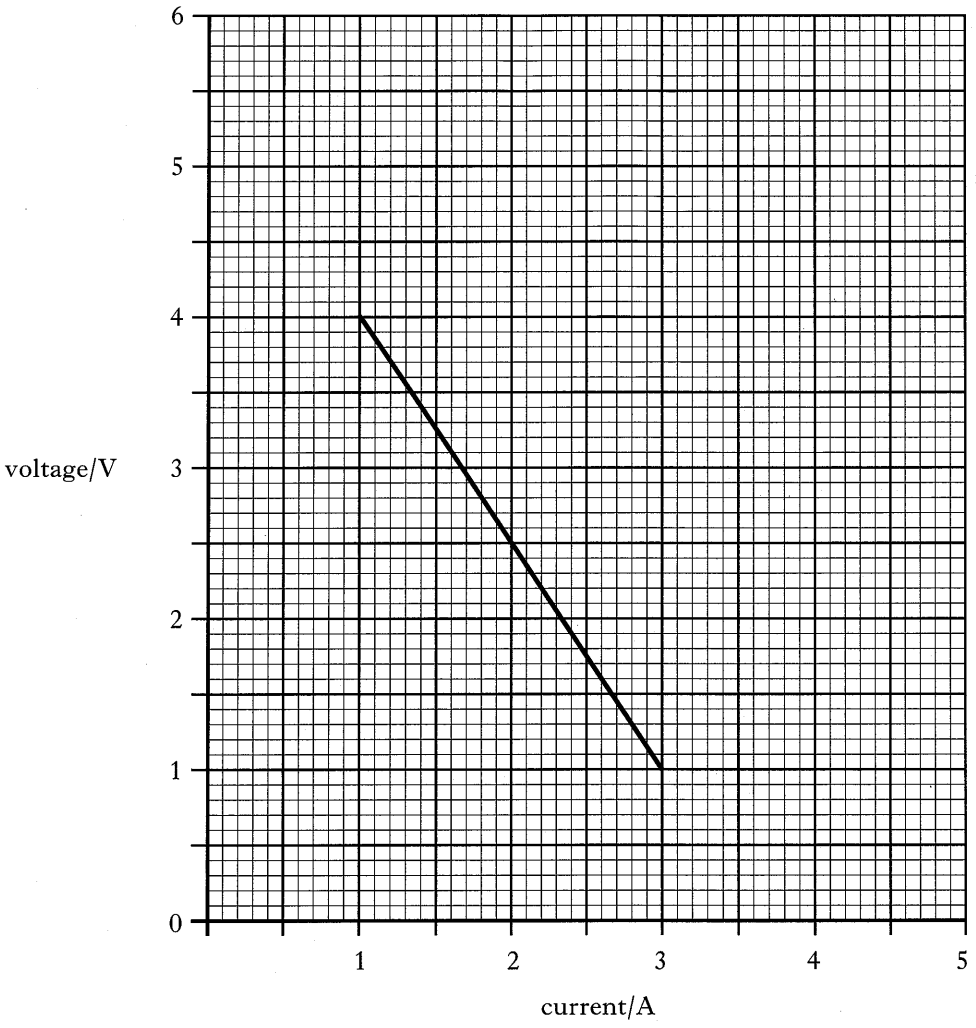



(*a*) Calculate the frequency of the output from the signal generator.

(*b*) The frequency and amplitude of the output from the signal generator are kept constant.
The time base control setting is changed to 5 ms/division.
What will be the effect on the trace shown on the oscilloscope? **3**

*Marks*

**35.** The graph shows how the voltage across the terminals of a battery changes as the current from the battery is varied.




(*a*) Calculate the internal resistance of the battery.

(*b*) What is the value of the current from the battery when it is short-circuited? **3**

**36.** A beam of monochromatic light of frequency $4{\cdot}85 \times 10^{14}$ Hz passes from air into liquid paraffin. In liquid paraffin the light has a speed of $2{\cdot}10 \times 10^{8}$ m s$^{-1}$.

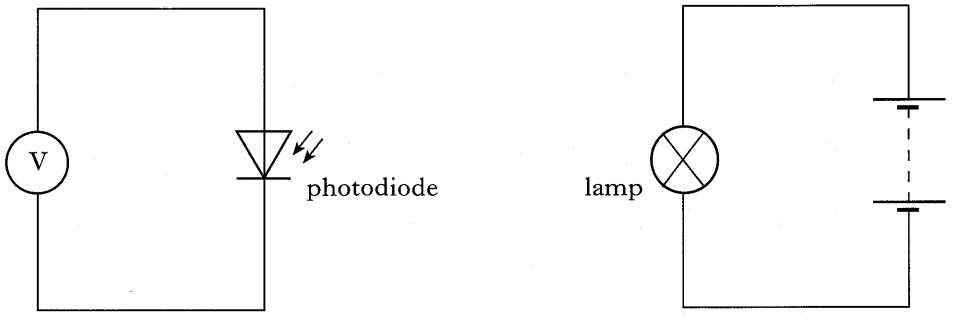
(*a*) Calculate the refractive index of the liquid paraffin.

(*b*) What is the frequency of the light when it is in the liquid paraffin? **3**

**[Turn over for Question 37 on *Page fourteen***

*Marks*

**37.** The diagram shows a photodiode connected to a voltmeter. A lamp is used to shine light onto the photodiode.




The reading on the voltmeter is 0·5 V.

The lamp is now moved closer to the photodiode.

Using the terms **photons**, **electrons** and **holes**, explain why the voltmeter reading changes. **2**

**38.** A grating or a prism can be used to produce spectra from a source of white light.

Give **two** differences between the spectra obtained using the grating and the prism. Diagrams may be used to illustrate your answer. **2**

*[END OF QUESTION PAPER]*

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