3220/201

SCOTTISH CERTIFICATE OF EDUCATION 1996

FRIDAY, 17 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 37)

9 Answer questions numbered 31 to 37 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 37.

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

SAB 3220/201 6/3/17210

SCOTTISH EXAMINATION BOARD

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

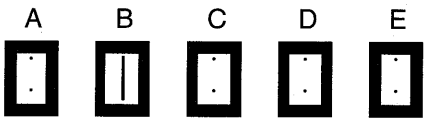
B kilowatt-hour

C watt

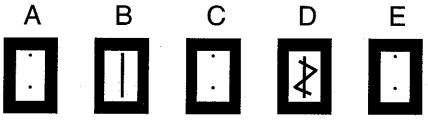
D coulomb

E volt.

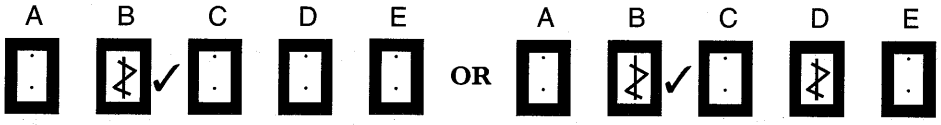
The correct answer to the question is B—kilowatt-hour. Record your answer by drawing a heavy vertical line joining the two dots in the appropriate box on your answer sheet in the column of boxes headed B. The entry on your answer sheet would now look like this:



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:



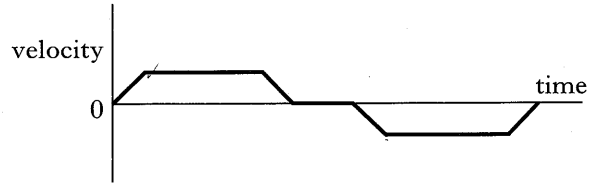
If you want to change back to an answer which has already been scored out, you should enter a tick (✓) to the RIGHT of the box of your choice, thus:



SECTION A

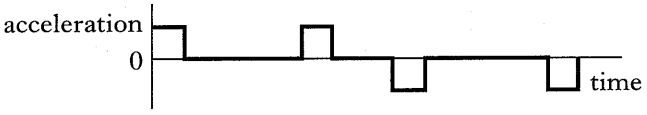
Answer questions 1–30 on the answer sheet.

1. A lift in a hotel makes a return journey from the ground floor to the top floor and then back again. The corresponding velocity-time graph is shown below.

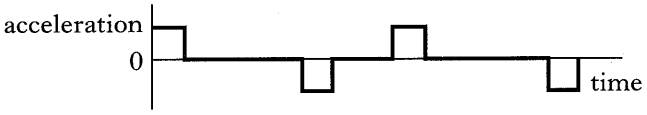


Which of the following shows the acceleration-time graph for the same journey?

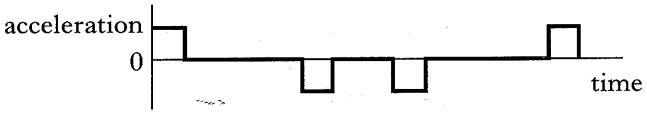
A



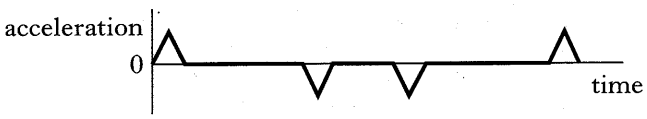
B



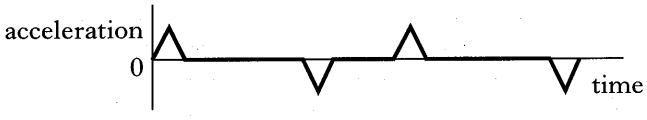
C



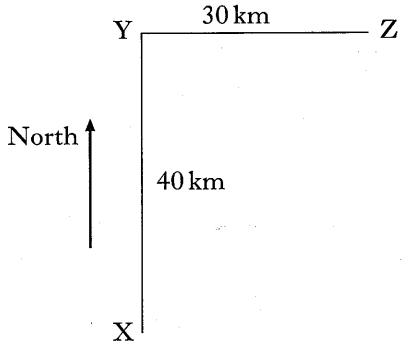
D



E



2. A car travels from X to Y and then it travels from Y to Z, as shown in the following diagram.



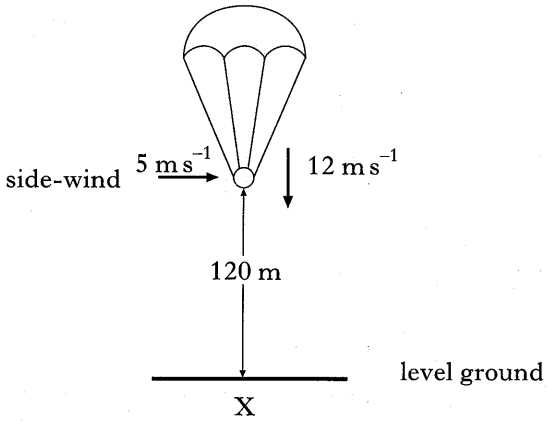
X to Y takes a time of one hour. Y to Z also takes one hour. Which of the following is a correct list of the magnitudes of the final displacement, average speed and average velocity for the complete journey?

	Displacement (km)	*Average speed* (km hr^{-1})	*Average velocity* (km hr^{-1})
A	50	35	35
B	70	35	25
C	50	35	25
D	70	70	50
E	50	70	25

[Turn over

3. An object attached to a parachute falls from a helicopter which is hovering at a height of 120 m above point X.

The object falls with a constant vertical component of velocity of value 12 $m\,s^{-1}$. A steady side-wind gives the object a constant horizontal component of velocity of value 5 $m\,s^{-1}$.



How far from point X does the object hit the ground?

A 24 m

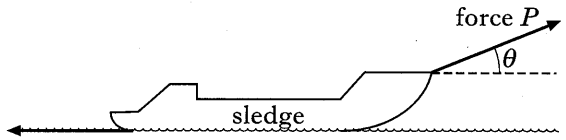
B 50 m

C 60 m

D 120 m

E 150 m

4. A sledge is dragged at a **constant velocity** along the snow against a horizontal frictional force F. The rope pulling the sledge is at an angle of θ to the horizontal, as shown.



When the sledge is moving horizontally with a constant velocity, the force P pulling the rope is equal to

A F

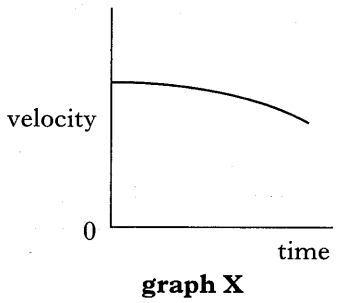
B $F\cos\theta$

C $F\sin\theta$

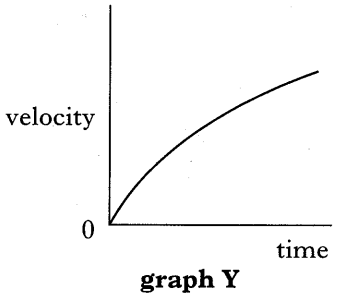
D $\dfrac{F}{\cos\theta}$

E $\dfrac{F}{\sin\theta}$.

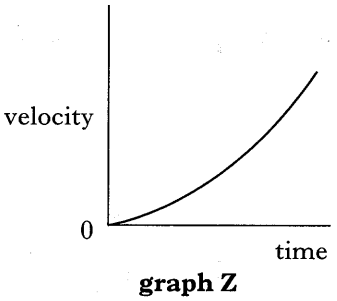
5. A ball is thrown horizontally over the edge of a cliff. When air resistance **is taken into account**, which graphs represent the horizontal and vertical components of the velocity of the ball during its flight?



graph X



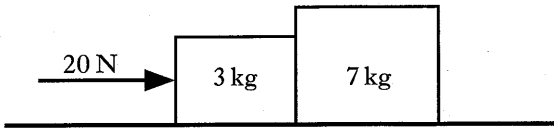
graph Y



graph Z

	Horizontal component of velocity	*Vertical component of velocity*
A	graph X	graph X
B	graph X	graph Y
C	graph Y	graph X
D	graph Y	graph Z
E	graph Z	graph Z

6. A horizontal force of 20 N is applied as shown to two wooden blocks of masses 3 kg and 7 kg. The blocks are in contact with each other on a frictionless horizontal surface.



What is the size of the horizontal force acting on the 7 kg block?

A 20 N

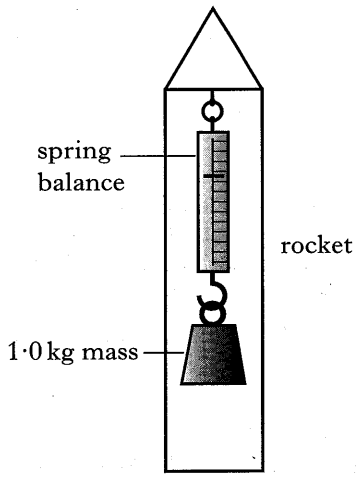
B 14 N

C 10 N

D 8 N

E 6 N

7. An object of mass 1·0 kg hangs from a spring balance which is suspended on the inside of a small rocket, as shown below.



What is the reading on the balance when the rocket is accelerating upwards from the Earth's surface at 2·0 $m\,s^{-2}$? Use $g = 9{\cdot}8\ m\,s^{-2}$.

A 0 N

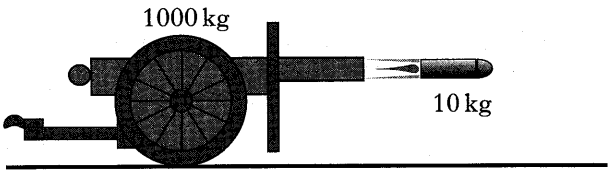
B 2·0 N

C 7·8 N

D 9·8 N

E 11·8 N

8. A field-gun of mass 1000 kg fires a shell of mass 10 kg with a velocity of 100 $m\,s^{-1}$ East.



The velocity of the field-gun just after firing the shell is

A 0 $m\,s^{-1}$

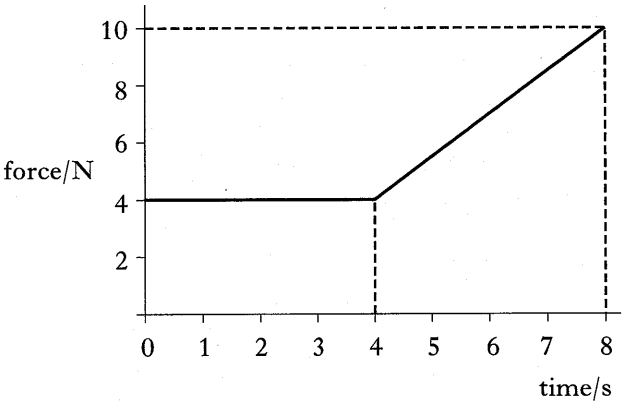
B 1 $m\,s^{-1}$ East

C 1 $m\,s^{-1}$ West

D 10 $m\,s^{-1}$ East

E 10 $m\,s^{-1}$ West.

9. The graph below shows the force which acts on an object over a time interval of 8 seconds.



The momentum gained by the object during this 8 seconds is

A 12 N s

B 32 N s

C 44 N s

D 52 N s

E 72 N s.

[Turn over

10. An aircraft cruises at an altitude at which the air pressure is $0{\cdot}4 \times 10^5$ Pa. The inside of the aircraft cabin is maintained at a pressure of $1{\cdot}0 \times 10^5$ Pa. The area of an external cabin door is 2 m^2.

What is the outward force produced on this door by the pressures stated?

A $0{\cdot}3 \times 10^5$ N

B $0{\cdot}7 \times 10^5$ N

C $1{\cdot}2 \times 10^5$ N

D $2{\cdot}0 \times 10^5$ N

E $2{\cdot}8 \times 10^5$ N

11. The volt is equivalent to the

A farad/coulomb

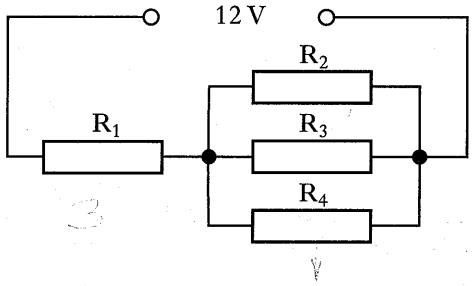
B ampere/ohm

C joule/ampere

D joule/ohm

E joule/coulomb.

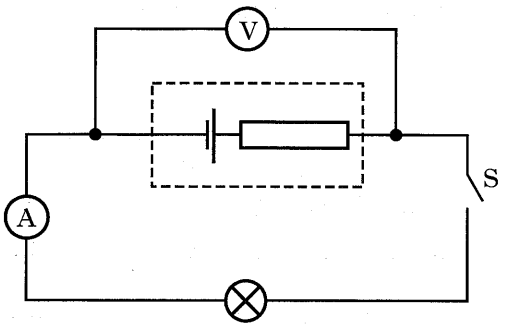
12. The diagram below illustrates a circuit in which the supply has an e.m.f. of 12 V and negligible internal resistance. Four load resistors, each of resistance 3 kΩ, are connected in the circuit as shown.



Which line in the table below indicates the potential differences in volts that would exist across the resistors?

	p.d. across R_1	*p.d. across* R_2	*p.d. across* R_3	*p.d. across* R_4
A	3 V	3 V	3 V	3 V
B	6 V	6 V	6 V	6 V
C	3 V	9 V	9 V	9 V
D	9 V	3 V	3 V	3 V
E	9 V	1 V	1 V	1 V

13. The circuit below can be used to determine the e.m.f. and the internal resistance of a cell.



Ammeter and voltmeter readings are taken when switch S is open and again when it is closed. The results are as follows:

Switch S open: Current = zero : Voltage = V_1

Switch S closed: Current = I : Voltage = V_2

The e.m.f. of the cell is equal to

A V_1

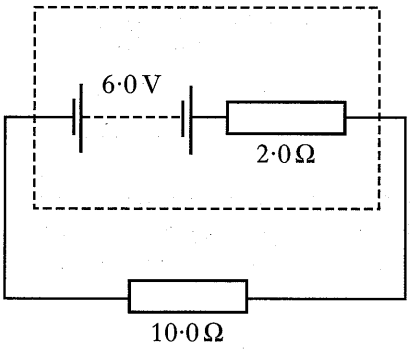
B V_2

C $V_1 - V_2$

D $\dfrac{V_1}{I}$

E $\dfrac{(V_2 - V_1)}{I}$.

14. A battery has an e.m.f. of 6·0 V and an internal resistance of 2·0 Ω. It is connected to a 10·0 Ω resistor, as shown below.



The p.d. across the 10·0 Ω resistor is

A 1·0 V

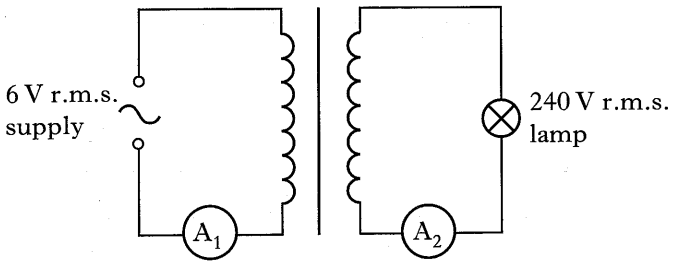
B 1·2 V

C 4·8 V

D 5·0 V

E 6·0 V.

15. The step-up transformer shown below is used to light a mains lamp at its correct rating. The input voltage to the primary is 6 V r.m.s. and the voltage across the lamp is 240 V r.m.s.



The a.c. ammeters A_1 and A_2 have negligible resistance.

The reading on A_1 is 5·0 A r.m.s. and the reading on A_2 is 0·1 A r.m.s.

The efficiency of the transformer is

A 2·5%

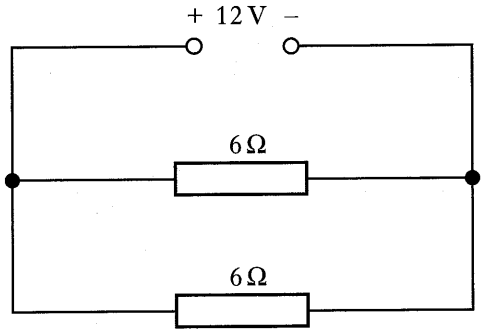
B 40%

C 50%

D 80%

E 100%.

16. The circuit below shows two 6 Ω resistors connected in parallel to a 12 V d.c. supply of negligible resistance.



The total power developed in this circuit is

A 12 W

B 24 W

C 48 W

D 300 W

E 1200 W.

17. An 8 μF capacitor requires

A 8 μC to charge it to 1 V

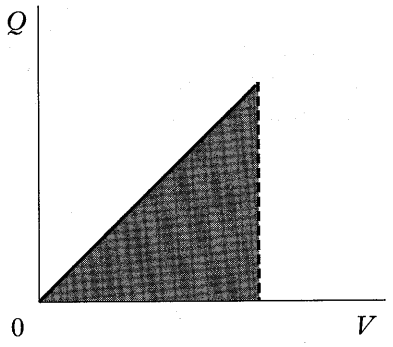
B 1 μC to charge it to 8 V

C 8 μC to charge it to 8 V

D 8 C to charge it to 8 μV

E 1 C to charge it to 8 μV.

18. The following graph shows how the charge Q on a capacitor is related to the p.d. V applied across its plates.



What does the shaded area under this graph represent?

A The distance between the plates of the capacitor

B The capacitance of the capacitor

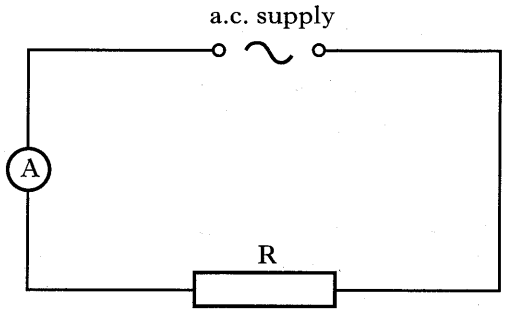
C The working voltage of the capacitor

D The charge stored on the plates of the capacitor

E The energy stored in the capacitor

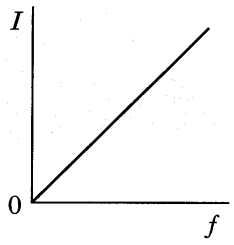
[Turn over

19. A resistor is connected in a circuit as shown. The output of the alternating supply can be varied in frequency but has a constant peak voltage.

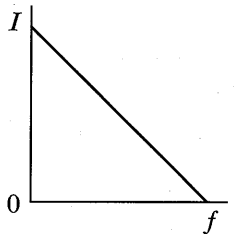


Which graph correctly represents the relationship between the r.m.s. current I in the resistor and the frequency f of the supply?

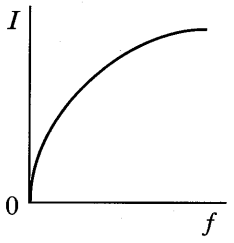
A



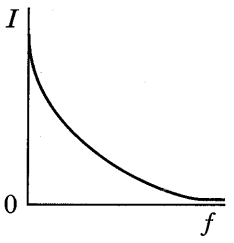
B



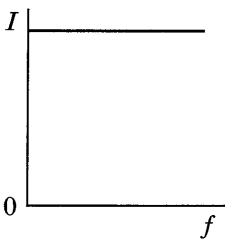
C



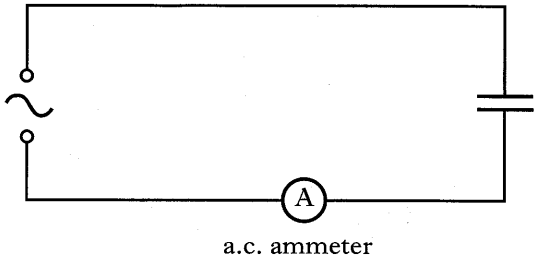
D



E



20. A capacitor is connected to a circuit as shown. The output of the alternating supply can be varied in frequency but has a constant peak voltage.



When the frequency of the output from the supply is steadily increased from 50 Hz to 5000 Hz, the reading on the a.c. ammeter will

A remain constant

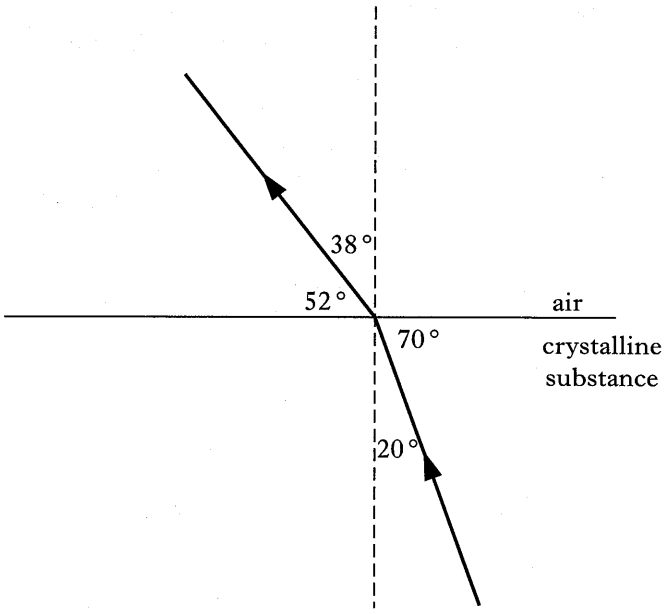
B decrease steadily

C increase steadily

D increase then decrease

E decrease then increase.

21. The diagram shows a ray of light going into air from a crystalline substance.



What is the refractive index of the crystalline substance?

A 1·2

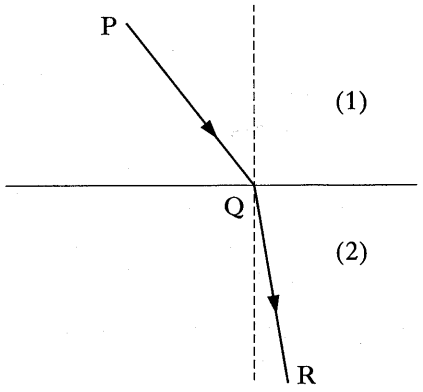
B 1·3

C 1·8

D 1·9

E 2·3

22. A ray of monochromatic light passing from medium (1) into medium (2) follows the path PQR.



When the light passes from medium (1) to medium (2), its

A frequency is increased

B frequency is decreased

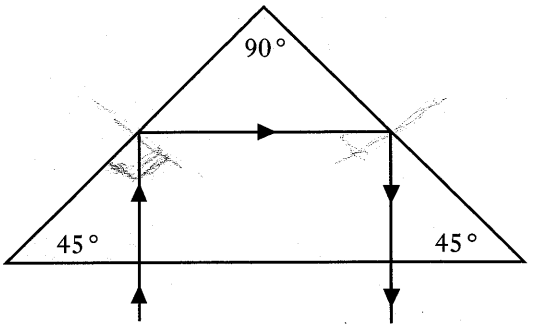
C wavelength is unchanged

D speed is increased

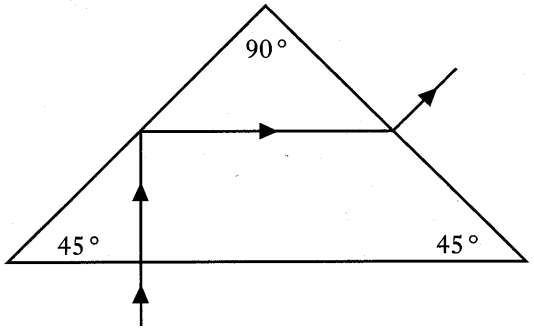
E speed is decreased.

23. Which one of the following diagrams shows the correct path for a ray of light travelling from air into a glass prism whose angles are 45°, 90° and 45°? The refractive index of the glass is 1·5.

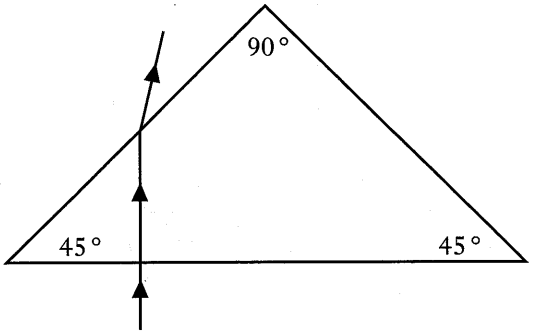
A



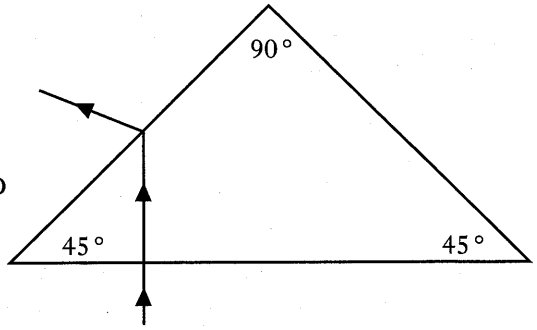
B



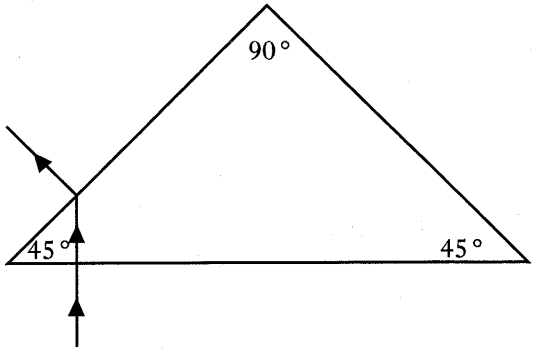
C



D



E

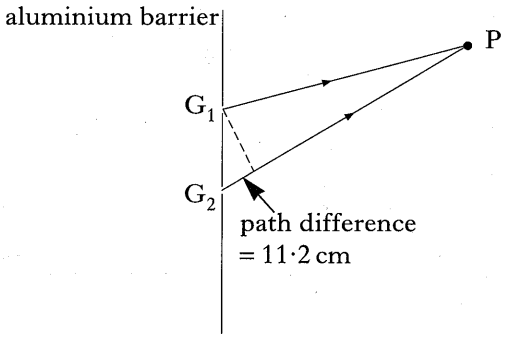


24. An n-type semiconductor is produced by adding arsenic impurity atoms to silicon. Which row in the following table describes the effect that this process has on the resistance and overall net charge of the material?

	Resistance	*Net Charge*
A	remains unchanged	remains unchanged
B	decreases	remains unchanged
C	increases	remains unchanged
D	decreases	more negative
E	remains unchanged	more negative

25. Microwaves of wavelength 2·8 cm pass through two narrow gaps G_1 and G_2 in an aluminium barrier.

Point P on the far side of the barrier is 11·2 cm further from one gap than the other.



Which of the following statements about the radiation arriving at P from G_2 is/are true?

I It arrives in phase with the radiation from G_1.

II It combines constructively with the radiation from G_1.

III It has travelled a whole number of wavelengths further than the radiation from G_1.

A II only

B III only

C I and II only

D II and III only

E I, II and III

26. When a grating was set up to produce an interference pattern on a screen using a monochromatic light source, the fringes were too close together to allow accurate measurement.

Which **one** of the following changes would produce an increase in the separation of the fringes on the screen?

A Increasing the distance between the grating and the screen

B Using a grating with a greater separation between the lines on it

C Using another light source of shorter wavelength

D Using another light source of greater intensity

E Increasing the distance between the source and the grating

27. A small lamp is placed 1 metre above a desk. At a point on the desk directly below the lamp, the intensity of the light is I. The lamp may be treated as a point source of light.

The lamp is now raised until it is 2 metres above the desk. What is the new intensity of light at the same point on the desk?

A $\frac{I}{4}$

B $\frac{I}{2\sqrt{2}}$

C $\frac{I}{2}$

D $\frac{I}{\sqrt{2}}$

E $\sqrt{2}\,I$

28. The last two changes in a radioactive decay series are shown below.

A Bismuth nucleus emits a beta particle and its product, a Polonium nucleus, emits an alpha particle.

$$\overset{P}{\underset{Q}{Bi}} \xrightarrow[\text{decay}]{\beta} \overset{R}{\underset{S}{Po}} \xrightarrow[\text{decay}]{\alpha} \overset{208}{\underset{82}{Pb}}$$

Which numbers are represented by P, Q, R and S?

	P	Q	R	S
A	212	85	212	84
B	212	83	212	84
C	211	85	207	86
D	210	83	208	81
E	210	83	210	84

29. The diagram below shows the energy levels in an atom.

$-5{\cdot}2 \times 10^{-19}$ J ——————— E_3

$-9{\cdot}0 \times 10^{-19}$ J ——————— E_2

$-16{\cdot}4 \times 10^{-19}$ J ——————— E_1

$-24{\cdot}6 \times 10^{-19}$ J ——————— E_0

An electron is excited from energy level E_2 to level E_3 by absorbing energy. What is the frequency of light being used to excite the electron?

A $1{\cdot}74 \times 10^{-15}$ Hz

B $5{\cdot}73 \times 10^{14}$ Hz

C $1{\cdot}69 \times 10^{15}$ Hz

D $2{\cdot}14 \times 10^{15}$ Hz

E $2{\cdot}92 \times 10^{15}$ Hz

30. A detector placed near a source of gamma rays records a count rate of 480 counts per second.

A slab of material of thickness 3 cm is then placed between the source and the detector. The half-value thickness of this material is 1 cm and the half-life of the source is 1 day.

After 1 day, what is the count rate recorded by the detector ?

A 240 counts per second

B 160 counts per second

C 80 counts per second

D 60 counts per second

E 30 counts per second

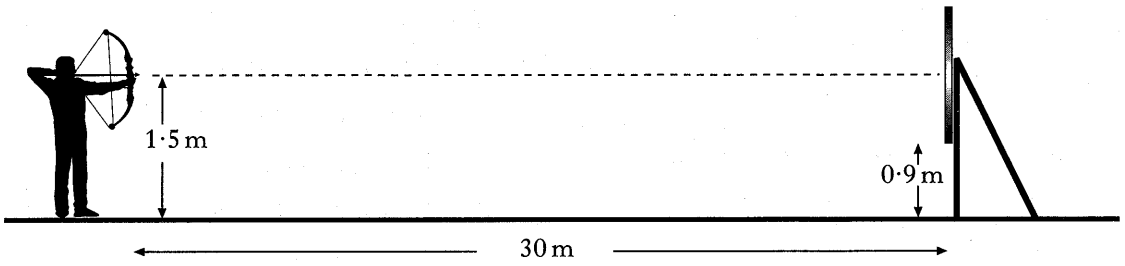
[Turn over

SECTION B

Write your answers to questions 31 to 37 in the answer book.

Marks

31. An archer fires an arrow at a target which is 30 m away.

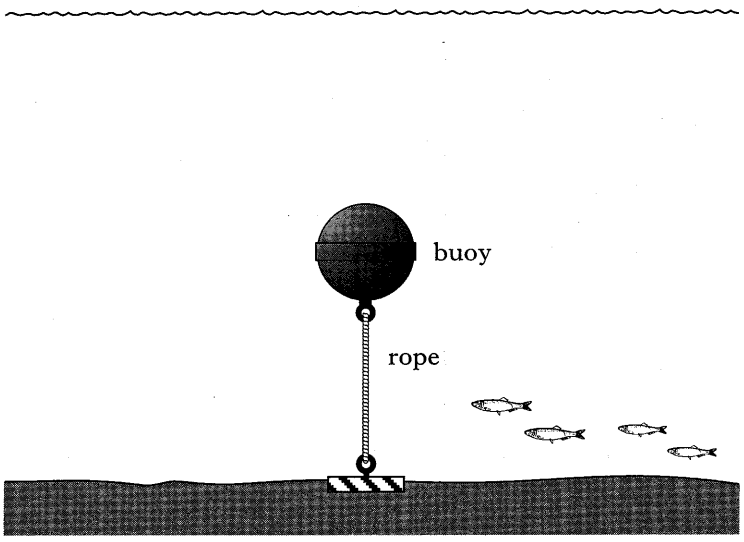


The arrow is fired horizontally from a height of 1·5 m and leaves the bow with a velocity of 100 m s^{-1}.

The bottom of the target is 0·9 m above the ground.

Show by calculation that the arrow hits the target. Use $g = 9{\cdot}8$ m s^{-2}. **3**

32. A mooring buoy is tethered to the seabed by a rope which is too short. The buoy floats under the water at high tide. The weight of the buoy is 50 N.



(*a*) (i) Draw a labelled diagram to show all the forces acting on the buoy in the vertical direction.

(ii) The tension in the rope is 1200 N.

Calculate the buoyancy force.

(*b*) The rope now snaps and the buoy starts to rise.

What is the size of the buoyancy force on the buoy when it is just below the surface of the water? **4**

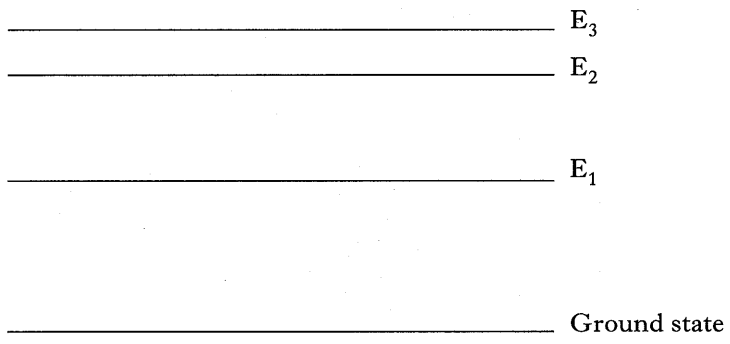
Marks

33. A cell of e.m.f. 1·5 V and internal resistance 0·2 Ω is connected across a lamp.
A second identical lamp is now connected in parallel with the first lamp.
Describe and explain what happens to the brightness of the first lamp. **2**

34. The peak value of an a.c. voltage is 12 V.
Calculate
(*a*) the r.m.s. voltage
(*b*) the power dissipated in a 4 Ω resistor by the r.m.s. voltage. **3**

35. Light of wavelength 600 nm is passed through a grating.
The grating has $2{\cdot}5 \times 10^5$ lines per metre.
Calculate the angle at which the first maximum appears. **2**

36. A particular atom has energy levels as shown below.



Transitions are possible between all these levels to produce emission lines in the spectrum.
(*a*) How many lines are in the spectrum of this atom?
(*b*) Between which two energy levels would an electron transition lead to the emission of radiation of the lowest frequency?
(*c*) Explain why some lines in the spectrum are more intense than others. **3**

37. The work function for sodium metal is $2{\cdot}9 \times 10^{-19}$ J.
Light of wavelength $5{\cdot}4 \times 10^{-7}$ m strikes the surface of this metal. What is the kinetic energy of the electrons emitted from the surface? **3**

[END OF QUESTION PAPER]