NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 1

PHYSICS **8866/01**

Paper 1 Multiple Choice Questions **26 September 2017**

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
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Write your name, class and tutor's name on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions in this section. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
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This document consists of **13** printed pages.

[Turn over

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	=	8.85×10^{-12} F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
acceleration of free fall,	g	=	9.81 m s^{-2}

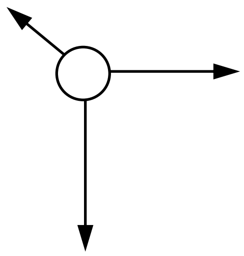
Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\Delta V$
hydrostatic pressure,	p	=	ρgh
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$

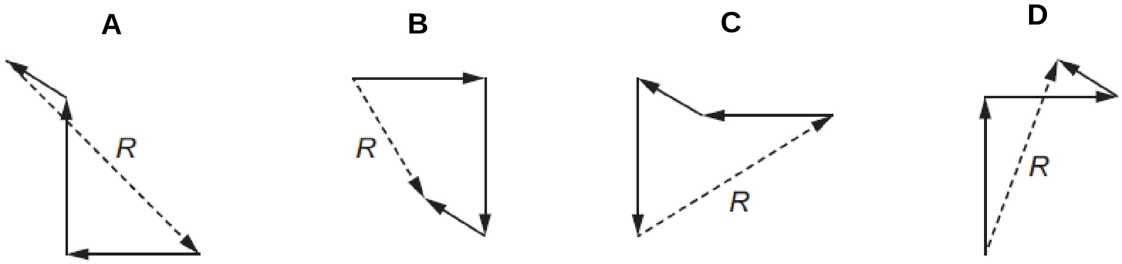
1 A body, dropped from the edge of a cliff, is timed to take (2.0 ± 0.1) s to fall to the surface of the sea. If the acceleration of free fall is taken as (9.8 ± 0.2) m s^{-2}, the calculated height of the cliff above the water surface should be quoted in metres as

A 20 ± 0.1 **B** 20 ± 0.2 **C** 20 ± 1 **D** 20 ± 2

2 Three wires each exert a horizontal force on a vertical pole, as shown.



Which vector diagram shows the resultant force *R* acting on the pole?



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A 18 m **B** 24 m **C** 36 m **D** 48 m

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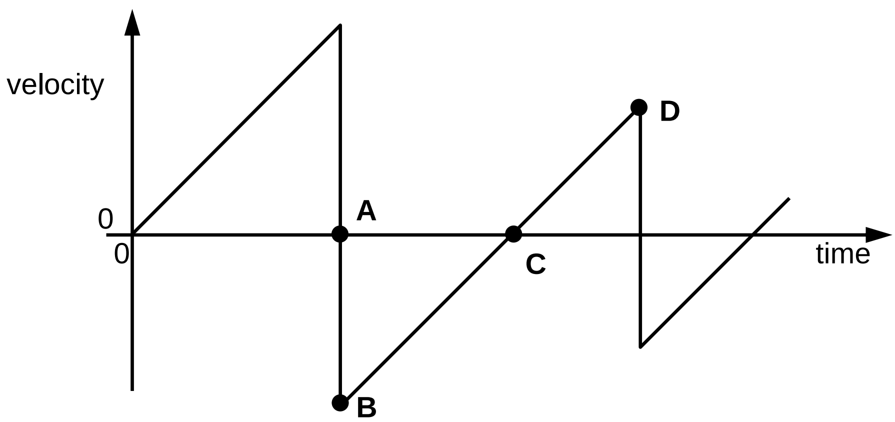
At which point on the graph does the ball reach its maximum height after the first bounce?



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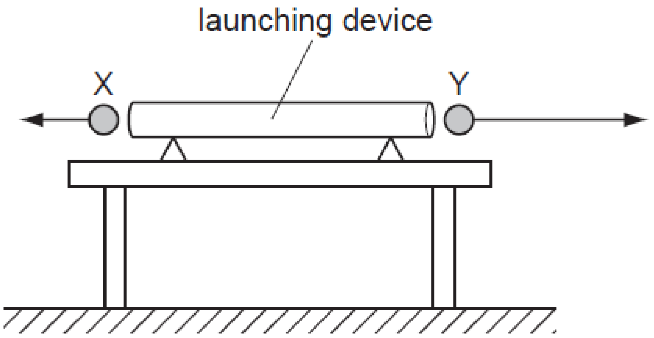


Which statement explains what an observer would see?

A Both X and Y reach the ground simultaneously, because air resistance will cause both to have the same final speed.

B Both X and Y reach the ground simultaneously, because gravitational acceleration is the same for both.

C X reaches the ground before Y, because X lands nearer to the launcher.

D Y reaches the ground before X, because Y has greater initial speed.

6 A tractor of mass 1000 kg pulls a trailer of mass 1000 kg via a tow-bar. The total resistance to motion has a constant value of 4000 N. One quarter of this resistance acts on the trailer. At first the acceleration of the tractor and trailer is 2.0 m s^{-2} but eventually they move at a constant speed of 6.0 m s^{-1}.

What is the force exerted on the tractor by the tow-bar when the acceleration of the tractor and trailer is 2.0 m s^{-2}?

A 1000 N **B** 3000 N **C** 5000 N **D** 8000 N

7 A student is studying Newton's third law of motion. He states that a rocket travelling in deep space can never accelerate because when the rocket's engines burn, the forwards force acting on the rocket is cancelled by an equal and opposite force.

Which statement explains why the student is wrong?

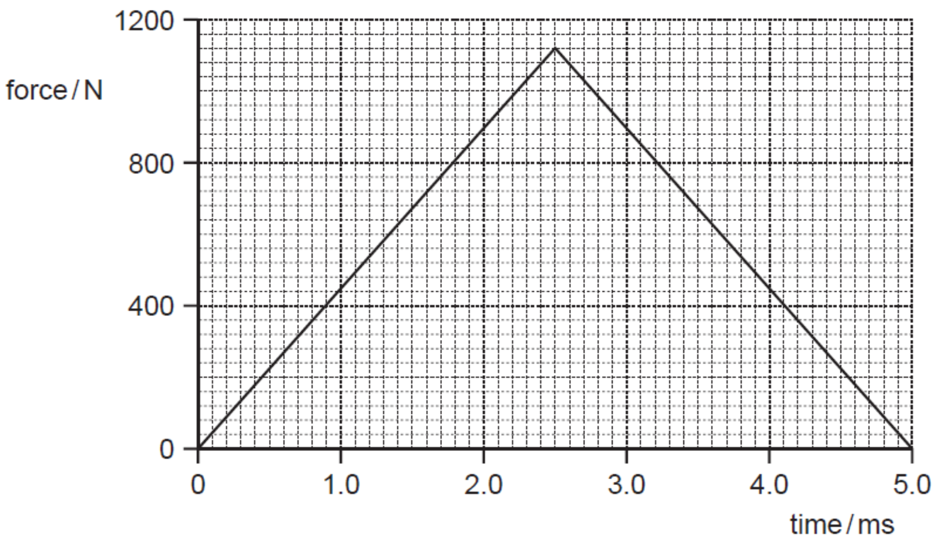
A The equal and opposite force does not act on the rocket.

B The equal and opposite force has a different line of action.

C The equal and opposite force is a reaction force.

D The equal and opposite force will be a different type of force.

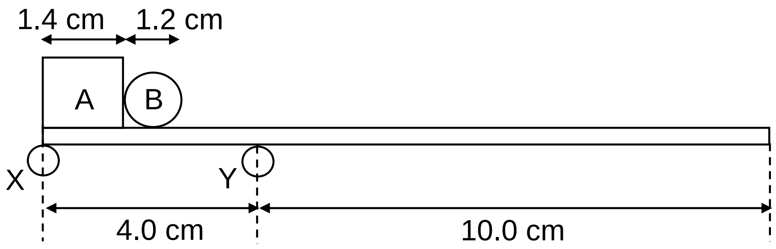
8 A tennis ball of mass 56 g is struck by a tennis racquet. The graph shows how the force exerted on the ball by the racquet varies with time.



What is the change in the velocity of the tennis ball?

A 50 cm s^{-1} **B** 100 cm s^{-1} **C** 50 m s^{-1} **D** 100 m s^{-1}

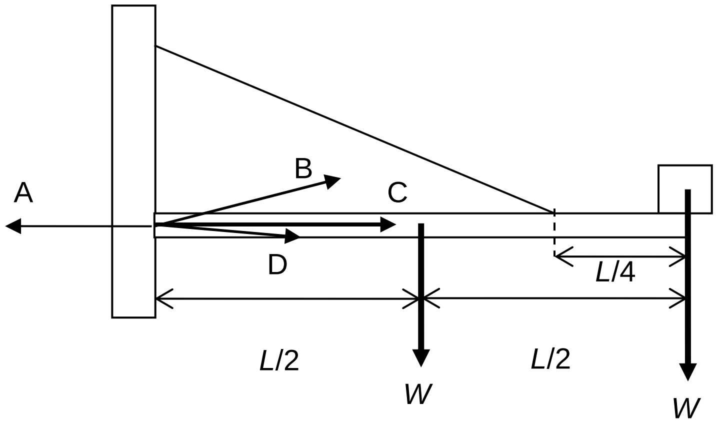
9 A beam of negligible mass is supported by two rods X and Y. A block A of mass 200 g and a ball B of mass 100 g rest on the beam as shown. Both A and B have uniform density.



If ball B were to start rolling to the right, what is the distance it would have moved before the beam just loses contact with rod X? Assume that there is negligible friction.

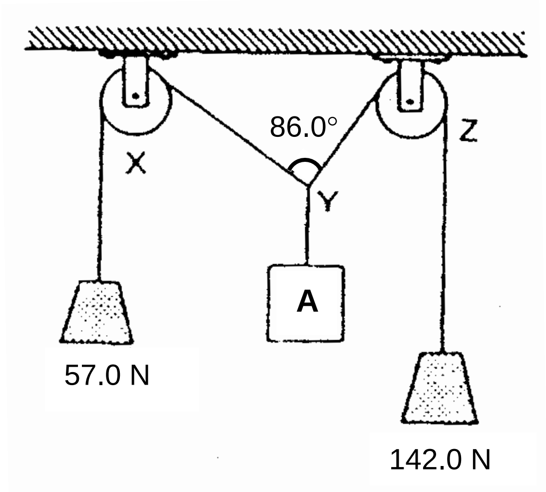
A 6.6 cm **B** 8.0 cm **C** 8.6 cm **D** 9.4 cm

10 A block of weight *W* is resting at one end of a horizontal, uniform rigid beam of the same weight. The other end of the beam is mounted on a wall and the length of the beam is *L*. A rope from the wall is attached to the beam at a point of *L*/4 from the far end of the beam as shown in the diagram.



Which of the arrows labelled from A to D shows the direction of the force of the wall acting on the beam? (The arrow vectors only show the directions but not their magnitudes.)

11 The diagram shows a body A supported by strings passing over two smooth pulleys with the weights attached. The system is in equilibrium with angle XYZ = 86.0°.



The weight of A is

A 126 N **B** 130 N **C** 134 N **D** 157 N

12 A gas is enclosed in a cylinder by a frictionless piston of cross-sectional area 3.0×10^{-3} m^2. When atmospheric pressure is 1.01×10^5 N m^{-2}, the piston is at a distance 80 mm from the end of the cylinder as shown in Fig.12.1. The gas is then heated and it expands by pushing the piston against atmospheric pressure until the piston is 160 mm from the end of the cylinder as shown in Fig 12.2. What is the work done by the gas?

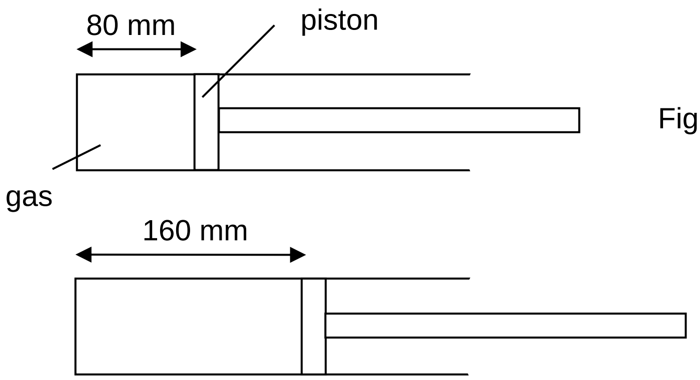


Fig.12.1

Fig.12.2

A 8.0 J **B** 24 J **C** 30 J **D** 48 J

13 In a tidal power station, 100 km^2 of water is raised to a height of 1.2 m by the tide behind a tidal barrier. What would be the mean power output of such a station if its efficiency is 20% and there are two tides per day? (Assume density of water to be 1000 kg m^{-3}.)

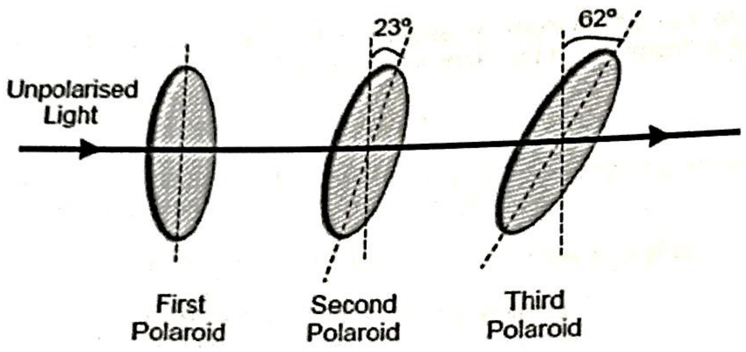
A 1.6 MW **B** 3.3 MW **C** 6.5 MW **D** 16 MW

14 A plane wave of amplitude *A* is incident on a surface area *S* placed so that it is perpendicular to the direction of travel of the wave. The energy per unit time intercepted by the surface is *E*.

The amplitude of the wave is increased to 3*A* and the area of the surface is reduced to *S*/3. How much energy per unit time is intercepted by this smaller surface?

A $\frac{1}{9}E$ **B** E **C** $3E$ **D** $9E$

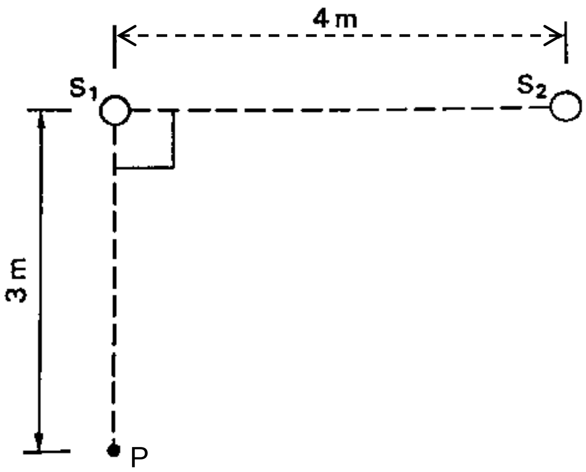
15 Light is polarised when it passes through a sheet material known as a polaroid. Three polaroids are stacked, with the polarising axis of the second and third polaroids at 23° and 62° respectively, to that of the first polaroid, as shown in the diagram below.



When unpolarised light of amplitude A_o is incident on the stack of polaroids, the light has amplitude of A_1 after it passes through the first polaroid, A_2 after it passes through the second polaroid, and A_3 after it passes through the third polaroid. What is the value of $\frac{A_3}{A_1}$?

A 0.25 **B** 0.31 **C** 0.43 **D** 0.72

16 Two wave generators S_1 and S_2 each produces water waves of wavelength 4 m. They are placed 4 m apart in a water tank and a detector P is placed on the water surface 3 m from S_1 as shown below.



When operated alone, each generator produces a wave at P which has an amplitude *A*. When the generators are operating together and in phase, what is the resultant amplitude at P?

A 0 **B** ½ A **C** 2A **D** 4A

17 A resonance tube open at both ends and responding to a tuning fork

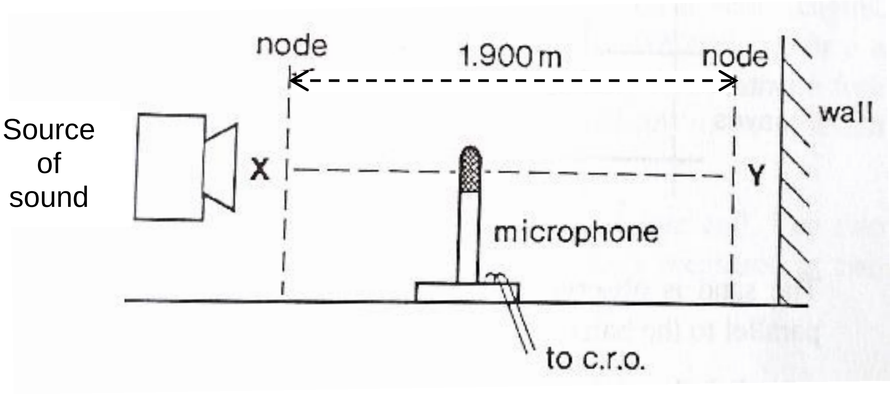
A always has a central node.

B always has an odd number of nodes.

C always has an even number of nodes.

D always has an odd number of nodes and antinodes.

18 A source of sound of frequency 2500 Hz is placed several metres from a plane reflecting wall in a large chamber containing a gas. A microphone, connected to a cathode-ray oscilloscope, is used to detect nodes and antinodes along the line XY between the source and the wall.



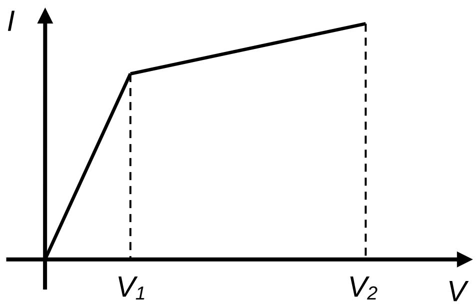
The microphone is moved from one node through 20 antinodes to another node, over a distance of 1.900 m. What is the speed of sound in the gas?

A 238 m s^{-1} **B** 250 m s^{-1} **C** 330 m s^{-1} **D** 475 m s^{-1}

19 There are 1.3×10^{19} electrons passing through a point in a series circuit in 1.0 hour. If the potential difference across a resistor connected in series to the source is 10 kV, what is the power dissipated in the resistor?

A 3.6 W **B** 5.1 W **C** 5.8 W **D** 21 W

20 The graph plots current *I* against potential difference *V* for an electrical component.



The resistance of the component

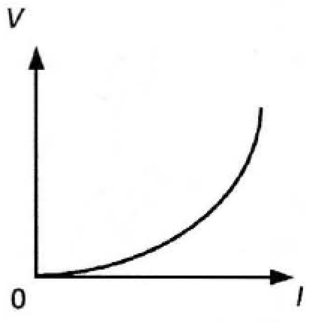
A is constant from 0 to V_1, then increases to another constant from V_1 to V_2.

B is constant from 0 to V_1, then decreases to another constant from V_1 to V_2.

C is constant from 0 to V_1, then decreases continuously from V_1 to V_2.

D is constant from 0 to V_1, then increases continuously from V_1 to V_2.

21 The figure shows the variation of current *I* through a filament lamp with the p.d. *V* applied across it.



It is not a straight line graph because

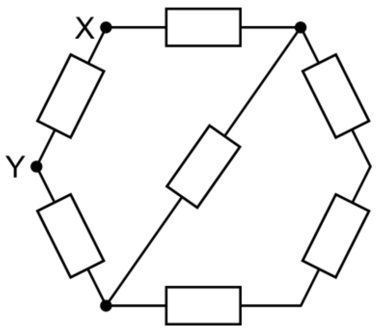
A the lamp is placed in a forward-biased position.

B the filament has a negative temperature coefficient.

C more mobile charge carriers are liberated due to a rise in temperature.

D the mobility of electrons decreased due to a rise in temperature.

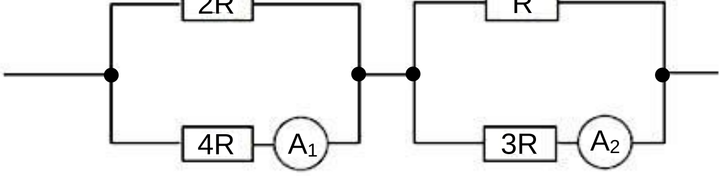
22 The diagram shows a network of 7 resistors, each with resistance R.



What is resistance between points X and Y?

A $\frac{2}{3}$ R **B** $\frac{3}{5}$ R **C** $\frac{5}{7}$ R **D** $\frac{11}{15}$ R

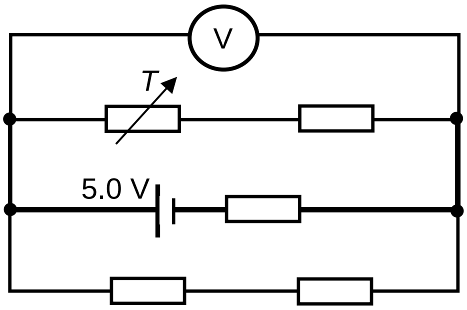
23 The ammeter A_1 of the circuit below reads 6.0 A.



Assuming that both ammeter have negligible resistance, what is the reading on A_2?

A 4.5 A **B** 6.0 A **C** 13.5 A **D** 18.0 A

24 A cell of e.m.f. 5.0 V and negligible internal resistance is connected to four identical resistors and a variable resistor *T*, as shown.

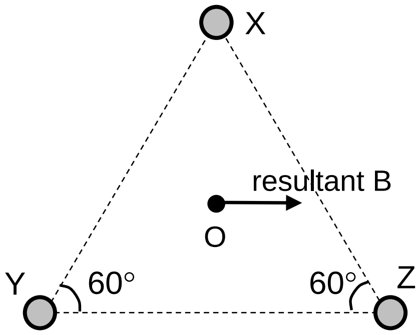


The resistance of each resistor is 1.0 kΩ and the resistance of *T* is 5.0 kΩ.

What is the reading on the ideal voltmeter?

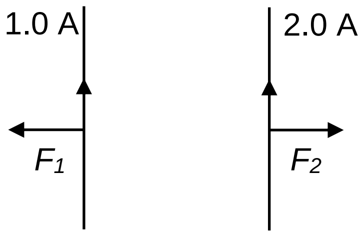
A 0 V **B** 2.0 V **C** 3.0 V **D** 5.0 V

25 Three parallel conductors each carrying current of the same magnitude, pass vertically through the three corners X, Y and Z of a horizontal equilateral triangle as shown in the diagram below. A resultant magnetic flux density *B,* acting at the centre of the triangle O acts in the direction as shown below. What must be the directions of the currents in X, Y and Z?



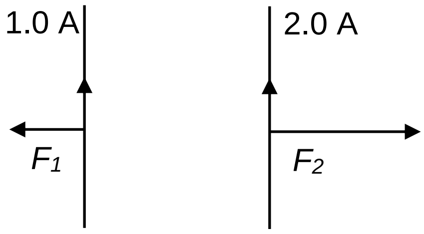
	Into the page	Out of the page
A	X	Y and Z
B	Z	X and Y
C	Y and Z	X
D	X, Y and Z	None

26 Two long straight parallel wires carry currents of 1.0 A and 2.0 A respectively. Which diagram shows the directions and relative magnitudes F_1 and F_2 of the forces per unit length on each of the wires?



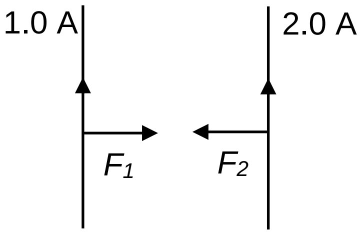
$F_1 = F_2$

A



$2F_1 = F_2$

B



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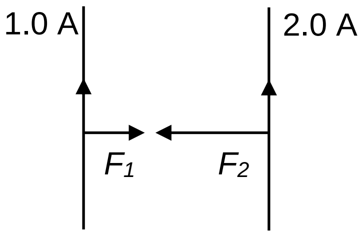
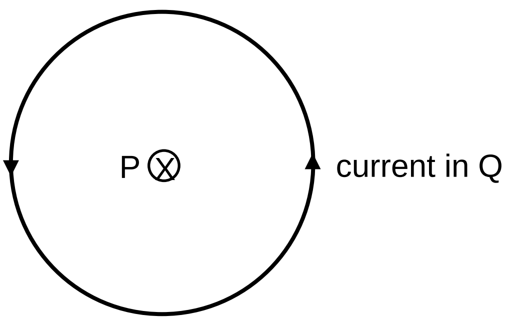


$2F_1 = F_2$

D

27 A long straight wire P is placed along the axis of a flat circular coil Q. The wire and the coil each carry a current as shown. Current in P is into the plane of the diagram.



What can be deduced about the force acting on each part of Q due to the current in P?

- **A** No force acts.
- **B** The force acts perpendicular to the plane of the diagram.
- **C** The force acts towards P.
- **D** The force acts away from P.

28 The first excitation energy and the ionization energy of a certain atom are 21.2 eV and 28.8 eV respectively. An electron of energy 22.4 eV strikes the atom at the ground state. What happens to the atom?

A The atom remains at the ground state.

B The atom is excited to the first excited state.

C The atom is excited to the second excited state.

D The atom is ionized.

29 Photons are emitted when the electrons transit from a higher energy level to a lower energy level. Consider the three lowest energy levels of a hydrogen atom. When electrons transit from the second lowest or third lowest energy level, the possible frequencies of photons emitted are f_1, f_2, and f_3, whose values are in ascending order. The magnitude of f_2 is equal to

A $f_3 - f_1$ **B** $½\,(f_1 + f_3)$ **C** $\frac{f_3 - f_1}{f_1 f_3}$ **D** $\sqrt{f_1 f_3}$

30 The de Broglie wavelength of a moving particle of mass m is λ. If the kinetic energy of the particle is halved, the de Broglie wavelength will become

A $\frac{\lambda}{2}$ **B** $\frac{\lambda}{\sqrt{2}}$ **C** $\sqrt{2}\lambda$ **D** 2λ

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1	2	3	4	5	6	7	8	9	10
D	B	D	C	B	B	A	C	C	C
11	12	13	14	15	16	17	18	19	20
D	B	C	C	D	A	D	D	C	D
21	22	23	24	25	26	27	28	29	30
D	D	A	C	C	C	A	B	A	C

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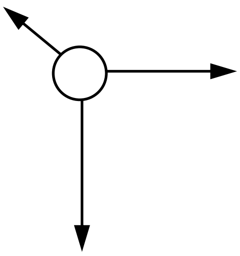
A 20 ± 0.1 **B** 20 ± 0.2 **C** 20 ± 1 **D** 20 ± 2

Answer: D

$s = ut + 1/2at^2 = 1/2at^2$

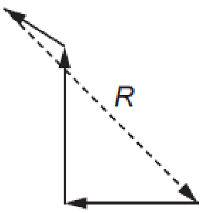
$$\frac{\Delta s}{s} = \frac{\Delta a}{a} + 2\frac{\Delta t}{t}$$

2 Three wires each exert a horizontal force on a vertical pole, as shown.

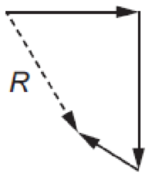


Which vector diagram shows the resultant force R acting on the pole?

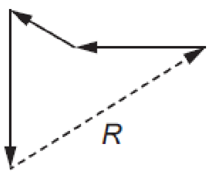
A



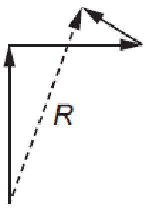
B



C



D



Answer: B

3 If a car can be brought to rest from 15 ms^{-1} in a distance of 12 m, what would be the braking distance if it is traveling at 30 ms^{-1} ? Assuming braking force and road conditions are the same.

A 18 m **B** 24 m **C** 36 m **D** 48 m

Answer : D

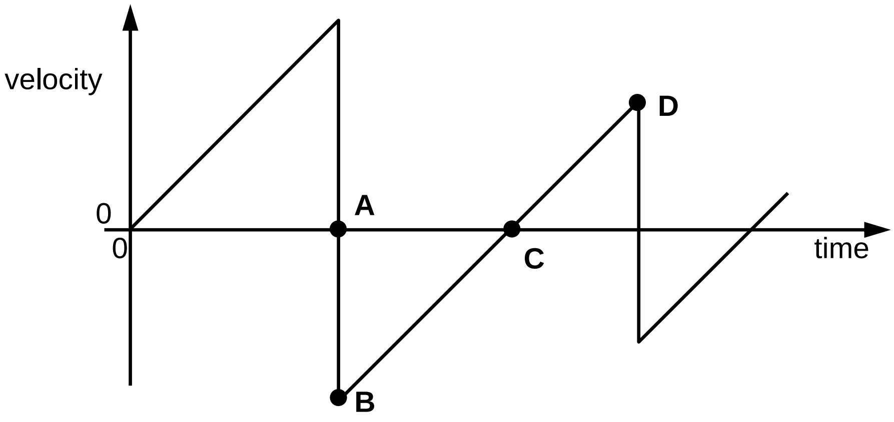
Using $v^2 = u^2 + 2as$

$u^2 \propto s$

Hence distance = 4(12) = 48 m

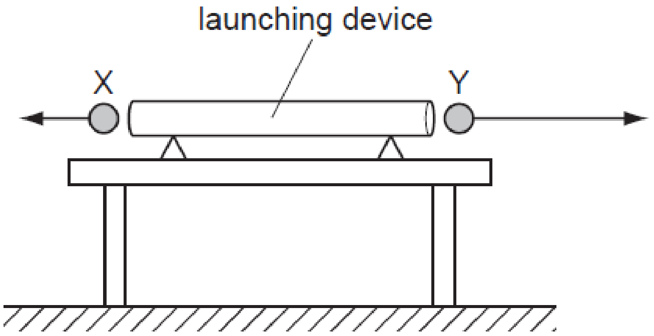
4 A ball is released from rest above a hard, horizontal surface. The graph shows how the velocity of the bouncing ball varies with time.

At which point on the graph does the ball reach its maximum height after the first bounce?



Answer : C
At the maximum height v = 0 and acceleration is still 9.81 m s^{-2}.

5 A double-ended launching device fires two identical steel balls X and Y at exactly the same time.
The diagram shows the initial velocities of the balls. They are both launched horizontally, but Y has greater speed.



Which statement explains what an observer would see?

A Both X and Y reach the ground simultaneously, because air resistance will cause both to have the same final speed.

B Both X and Y reach the ground simultaneously, because gravitational acceleration is the same for both.

C X reaches the ground before Y, because X lands nearer to the launcher.

D Y reaches the ground before X, because Y has greater initial speed.

Answer : B
Since the vertical distance travelled is the same and $u_y = 0$ for both case, the time taken should be the same.

6 A car pulls a trailer of mass 500 kg. The friction acting on the car is 1200 N and that on the trailer is 400 N. At first, the acceleration of the car and trailer system is 2 m s^{-1}. What is the tension in the coupling between the car and trailer for this acceleration?

A zero **B** 1400 N **C** 1800 N **D** 2600 N

T-400 = (500)(2)
T = 1400 N

7 A student is studying Newton's third law of motion. He states that a rocket travelling in deep space can never accelerate because when the rocket's engines burn, the forwards force acting on the rocket is cancelled by an equal and opposite force.
Which statement explains why the student is wrong?

A The equal and opposite force does not act on the rocket.

B The equal and opposite force has a different line of action.

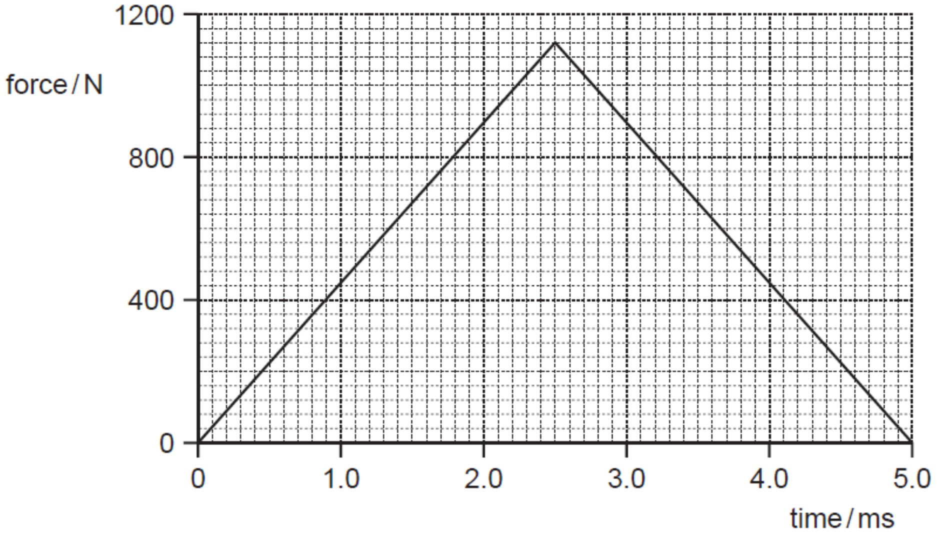
C The equal and opposite force is a reaction force.

D The equal and opposite force will be a different type of force.

Answer : A

Action and reaction has to be on different bodies.

8 A tennis ball of mass 56 g is struck by a tennis racquet. The graph shows how the force exerted on the ball by the racquet varies with time.



What is the change in the velocity of the tennis ball?
A 50 cm s^{-1} **B** 100 cm s^{-1} **C** 50 m s^{-1} **D** 100 m s^{-1}

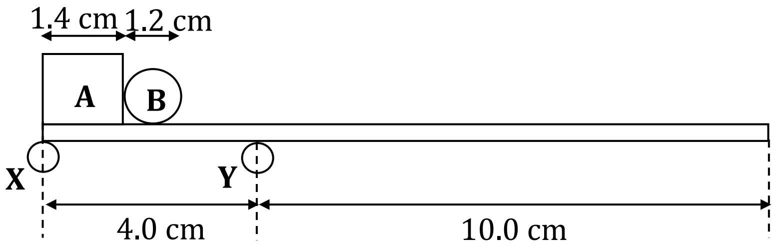
Answer: C

m Δv = area under F-t graph

0.056 Δv = ½ (5.0 X 10^{-3})(1120)

Δv = 50 m s^{-1}

9 A beam of negligible mass is supported by two rods **X** and **Y.** A block **A** of mass 200 g and a ball **B** of mass 100 g rest on the beam as shown. Both **A** and **B** have uniform density.



If ball **B** starts to roll to the right, what is the distance it has moved when the beam just loses contact with rod **X**?

A 6.6 cm **B** 8.0 cm **C** 8.6 cm **D** 9.4 cm

Answer : C

For losing contact, taking moments about pivot at Y,
Clockwise moment = anticlockwise moment
(0.100)(g)x = (0.200)(g)(3.3 cm)
x = 6.6 cm. (from Y)
distance moved = 10.6 – 2.0 = 8.6 cm

10 A block of weight *W* is resting at one end of a horizontal, uniform rigid beam of the same weight. The other end of the beam is mounted on a wall and the length of the beam is *L*. A rope from the wall is attached to the beam at a point of *L*/4 from the far end of the beam as shown in Fig. 10.

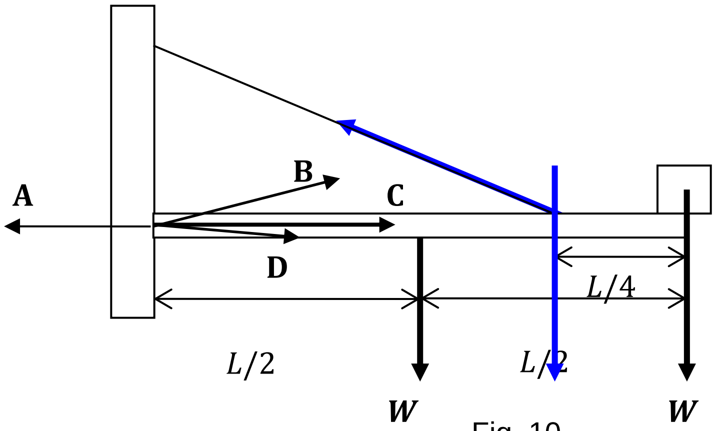


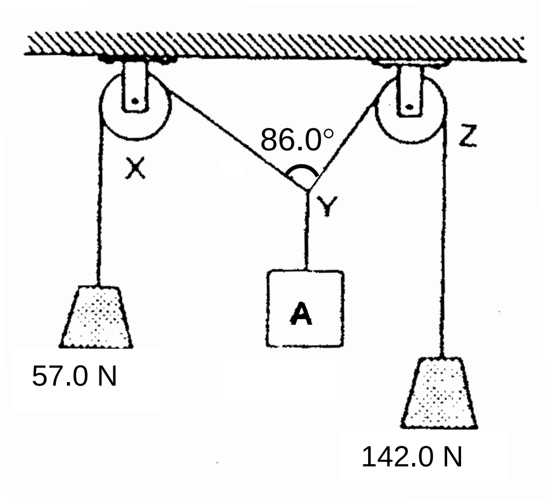
Fig. 10

Which of the arrows labelled from A to D shows the direction of the force of the wall acting on the beam? (The arrow vectors only show the directions but not their sizes.)

Answer : C

Since only C pass thru the intersection point.

11 The diagram shows a body A supported by strings passing over two smooth pulleys with the weights attached. The system is in equilibrium with angle XYZ = 86.0°.

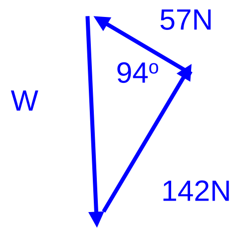


The weight of A is

A 126 N **B** 130 N **C** 134 N **D** 157 N

Answer : D

By considering the forces of triangle,



Using cosine rule,
$W^2 = 57^2 + 142^2 - (2)(57)(142)\cos(94)$
W = 157 N

12 A gas is enclosed in a cylinder by a frictionless piston of cross-sectional area 3.0×10^{-3} m^2. When atmospheric pressure is 1.01×10^5 N m^{-2}, the piston settles 80 mm from the end of the cylinder as shown in Fig.12.1. The gas is then heated and it expands by pushing the piston against atmospheric pressure until the piston is 160 mm from the end of the cylinder as shown in Fig 12.2. What is the work done by the gas?

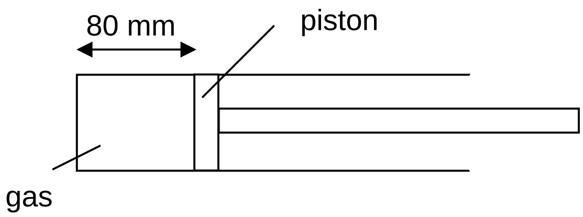


Fig.12. 1

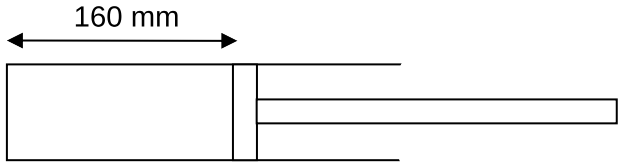


Fig.12.2

A 8.0 J **B** 24 J **C** 30 J **D** 48 J

Answer : B
Work done = P ΔV = $(1.01 \times 10^5)(3 \times 10^{-3})(0.080)$ = 24 J

13 In a tidal power station, 100 km^2 of water is raised to a height of 1.2 m by the tide behind a tidal barrier. What would be the mean power output of such a station if its efficiency is 20% and there are two tides per day? (Assume density of water to be 1000 kg m^{-3})

A 1.6 MW **B** 3.3 MW **C** 6.5 MW **D** 16 MW

Answer : C

Power = rate of work done
= increase in gpe / time taken
= 2x (100 x 10^6)(1.2)^2(1000)(9.81)(0.2) / (24 x 60 x 60) = 6.5 M W

14 A plane wave of amplitude A is incident on a surface area S placed so that it is perpendicular to the direction of travel of the wave. The energy per unit time intercepted by the surface is E.

The amplitude of the wave is increased to 3A and the area of the surface is reduced to S/3. How much energy per unit time is intercepted by this smaller surface?

A $\frac{1}{9}E$ **B** E **C** $3E$ **D** $9E$

Ans: **C**

$I = \frac{E}{S}$

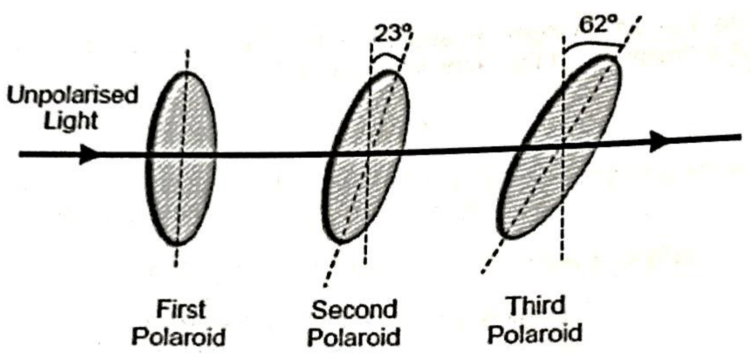
$I \propto A^2$

$\Rightarrow \frac{E}{S} \propto A^2$

$E \propto A^2 S$

$E' = 3^2\left(\frac{1}{3}\right)E = 3E$

15 Light is polarised when it passes through a sheet material known as a polaroid. Three polaroids are stacked, with the polarising axis of the second and third polaroids at 23° and 62° respectively, to that of the first polaroid, as shown in the diagram below.

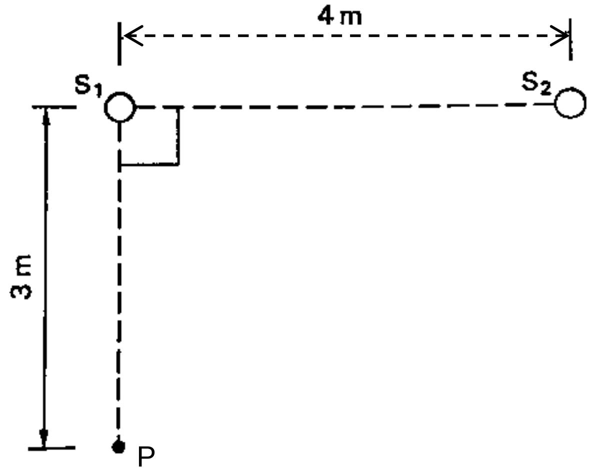


When unpolarised light of amplitude A_o is incident on the stack of polaroids, the light has amplitude of A_1 after it passes through the first polaroid, A_2 after it passes through the second polaroid, and A_3 after it passes through the third polaroid. What is the value of $\frac{A_3}{A_1}$?

A 0.25 **B** 0.31 **C** 0.43 **D** 0.72

Ans: **D**

16 Two wave generators S_1 and S_2 each produces water waves of wavelength 4 m. They are placed 4 m apart in a water tank and a detector P is placed on the water surface 3 m from S_1 as shown below.



When operated alone, each generator produces a wave at P which has an amplitude *A*. When the generators are operating together and in phase, what is the resultant amplitude at P?

A 0 **B** ½ A **C** 2A **D** 4A

Ans: **A**
$S_2P = 5$ m
Path difference = 2 m = $\lambda/2$
Hence destructive interference will occur at P.

17 A resonance tube open at both ends and responding to a tuning fork

A always has a central node.

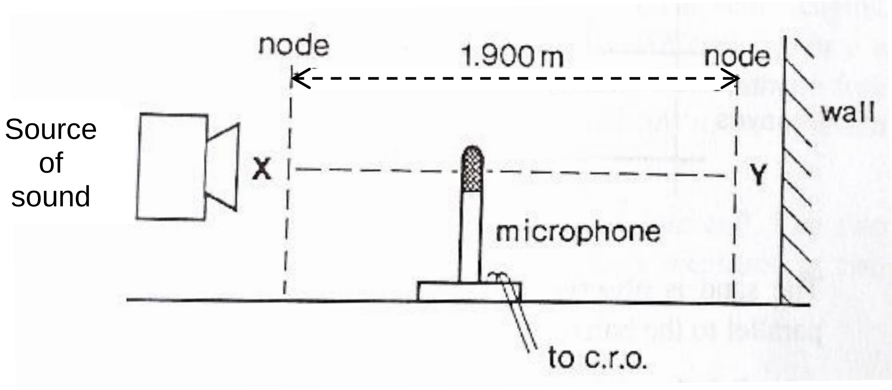
B always has an odd number of nodes.

C always has an even number of nodes.

D always has an odd number of nodes and antinodes.

Ans: **D**

18 A source of sound of frequency 2500 Hz is placed several metres from a plane reflecting wall in a large chamber containing a gas. A microphone, connected to a cathode-ray oscilloscope, is used to detect nodes and antinodes along the line XY between the source and the wall.



The microphone is moved from one node through 20 antinodes to another node, over a distance of 1.900 m. What is the speed of sound in the gas?

A 238 m s^{-1} **B** 250 m s^{-1} **C** 330 m s^{-1} **D** 475 m s^{-1}

Ans: **D**

$10\lambda = 1.900$

$\lambda = 0.190$ m

$v = f\lambda = (2500)(0.190) = 475$ m s^{-1}

19 There are 1.3×10^{19} electrons passing through a point in a series circuit in 1.0 hour. If the potential difference across a resistor connected in series to the source is 10 kV, what is the power dissipated in the resistor?

A 3.6 W **B** 5.1 W **C** 5.8 W **D** 21 W

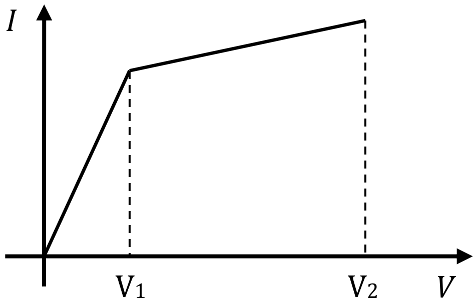
Ans: **C**

$P_{dissipated} = I_{resistor}V_{resistor}$

$P_{dissipated} = \frac{Ne}{t}V_{resistor}$

$P_{dissipated} = \frac{1.3 \times 10^{19} \times 1.6 \times 10^{-19}}{3600} \times 10000 = 5.8 \text{ W}$

20 The graph plots current *I* against potential difference *V* for an electrical component.



The resistance of the component

A Is constant from 0 to V_1, then increases to another constant from V_1 to V_2

B Is constant from 0 to V_1, then decreases to another constant from V_1 to V_2

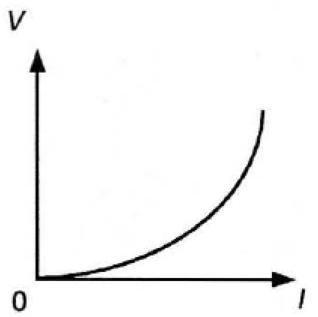
C Is constant from 0 to V_1, then decreases continuously from V_1 to V_2

D Is constant from 0 to V_1, then increases continuously from V_1 to V_2

Ans: **D**

From V_1 to V_2, the ratio I/V decreases. Since $R = V/I$, the resistance increases.

21 The figure shows the current *I* through a filament lamp changes with the p.d. *V* applied across it

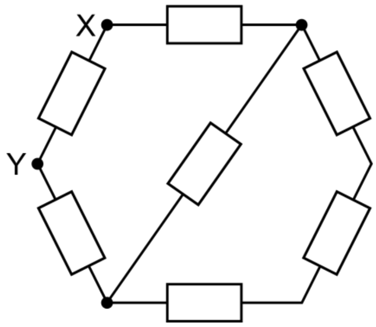


It is not a straight line graph because

A the lamp is placed in a forward-biased position
B the filament has a negative temperature coefficient
C more mobile charge carriers are liberated due to a rise in temperature
D the mobility of electrons decreased due to a rise in temperature

Ans: **D**

22 The diagram shows a network of 7 resistors, each with resistance R.



What is resistance between points X and Y?

A $\frac{2}{3}$ R

B $\frac{3}{5}$ R

C $\frac{7}{11}$ R

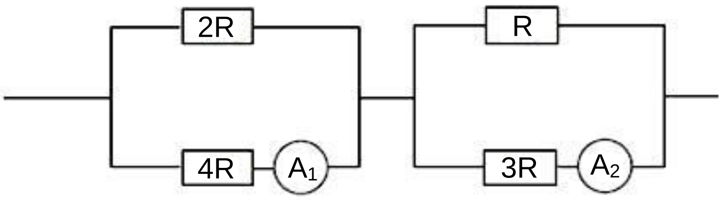
D $\frac{11}{15}$ R

Ans: **D**

$$(R_{XY})^{-1} = \left(R + \frac{3R \times R}{3R + R} + R\right)^{-1} + R^{-1}$$

$$R_{XY} = \frac{11}{15}R$$

23 The ammeter A_1 of the circuit below reads 6.0 A.

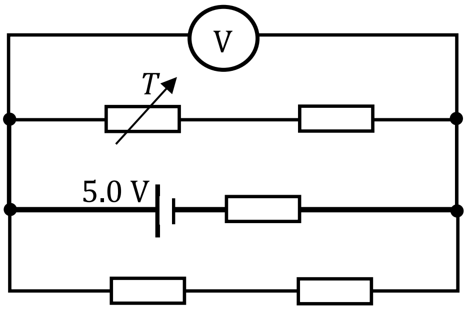


Assuming that both ammeter have negligible resistance, what is the reading on A_2?

A 4.5 A **B** 6.0 A **C** 13.5 A **D** 18.0 A

Ans: **A**

24 A cell of e.m.f. 5.0 V and negligible internal resistance is connected to four similar resistors and a variable resistor *T*, as shown.



The resistance of each resistor is 1.0 kΩ and the resistance of *T* is 5.0 kΩ.

What is the reading on the ideal voltmeter?

A 0 V **B** 2.0 V **C** 3.0 V **D** 5.0 V

Ans: **C**

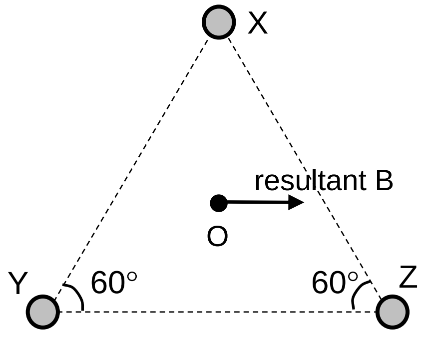
Effective resistance of the circuit

$$= 1000 + \frac{(1000 + 1000)(5000 + 1000)}{(1000 + 1000) + (5000 + 1000)}$$
$$= 2500$$

p.d. across voltmeter

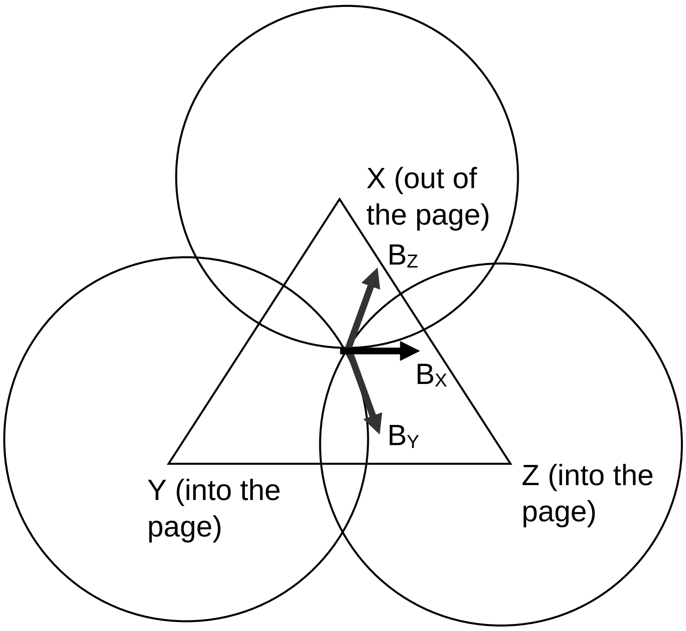
$$= 5 - 5 \times \frac{1000}{2500}$$
$$= 3.0\ V$$

25 Three parallel conductors, carrying currents of the same magnitude, pass vertically through the three corners X, Y and Z of a horizontal equilateral triangle as shown in the diagram below. A resultant magnetic flux density, B, acting at the centre of the triangle, O, acts in the direction as shown below. What must be the directions of the currents in X, Y and Z?

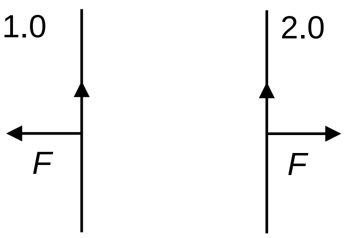


	Into the page	Out of the page
A	X	Y and Z
B	Z	X and Y
C	Y and Z	X
D	X, Y and Z	None

Ans: C
For the resultant flux density at O to be as shown, the directions of B_X, B_Y and B_Z must be as shown in diagram below. Using the Right Hand Grip Rule, the corresponding direction of current can be found.

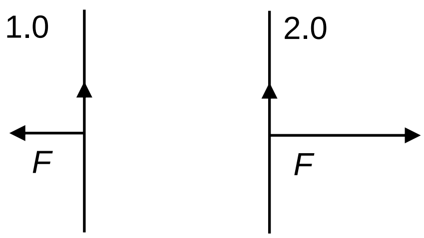


26 Two long straight parallel wires carry currents of 1.0 A and 2.0 A. Which diagram shows the directions and relative magnitudes F_1 and F_2 of the forces per unit length on each of the wires?



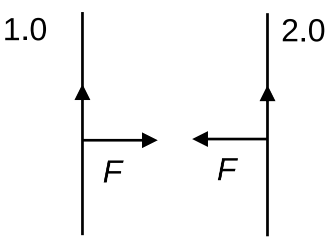
$F_1 = F_2$

A



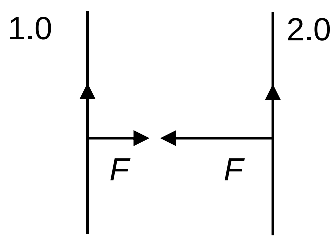
$2F_1 =$

B



$F_1 = F_2$

C



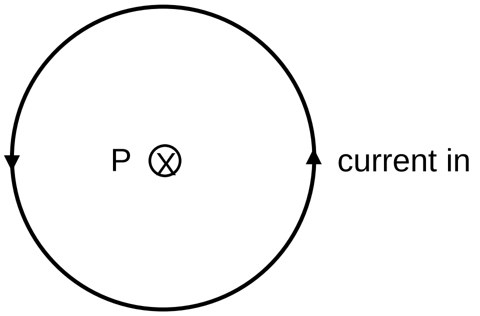
$2F_1 =$

D

Ans: C

Using Fleming's Left Hand Rule, the forces F_1 are F_2 found to act towards each other. By Newton's Third Law, the magnitude of the forces should be equal.

27 A long straight wire P is placed along the axis of a flat circular coil Q. The wire and the coil each carry a current as shown. Current in P is into the plane of the diagram.



What can be deduced about the force acting on each part of Q due to the current in P?

A No force acts.

B The force acts perpendicular to the plane of the diagram.

C The force acts towards P.

D The force acts away from P.

Ans: A

Since the magnetic flux density at P due to Q acts along the same axis as the current of P, no electromagnetic force will be experienced by P.

28 The first excitation energy and the ionization energy of a certain atom are 21.2 eV and 28.8 eV respectively. An electron of energy 22.4 eV strikes the atom at the ground state. What happens to the atom?

A The atom remains at the ground state.
B The atom is excited to the first excited state.
C The atom is excited to the second excited state.
D The atom is ionized.

Ans B

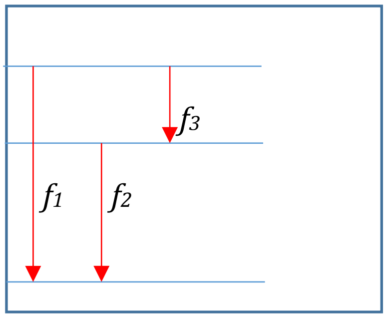
The answer has to be B. There is no information offered regarding the 2^{nd} excited state, hence it cannot be determined whether the atom can reach the 2^{nd} state but it will definitely reach the 1^{st} excited state.

29 Photons are emitted when the electrons drop from a higher energy level to a lower energy level. Consider the three lowest energy levels of a hydrogen atom. When electrons drop from the second lowest or third lowest energy level, the possible frequencies of photons emitted are f_1, f_2, and f_3, which are in ascending order. The magnitude of f_2 is equal to

A $f_3 - f_1$ **B** ½ $(f_1 + f_3)$ **C** $\frac{f_3 - f_1}{f_1 f_3}$ **D** $\sqrt{f_1 f_3}$

Ans A

Consider the 3 lowest energy levels of the atom:



Since $E_1 = E_2 + E_3$
$hf_1 = hf_2 + hf_3$

Therefore
$f_2 = f_1 - f_3$

30 The de Broglie wavelength of a moving particle of mass m is λ. If the kinetic energy of the particle is halved, the de Broglie wavelength will become

A $\frac{\lambda}{2}$ **B** $\frac{\lambda}{\sqrt{2}}$ **C** $\sqrt{2}\lambda$ **D** 2λ

Ans C

$E_k = \frac{p^2}{2m}$
If $E_k{}' = \frac{1}{2} E_k$
Then $p' = \frac{1}{\sqrt{2}} p$

Since $\lambda = \frac{h}{p}$
Therefore $\lambda' = \sqrt{2}\lambda$

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PHYSICS

8866/02

Paper 2 Structured Questions

18 September 2017

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section **A**
Answer **all** questions.

Section **B**
Answer any **two** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
1	
2	
3	
4	
5	
Section B	
6	
7	
8	
Total	

This document consists of **21** printed pages.

[Turn over

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	=	8.85×10^{-12} F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
acceleration of free fall,	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\Delta V$
hydrostatic pressure,	p	=	ρgh
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$

Section A

Answer **all** the questions in this section.

1 A uniform plank AB of length 5.0 m and weight 200 N is placed across a stream, as shown in Fig. 1.1.

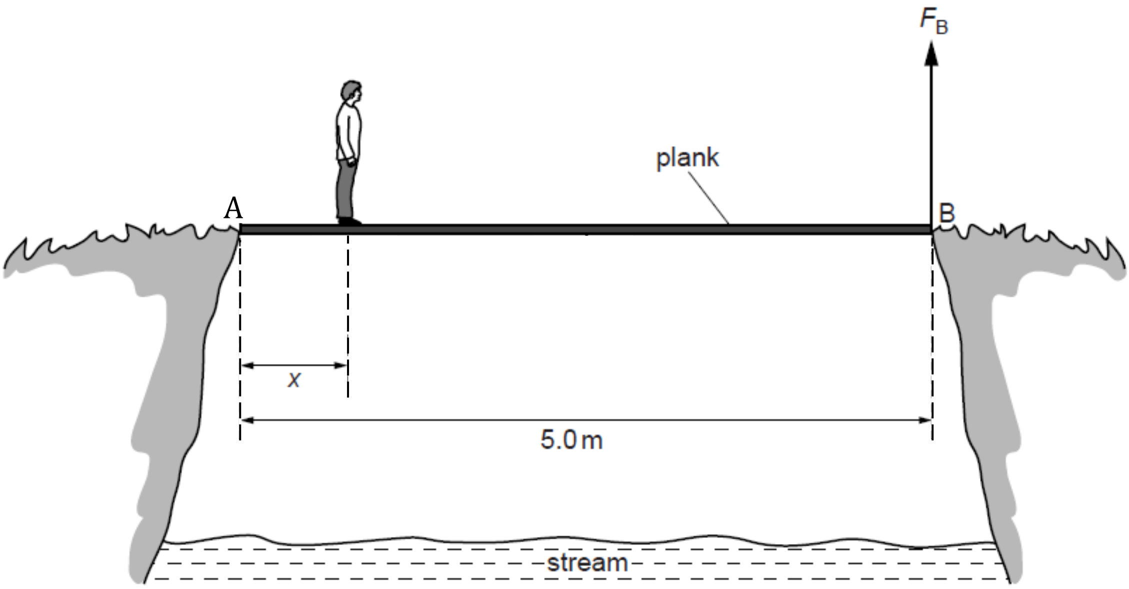

Fig. 1.1

A man of weight 880 N stands at a distance x from end A. The ground exerts a vertical force F_B on the plank at end B. As the man moves along the plank, the plank is always in equilibrium.

(a) **(i)** Draw all other forces on the plank and label them clearly. [3]

(ii) Define moment of a force.

....

....

....[1]

(iii) The man stands at a distance x = 0.50 m from end A. Calculate the magnitude of F_B.

F_B = ... N [2]

(b) If the plank is not uniform and the centre of gravity is nearer to point B, state and explain if there is any change to the magnitude of F_B.

....

....

....

....

....[2]

2 **(a)** **(i)** By using the equations of motion, show that the kinetic energy E_K of an object travelling with speed v is given by

$$E_K = \frac{1}{2}mv^2$$

[2]

(ii) State one assumption, other than that of the object having a constant acceleration.

....

....[1]

(b) State the principle of conservation of energy.

....

....

....[2]

(c) The cable of a passenger lift of mass 1800 kg snaps when the lift is at rest at the first floor of a high rise building as shown in Fig. 2.1. At this moment, the bottom of the lift is at a height h = 3.7 m above an uncompressed spring of spring constant k = 0.15 MN m^{-1}. A safety device that is activated because of this fault, clamps the lift against guide rails so that a constant frictional force F of 4.4 kN opposes the lift's motion at all times.

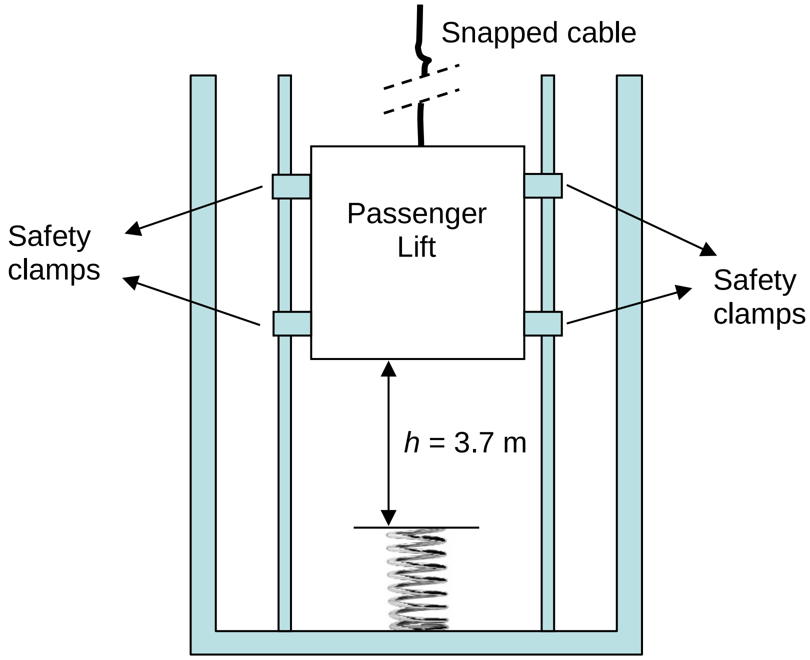

Fig. 2.1

Assuming that the frictional force still acts during the spring's compression, determine the maximum compression of the spring.

maximum compression = ... m [3]

3 **(a)** State the principle of superposition.

....

....

....

....[1]

(b) A double slit with slit separation 0.800 mm is situated a distance 2.50 m from a thin jet of high speed smoke as shown in Fig. 3.1.

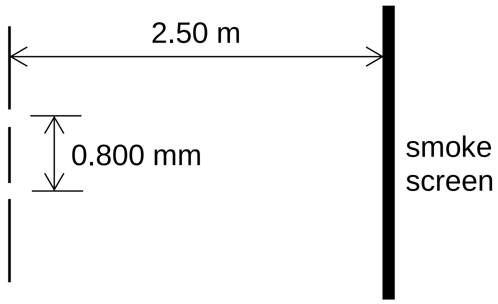

Fig. 3.1

The double slit is illuminated with coherent light of wavelength 589 nm. Fringes are observed in the moving smoke.

(i) Calculate the separation of these fringes.

separation = ...m [2]

(ii) Describe changes that would be observed in the pattern of fringes, if the following adjustments were made in the experimental arrangement. In each case, only one adjustment is made and all the other arrangements are the same as those in **(b)(i)**.

1. The coherent light of wavelength 589 nm is replaced with coherent monochromatic red light.

....

....

....

....[1]

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2. The speed of the smoke screen is doubled.

....

....

....[1]

3. The direction of the smoke stream is rotated through 45^o as shown in Fig. 3.2.

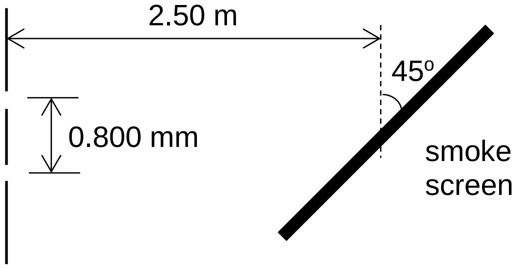

Fig. 3.2

....

....

....

....

....[2]

4 A conducting rod of mass 15.0 g rests on a set of smooth parallel horizontal rails as shown in Fig. 4.1. The rod and rails are in a region where there is a magnetic field.

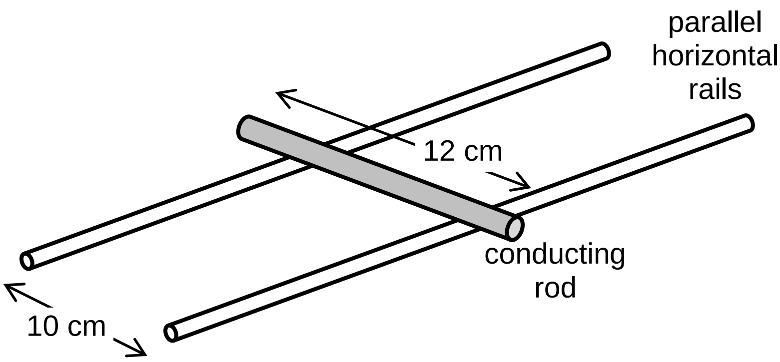

Fig. 4.1

When a potential difference is applied across the rails, the rod experiences an initial horizontal acceleration of 1.20 m s^{-2} due to a 3.0 A current passing through the rod.

(a) Determine the magnitude of the magnetic force on the rod.

magnetic force = ... N [1]

(b) Show that the minimum flux density of a magnetic field that can produce this acceleration is 60 mT.

[2]

(c) The actual flux density due to the magnetic field is 120 mT. To produce the same magnetic force in **(a)**, draw the directions of this magnetic field, the force on the rod and the current in the rod clearly on Fig. 4.2 which shows the front view of the rod on the rails.

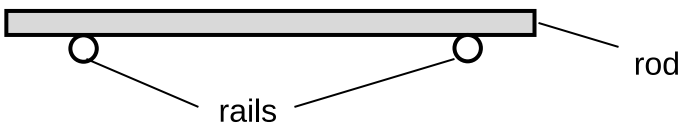

Fig. 4.2 (Front view)

[2]

(d) The rails may be inclined at an angle to restore the equilibrium of the rod. Determine the angle of inclination of the rails such that the net force on the rod is zero.

angle of inclination = ...° [2]

5 The walls of music halls are acoustically covered with a sound-absorbing panel that is able to absorb certain sound frequencies more than others.

One particular design is to use the resonance of a perforated panel as shown in Fig. 5.1.

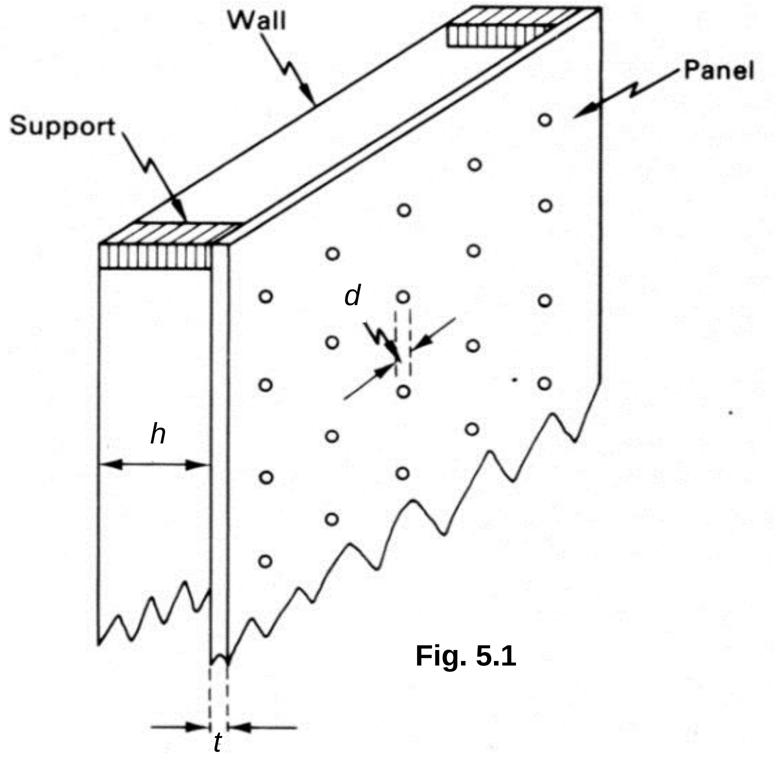

Fig. 5.1

It is found that this panel resonates at a particular frequency and hence can absorb sounds of that frequency more than others. A suggested formula for this resonant frequency f is given as:

$$f = k\sqrt{\frac{x}{h(t+0.8d)}} \qquad \text{--- Equation 5.1}$$

where k = 5000 mm s^{-1},
h = depth of airspace with unit mm,
t = thickness of panel with unit mm,
d = hole diameter with unit mm, and
x = percentage of panel surface area occupied by holes (e.g. x = 10 %)

Using identical hardboard panels having holes of the same diameter of 10 mm, the resonant frequencies f for different x values are measured, keeping h and t constant. The results are shown in Fig. 5.2:

x / %	2	4	6	8	10	12
f / Hz	530	750	920	1070	1190	1300

Fig. 5.2

For Examiner's Use

(a) Fig.5.3 shows the plot of some of the data from Fig. 5.2. Plot a point in Fig. 5.3 corresponding to the data for x = 10 %. [1]

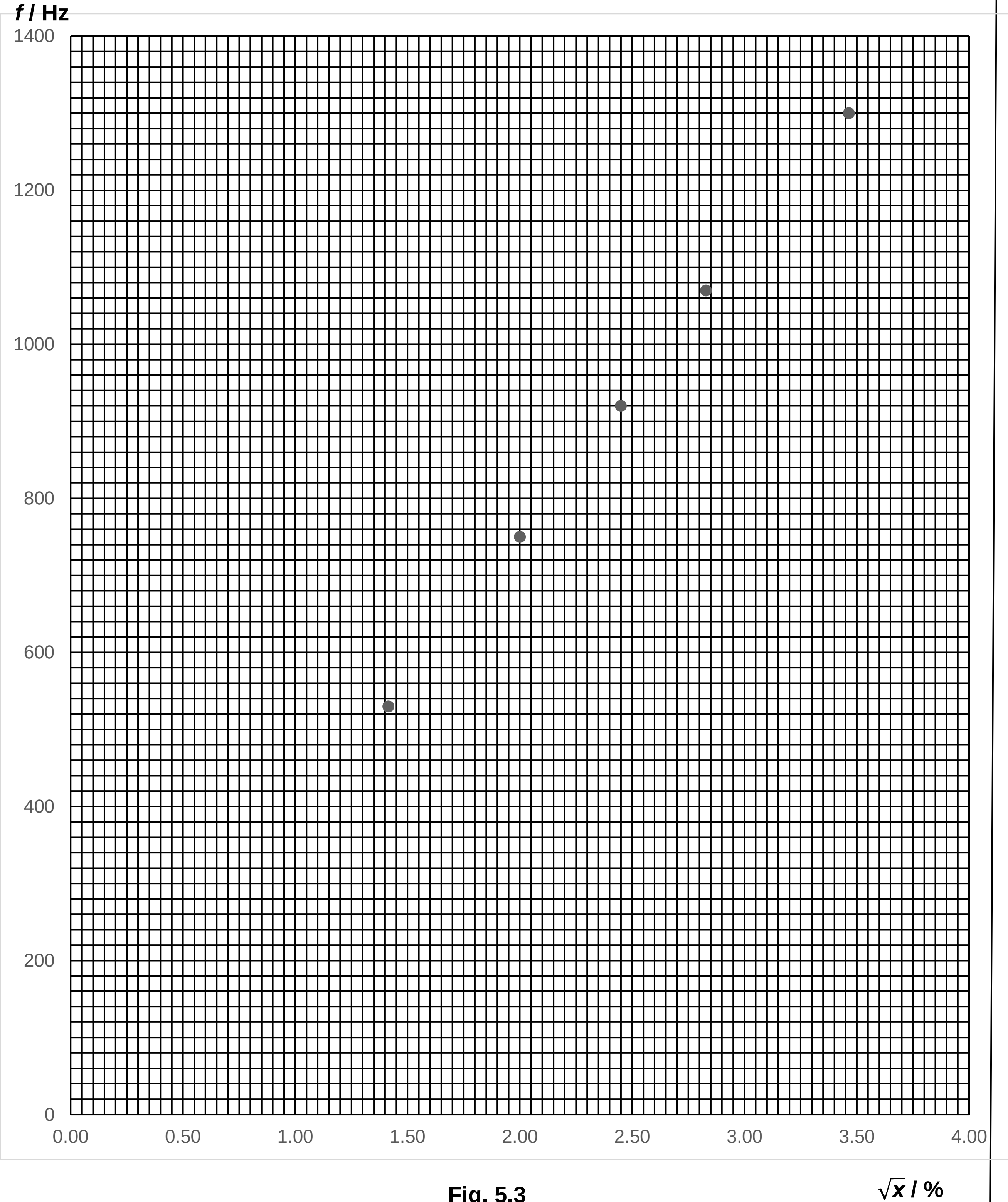

Fig. 5.3

(b) Explain whether the graph of Fig. 5.3 supports the suggestion that f is proportional to $\sqrt{x}$.

....

....

....

....

....[2]

(c) Determine the gradient of the graph in Fig. 5.3.

gradient = ... [2]

(d) Hence suggest suitable values for h and t when x = 10 %.

h = ...mm

t = ...mm [2]

(e) Using a panel with x fixed at 10 % and d fixed at 5 mm, the engineer decides to investigate the effect of filling the air space with 2 different absorbers. He obtains the absorption characteristics shown in Fig. 5.4.

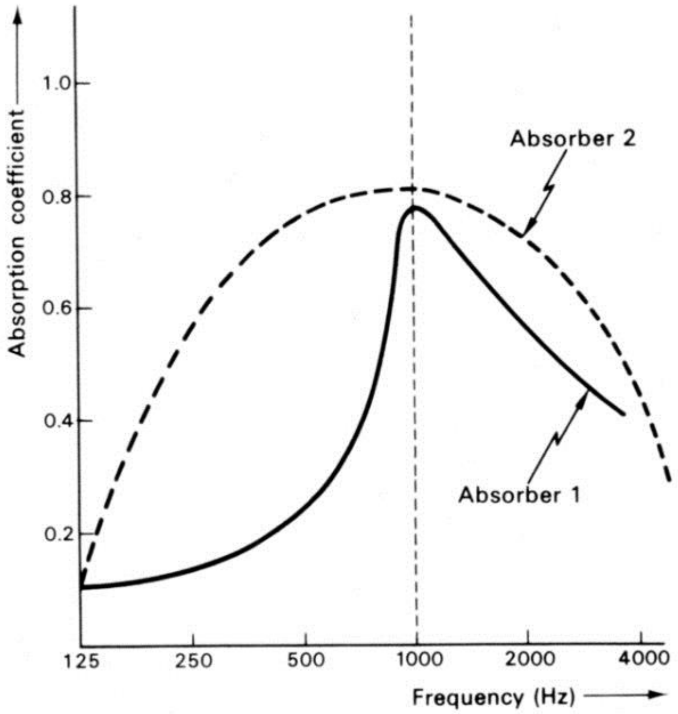

Fig. 5.4

Absorption coefficient is an indication of how much sound waves can be absorbed, i.e. the higher the absorption coefficient, the stronger the absorption.

(i) Suggest how the absorption coefficient is calculated.

....

....[1]

(ii) State and explain which of the two absorbers would be preferred in a room in which

1. absorption over a wide frequency range is required,

....

....

....[1]

2. sounds below 500 Hz need amplification.

....

.... [1]

Section B

Answer **two** of the questions from this section.

6 **(a)** Write down in terms of the mass *m* and the velocity *v* of a body, expressions for its momentum *p* and its kinetic energy *K*.

p = ...

K = ...[2]

(b) A tennis ball has a horizontal momentum of 2.40 N s and a kinetic energy of 45.0 J at the instant just before it is struck by a tennis racket.
Calculate the mass and the velocity of the tennis ball.

mass = ...kg

velocity = ...m s^{-1} [3]

(c) When the racket hits the ball it strikes the ball with a constant force of 60 N in a direction opposite to the momentum of the ball, bringing it to rest momentarily.

(i) Show that the time taken for the tennis ball to come to rest is 0.040s.

[2]

(ii) Calculate the distance travelled by the tennis ball travels from the time it is hit by the racket till the time when it comes to rest.

distance = ...m [2]

For Examiner's Use

(iii) Suggest why, in practice, it is impossible for a constant force to be applied to the ball.

....

....

....

....[2]

(d) The force of 60 N then continues to act on ball for a further 0.060 s.

(i) Without performing any calculations, predict and explain whether the final velocity of the ball will have a larger magnitude than that of the velocity before impact with the racket.

....

....

....

....[2]

(ii) State the principle of conservation of linear momentum.

....

....

....

....

....[2]

(iii) Explain whether the law of conservation of linear momentum applies to the racket and the ball in this collision between the racket and the ball.

....

....

....

....[2]

(e) The ball leaves the racket horizontally. By considering the forces acting on the ball, describe and explain the subsequent motion of the ball before it reaches the ground. Assume viscous force by air is negligible.

....

....

....

....

....

....[3]

7 A student wants to light a lamp marked '3.00 V, 0.600 W' but has only a 12.00 V battery of unknown internal resistance. In order to reduce the battery voltage, the student sets up the circuit as shown in Fig. 7.1 below. The digital voltmeter is included so that the voltage can be checked before connecting the lamp. The variable resistor CD has a maximum resistance of 1000 Ω.

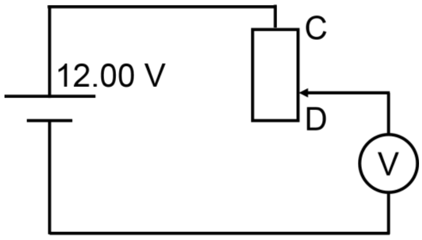

Fig. 7.1

(a) Explain what is meant by the "12.00 V" when applied to a 12.00 V battery.

....

....

....[1]

(b) It is found that when the sliding contact of the rheostat is placed at C, the digital voltmeter reading is 11.99 V. When the sliding contact is moved down from C to D, the digital voltmeter reading drops from 11.99 V to 11.00 V.

(i) State the potential difference across the internal resistance of the battery when the sliding contact of the rheostat is placed at C.

potential difference: .... V [1]

(ii) Using the potential divider concept or otherwise, determine the internal resistance *r* of the battery and the resistance *R* of the voltmeter.

r = ... Ω

R = ...Ω [4]

(iii) Explain**,** using the concept of a potential divider, why the presence of internal resistance reduces the output power of the 12.00 V battery.

....

....

....

....[2]

(c) The circuit in Fig. 7.1 is modified as shown in Fig. 7.2 and the potentiometer is adjusted to give a digital voltmeter reading of 3.00 V.

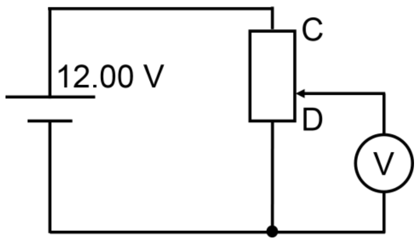

Fig. 7.2

(i) Determine the current through the digital voltmeter given that its resistance is 11.1 kΩ.

current = ... A [1]

(ii) Deduce the effect on the current through the battery if a voltmeter of lower resistance is used.

....

....[1]

(d) The student removes the digital voltmeter and connects the lamp in its place.

(i) Explain the significance of the marking '3.00 V, 0.600 W' on the lamp.

....

....[1]

(ii) Calculate the resistance of the lamp when it is operating normally.

resistance = ... Ω [1]

(iii) A fuse in the lamp is introduced to prevent the lamp from operating above 0.800 W at 3.00 V. Determine the current needed to blow the fuse.

current = ... A [1]

(e) The characteristic *I*−*V* graph in Fig.7.3 is that of a filament lamp.

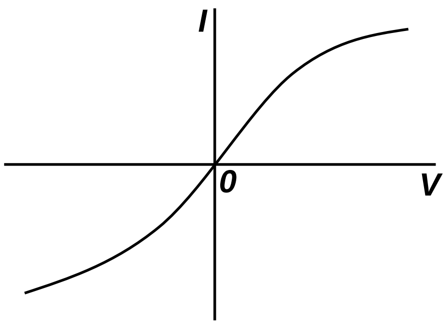

Fig. 7.3

Explain why, as the voltage is increased either positively or negatively from zero, the graph has the form shown in the Fig.7.3.

....

....

....

....

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....

....[4]

(f) In order to light up another set of lamps, each having a resistance of 20 Ω, the student sets up another circuit as shown in Fig. 7.4.

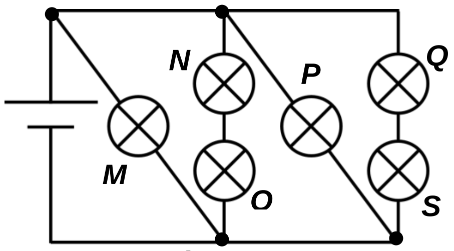


Fig. 7.4

For Examiner's Use

(i) Determine the effective resistance of the circuit.

effective resistance = ... Ω [1]

(ii) State and explain which (if any) of the lamps is likely to blow if the battery connected to the circuit is marked 4.50 V and lamps are marked '4.50 V, 0.800 W'. Assume that internal resistance of the battery is negligible.

....

....[2]

8 **(a)** Observations from the photoelectric experiment provided the first evidence for the particulate nature of light. Describe two of these observations and how each deviates from predictions of the classical wave theory of light.

....

....

....

....

....

....

....

....

....

....[4]

(b) Two metal plates X and Y are contained in an evacuated container and are connected to a circuit as shown in Fig. 8.1. Graph A shown in Fig. 8.2 shows the current I through the microammeter as a function of the p.d. applied across XY when monochromatic light is allowed to fall on plate X.

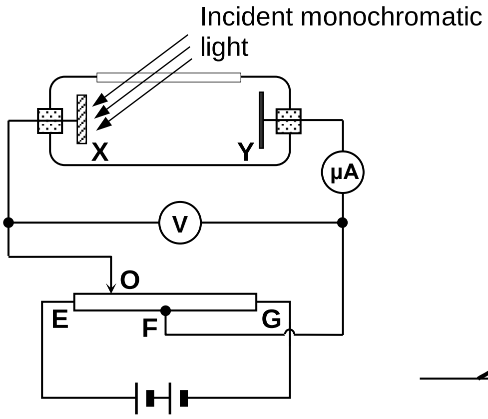


Fig. 8.1

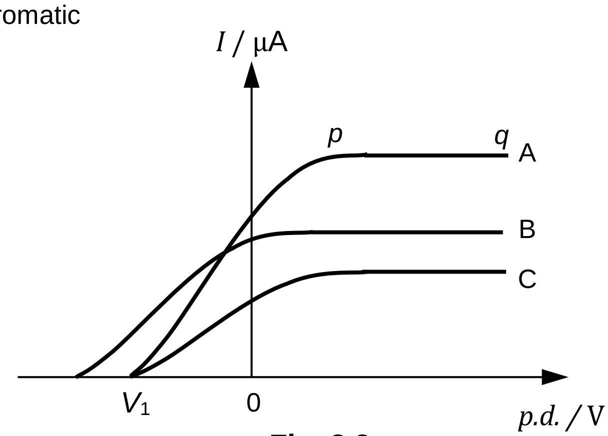


Fig. 8.2

(i) Suggest and explain where the sliding contact **O** should be to give the part of the graph *pq*.

....

....

....

....

....

....[2]

For Examiner's Use

(ii) Given that the work function of X is 1.3 eV and the wavelength of the light is 550 nm, calculate the value of V_1.

V_1 = ... V [2]

(iii) Suggest the changes that can be made to the experiment in Fig. 8.1 to produce the lines B and C.

....

....

....

....[2]

(c) The graph in Fig. 8.3 shows part of the visible region of the spectrum of a hot star far away from Earth.

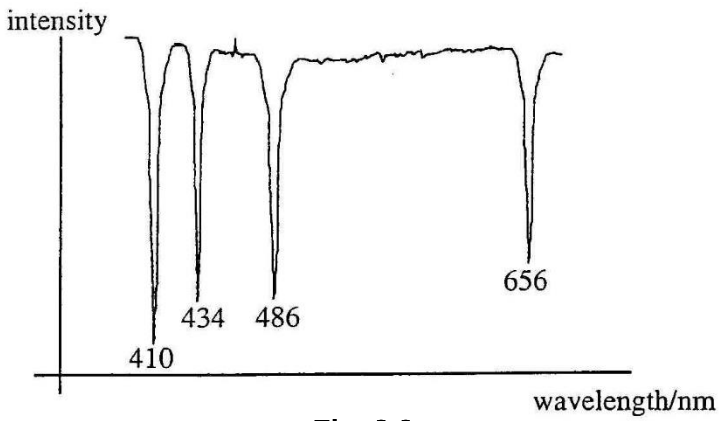


Fig. 8.3

The absorption lines are due to the large number of excited hydrogen atoms on the star.

(i) Explain how absorption lines are produced by the hydrogen atoms.

....

....

....

....

....

....[2]

(ii) Sketch a labelled graph of intensity against wavelength for the emission spectrum of hydrogen. [1]

(iii) Fig. 8.4 shows the first six energy levels of a hydrogen atom. Draw arrows to represent the energy transitions that give rise to the emission lines corresponding to those shown in Fig. 8.3. Label the transitions with the corresponding wavelengths. Hence calculate the values of E_2, E_5 and E_6.

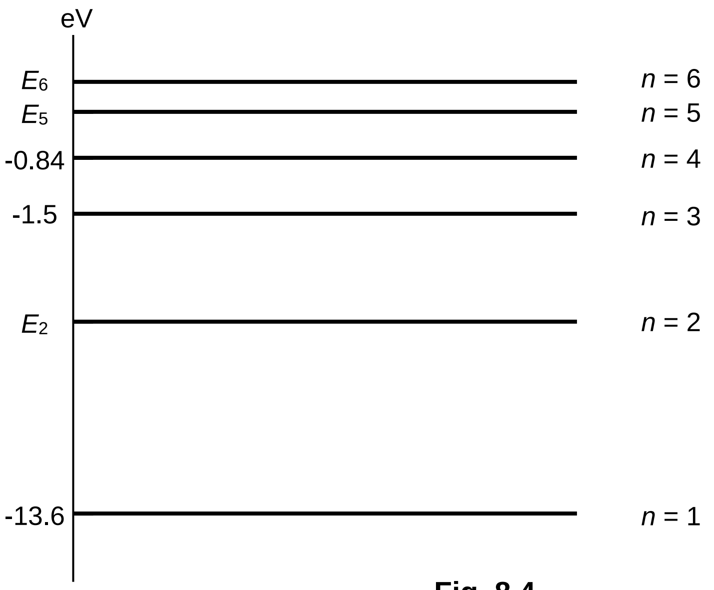


Fig. 8.4

E_2 = ... eV

E_5 = ...eV

E_6 = ...eV [6]

(iv) State the region of the electromagnetic spectrum in which radiation corresponding to a transition between n = 4 and n = 3 would lie.

....[1]

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 1

CANDIDATE NAME: **SOLUTION**

CLASS:

TUTOR'S NAME:

PHYSICS

8866/02

Paper 2 Structured Questions

18 September 2017

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section **A**
Answer **all** questions.

Section **B**
Answer any **two** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
1	
2	
3	
4	
5	
Section B	
6	
7	
8	
Total	

This document consists of **21** printed pages.

[Turn over

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	=	8.85×10^{-12} F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
acceleration of free fall,	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\Delta V$
hydrostatic pressure,	p	=	ρgh
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$

Section A

Answer **all** the questions in this section.

1 A uniform plank AB of length 5.0 m and weight 200 N is placed across a stream, as shown in Fig. 1.1.

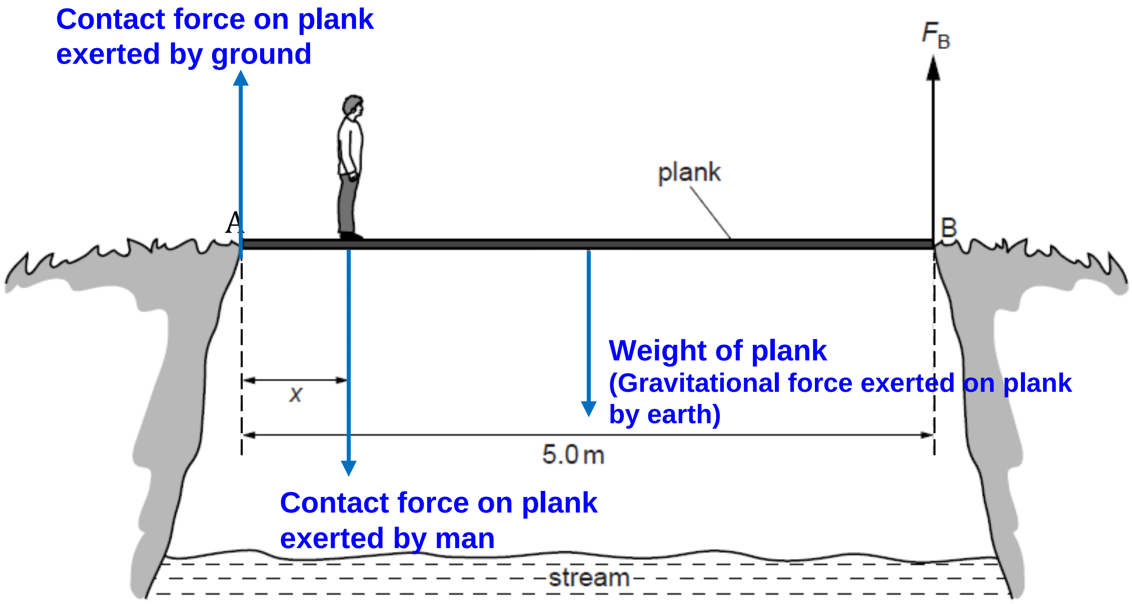


Fig. 1.1

A man of weight 880 N stands at a distance x from end A. The ground exerts a vertical force F_B on the plank at end B. As the man moves along the plank, the plank is always in equilibrium.

(a) **(i)** Draw all other forces on the plank and label them clearly. [3]

(ii) Define moment of a force.

The moment of a force about a point is defined as the product of the force and the perpendicular distance from the line of action of the force to that point.

....[1]

(iii) The man stands at a distance x = 0.50 m from end A. Calculate the magnitude of F_B.

(anticlockwise moments) = (clockwise moments)
$F_B \times 5.0 = 880 \times 0.5 + 200 \times 2.5$
$F_B = (440 + 500) / 5.0 = 188$ N

F_B = ...N [2]

For Examiner's Use

(b) If the plank is not uniform and the centre of gravity is nearer to point B, state and explain if there is any change to the magnitude of F_B.

The clockwise moment due to the weight will increase, thus, the anticlockwise moment due to F_B will have to increase as well and magnitude of F_B will increase.

....[2]

2 **(a)** **(i)** By using the equations of motion, show that the kinetic energy E_K of an object travelling with speed v is given by

$$E_K = \frac{1}{2}mv^2$$

Work Done = Force x displacement = ma s
($v^2 = u^2 + 2as$, so $as = ½ (v^2 – u^2)$)
Since work done by external agent to move a body from rest converts to kinetic energy of the body,
$E_k = m\ ½ (v^2 – u^2)$
Since body is at rest initially,
Hence $E_k = ½ mv^2$

[2]

(ii) State one assumption, other than that of the object having a constant acceleration.

There is no change in gravitational potential energy, (no increase in vertical distance)
The initial speed is zero.

....[1]

(b) State the principle of conservation of energy.

The principle of conservation of energy states that in a closed system, the total energy is constant.
Or
Energy can neither be created nor destroyed in any process. It can only be transformed (converted) from one form to another.
....[2]

(c) The cable of a passenger lift of mass 1800 kg snaps when the lift is at rest at the first floor of a high rise building as shown in Fig. 2.1. At this moment, the bottom of the lift is at a height h = 3.7 m above an uncompressed spring of spring constant k = 0.15 MN m^{-1}. A safety device that is activated because of this fault, clamps the lift against guide rails so that a constant frictional force F of 4.4 kN opposes the lift's motion at all times.

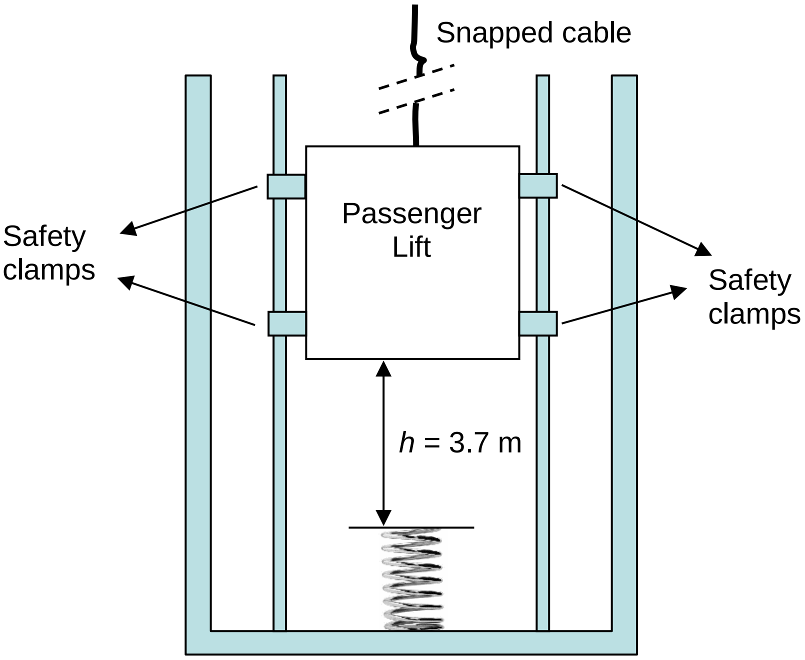


Fig. 2.1

Assuming that the frictional force still acts during the spring's compression, determine the maximum compression of the spring.

Let the spring compression height be *x* m.
By the principle of conservation of energy,
GPE Loss = Energy stored in the spring + Work done against friction

$$mg(h+x)=\frac{1}{2}kx^2+F(h+x)$$

$$\frac{1}{2}kx^2+(F-mg)x+h(F-mg)=0$$

$$(7.5 \text{ x } 10^4)x^2+\left[4.4 \text{ x } 10^3-(1800)(9.81)\right]x+\left[4.4 \text{ x } 10^3-(1800)(9.81)\right](3.7)=0$$

$$x^2-0.1768x-0.6541=0$$

$$x=\frac{-(-0.1768)\pm\sqrt{(-0.1768)^2-4(1)(-0.6541)}}{2(1)}$$

Taking *x* > 0, *x* = 0.902 m

maximum compression = ... m [3]

For Examiner's Use

3 **(a)** State the principle of superposition.

When waves meet, the displacement of the resultant wave is the vector sum of the separate displacements of the individual waves, and each wave proceeds as though no other waves exist.

....[1]

(b) A double slit with slit separation 0.800 mm is situated a distance 2.50 m from a thin jet of high speed smoke as shown in Fig. 3.1.

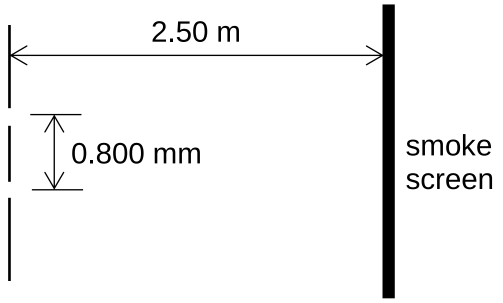


Fig. 3.1

The double slit is illuminated with coherent light of wavelength 589 nm. Fringes are observed in the moving smoke.

(i) Calculate the separation of these fringes.

$$\lambda = \frac{ax}{D}$$

$$589 \times 10^{-9} = \frac{\left(0.800 \times 10^{-3}\right)x}{2.50}$$

$$x = 1.84 \times 10^{-3} \text{ m}$$

separation = ... m [2]

(ii) Describe changes that would be observed in the pattern of fringes, if the following adjustments were made in the experimental arrangement. In each case, only one adjustment is made and all the other arrangements are the same as those in **(b)(i)**.

1. The coherent light of wavelength 589 nm is replaced with coherent monochromatic red light.

Since the wavelength of the light increases, the separation of the fringes will increase.
The fringes will still be uniformly separated and the positions of the maxima and minima remain unchanged.

....[1]

2. The speed of the smoke screen is doubled.

There will be no change to the fringe pattern.

....[1]

3. The direction of the smoke stream is rotated through 45° as shown in Fig. 3.2.

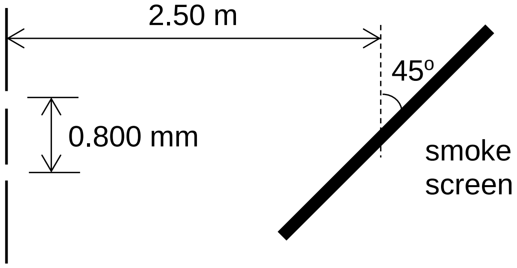


Fig. 3.2

Since the distance between the slits and the smoke screen (i.e. *D*) is now different at different positions along the smoke screen, the separation of the fringes will no longer be uniform. Moving from one end of the screen nearer the slits to the other end of the screen, the separation of the fringes will increase progressively.

Bright fringes observed on the part of the smoke screen which is nearer to the slits will have greater intensity than the other parts which are further away from the slits, hence the contrast between the bright and dark fringes on this part of the screen will also be greater. [2]

The positions of the maxima and minima remain unchanged.

4 A conducting rod of mass 15.0 g rests on a set of smooth parallel horizontal rails as shown in Fig. 4.1. The rod and rails are in a region where there is a magnetic field.

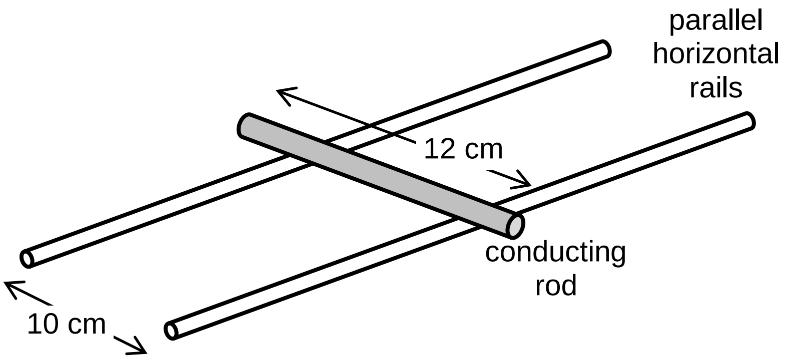


Fig. 4.1

When a potential difference is applied across the rails, the rod experiences an initial horizontal acceleration of 1.20 m s^{-2} due to a 3.0 A current passing through the rod.

(a) Determine the magnitude of the magnetic force on the rod.

$\Sigma F = m a$
$F_B = 0.0150 \times 1.20$
$\quad = 1.80 \times 10^{-2}$ N

magnetic force = ... N [1]

(b) Show that the minimum flux density of a magnetic field that can produce this acceleration is 60 mT.

$F_B = B\,I\,L$
$B = F_B / I\,L$
$= 1.80 \times 10^{-2} / (3.0 \times 0.10)$
$= 6.0 \times 10^{-2}$ T [shown]

[2]

(c) The actual flux density due to the magnetic field is 120 mT. To produce the same magnetic force in **(a)**, draw the directions of this magnetic field, the force on the rod and the current in the rod clearly on Fig. 4.2 which shows the front view of the rod on the rails.

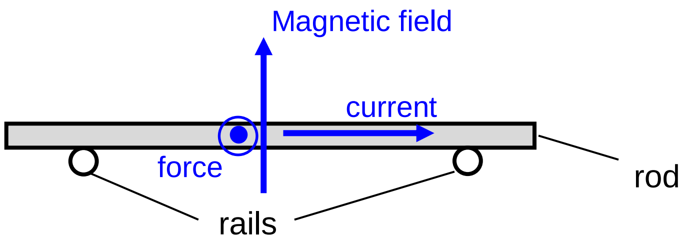
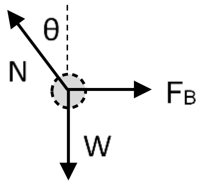


Fig. 4.2 (Front view)

4 possible sets of answers. As long as the components obey Fleming's Left Hand Rule and that current is along the rod, force is in or out of page and flux density is up or down.

[2]

(d) The rails may be inclined at an angle to restore the equilibrium of the rod. Determine the angle of inclination of the rails such that the net force on the rod is zero.



$\Sigma F = m\,a$
Horizontal: $N \sin\theta = F_B$
Vertical: $N \cos\theta = W$
Solving: $\tan\theta = F_B / W$
$= 1.8 \times 10^{-2} / 0.015 \times 9.81$
$\theta = 7.0°$

angle of inclination = ...° [2]

5 The walls of music halls are acoustically covered with a sound-absorbing panel that is able to absorb certain sound frequencies more than others.

One particular design is to use the resonance of a perforated panel as shown in Fig. 5.1.

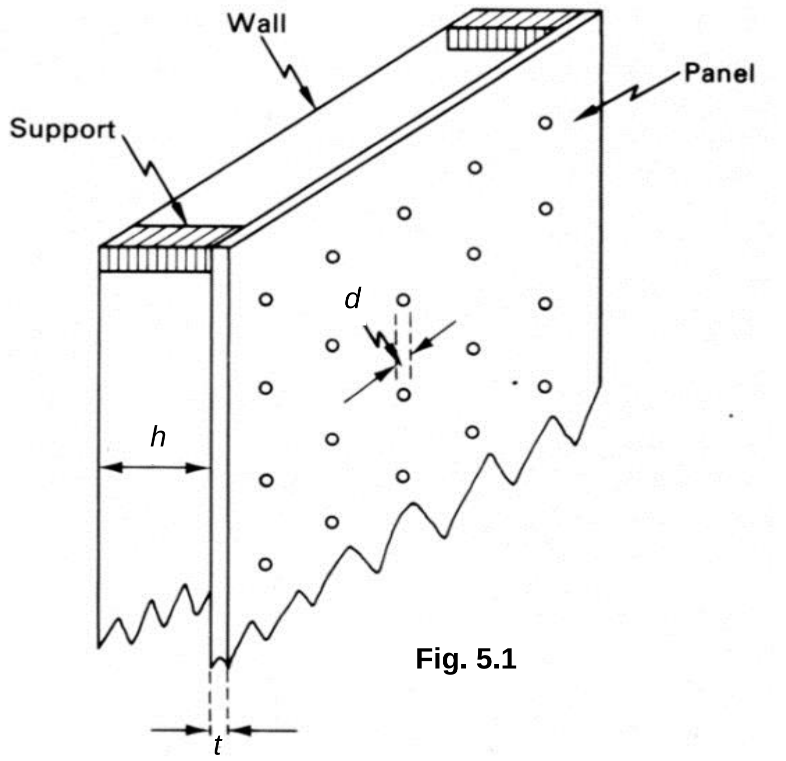


Fig. 5.1

It is found that this panel resonates at a particular frequency and hence can absorb sounds of that frequency more than others. A suggested formula for this resonant frequency *f* is given as:

$$f = k\sqrt{\frac{x}{h(t+0.8d)}} \quad \text{--- Equation 5.1}$$

where $k = 5000$ mm s^{-1},
h = depth of airspace with unit mm,
t = thickness of panel with unit mm,
d = hole diameter with unit mm, and
x = percentage of panel surface area occupied by holes (e.g. x = 10 %)

Using identical hardboard panels having holes of the same diameter of 10 mm, the resonant frequencies *f* for different *x* values are measured, keeping *h* and *t* constant. The results are shown in Fig. 5.2:

x / **%**	2	4	6	8	10	12
f / Hz	530	750	920	1070	1190	1300

Fig. 5.2

For Examiner's Use

(a) Fig.5.3 shows the plot of some of the data from Fig. 5.2. Plot a point in Fig. 5.3 corresponding to the data for x = 10 %. [1]

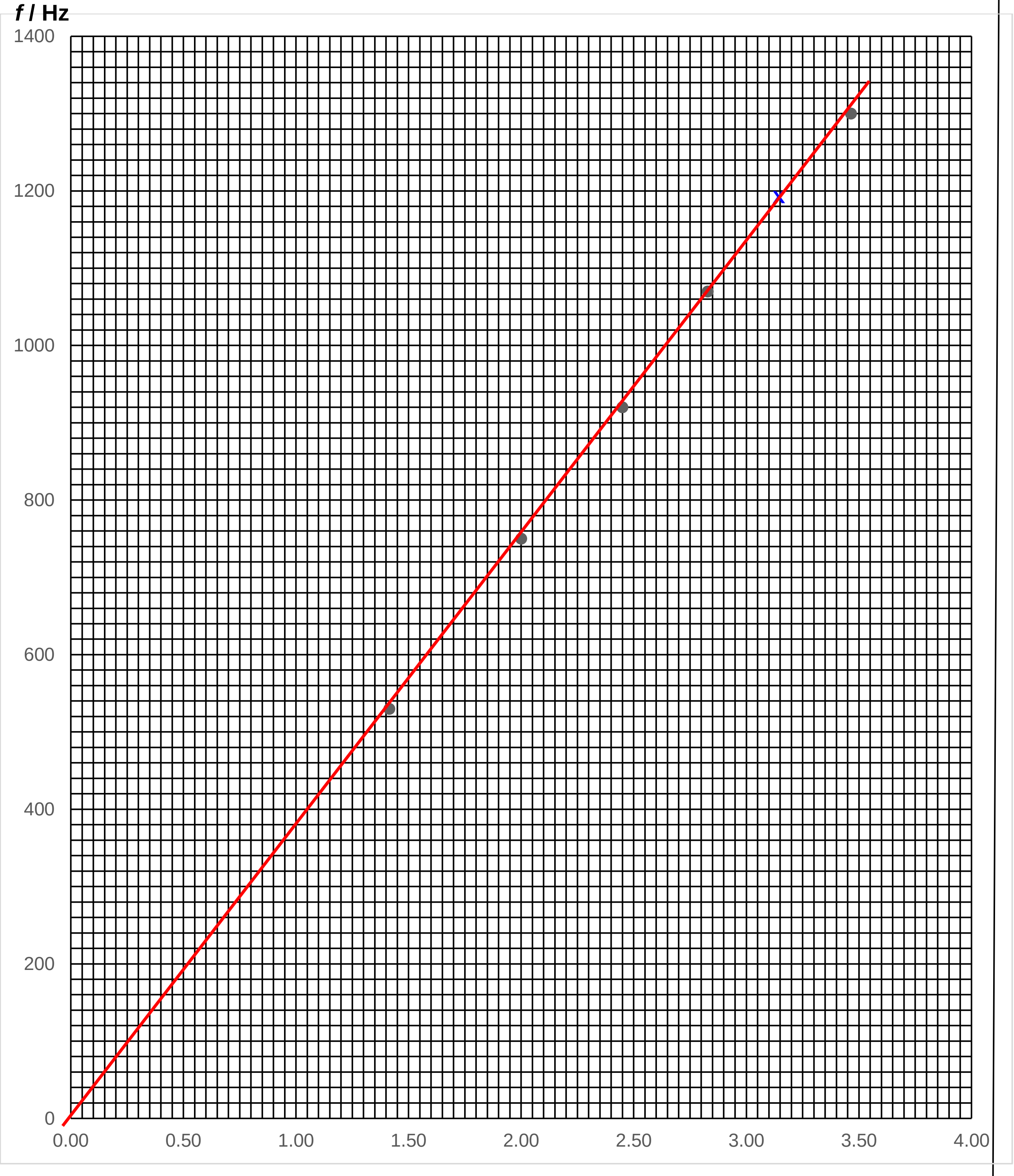


Fig. 5.3

(b) Explain whether the graph of Fig. 5.3 supports the suggestion that f is proportional to $\sqrt{x}$.

Since the line of best fit is a straight line passing the origin, f is proportional to √x

....[2]

(c) Determine the gradient of the graph in Fig. 5.3.

Gradient = $\dfrac{1200-200}{3.20-0.53}=375$

gradient = ... [2]

(d) Hence suggest suitable values for h and t when x = 10 %.

A = 375, ⇒ $\dfrac{k}{\sqrt{h(t+0.8d)}}=375$

Assume t = 2mm , h = 18 mm

Acceptable range for t: 1 – 6 mm
Acceptable range for h = 18 – 12 mm

h = ...mm

t = ...mm [2]

(e) Using a panel with *x* fixed at 10 % and *d* fixed at 5 mm, the engineer decides to investigate the effect of filling the air space with 2 different absorbers. He obtains the absorption characteristics shown in Fig. 5.4.

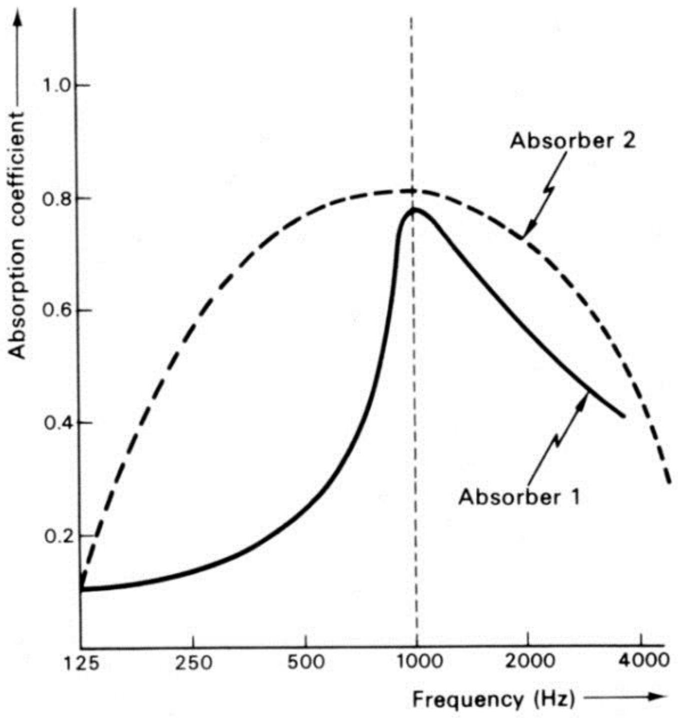


Fig. 5.4

Absorption coefficient is an indication of how much sound waves can be absorbed, i.e. the higher the absorption coefficient, the stronger the absorption.

(i) Suggest how the absorption coefficient is calculated.

It is calculated by taking the ratio of the intensity of sound after passing though absorber to intensity of sound directed at absorber. [1]

(ii) State and explain which of the two absorbers would be preferred in a room in which

1. absorption over a wide frequency range is required,

From the graph, the absorption coefficient for absorber 2 is higher than absorber 1 for all frequencies. Hence absorber 2 is preferred.

....[1]

2. sounds below 500 Hz need amplification.

From the graph, the absorption coefficient for absorber 1 for frequency < 500 Hz is significantly lower than those values above 500 Hz. Hence absorber 1 is preferred. [1]

Section B

Answer **two** of the questions from this section.

6 **(a)** Write down in terms of the mass *m* and the velocity *v* of a body, expressions for its momentum *p* and its kinetic energy *K*.

p = mv

K = ½ kx^2 [2]

(b) A tennis ball has a horizontal momentum of 2.40 N s and a kinetic energy of 45.0 J at the instant just before it is struck by a tennis racket.
Calculate the mass and the velocity of the tennis ball.

$m\,v = 2.4$

$\frac{1}{2} m\,v^2 = 45$

$$\frac{\frac{1}{2} m\,v^2}{m\,v} = \frac{4.5}{2.4}$$

$v = 37.5 \text{ m s}^{-1}$

$$m = \frac{2.4}{37.5} = 0.0641 \text{ kg}$$

mass = ...kg

velocity = ...m s^{-1} [3]

(c) When the racket hits the ball it strikes the ball with a constant force of 60 N in a direction opposite to the momentum of the ball, bringing it to rest momentarily.

(i) Show that the time taken for the tennis ball to come to rest is 0.040s.

$$F = m\left(\frac{v - u}{t}\right)$$

$$60 = 0.0641\left(\frac{0 - 37.5}{t}\right)$$

$t = 0.040$ s

[2]

(ii) Calculate the distance travelled by the tennis ball travels from the time it is hit by the racket till the time when it comes to rest.

$s = u\,t + \frac{1}{2} a\,t^2$

$$= 37.5\,(0.040) + \frac{1}{2}\left(\frac{60}{0.0641}\right)(0.040)^2 = 0.75\text{m}$$

distance = ...m [2]

(iii) Suggest why, in practice, it is impossible for a constant force to be applied to the ball.

When the ball strikes the strings of the racket, the strings stretch but the force of stretching is not uniform

[2]

(d) The force of 60 N then continues to act on ball for a further 0.060 s.

(i) Without performing any calculations, predict and explain whether the final velocity of the ball will have a larger magnitude than that of the velocity before impact with the racket.

The velocity will be larger. With a force of the same magnitude and a longer impact time, the change in velocity will be larger. The initial velocity being zero, the final velocity will be larger.

[2]

(ii) State the principle of conservation of linear momentum.

When bodies in a system interact, the total momentum remains constant provided no resultant external force acts on the system.

[2]

(iii) Explain whether the law of conservation of linear momentum applies to the racket and the ball in this collision between the racket and the ball.

The momentum of the racket and the ball is not conserved because the player is exerting a force on the racket.

[2]

(e) The ball leaves the racket horizontally. By considering the forces acting on the ball, describe and explain the subsequent motion of the ball before it reaches the ground. Assume viscous force by air is negligible.

The ball will execute a parabolic path downwards towards the ground. Gravitational force acts on the ball in the downwards direction. Gravitational force causes an increase in the downwards velocity of the ball while the horizontal component of the velocity remains the same.

[3]

7 A student wants to light a lamp marked '3.00 V, 0.600 W' but has only a 12.00 V battery of unknown internal resistance. In order to reduce the battery voltage, the student sets up the circuit as shown in Fig. 7.1 below. The digital voltmeter is included so that the voltage can be checked before connecting the lamp. The variable resistor CD has a maximum resistance of 1000 Ω.

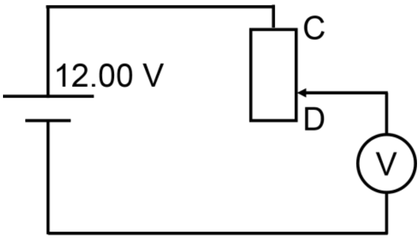


Fig. 7.1

(a) Explain what is meant by the "12.00 V" when applied to a 12.00 V battery.

The potential difference across the battery is 12.00 V when 12.00 J of electrical energy is converted from other forms of energy when 1 C of charge passes the terminals of the battery. [1]

(b) It is found that when the sliding contact of the rheostat is placed at C, the digital voltmeter reading is 11.99 V. When the sliding contact is moved down from C to D, the digital voltmeter reading drops from 11.99 V to 11.00 V.

(i) State the potential difference across the internal resistance of the battery when the sliding contact of the rheostat is placed at C.

potential difference: 0.01 V [1]

(ii) Using the potential divider concept or otherwise, determine the internal resistance r of the battery and the resistance R of the voltmeter.

Using potential divider concept,

$$\left(\frac{r}{r+R}\right)\varepsilon = V_r$$

$$r\varepsilon = rV_r + RV_r$$

$$r(\varepsilon - V_r) = RV_r$$

$$r = \frac{V_r}{\varepsilon - V_r}R \qquad -(1)$$

$$\left(\frac{R}{r+1000+R}\right)\varepsilon = V_R$$

$$R\varepsilon = rV_R + RV_R + 1000V_R$$

$$rV_R = R(\varepsilon - V_R) - 1000V_R$$

$$r = \frac{\varepsilon - V_R}{V_R}R - 1000 \qquad -(2)$$

Substitute (1) into (2),

$$\frac{V_r}{\varepsilon - V_r}R = \frac{\varepsilon - V_R}{V_R}R - 1000$$

$$\frac{0.01}{12.00 - 0.01}R = \frac{12.00 - 11.00}{11.00}R - 1000$$

$R = 11100\ \Omega$

Substitute $R = 11100\ \Omega$ into (1),

$r = \frac{V_r}{\varepsilon - V_r} 11100$

$r = 9.26\ \Omega$

r = ... Ω

R = ...Ω [4]

(iii) Explain**,** using the concept of a potential divider, why the presence of internal resistance reduces the output power of the 12.00 V battery.

Internal resistance reduces the terminal potential difference of the battery. Since the output power is proportional to its terminal p.d., the presence of internal resistance reduces the output power of the battery.

....[2]

(c) The circuit in Fig. 7.1 is modified as shown in Fig. 7.2 and the potentiometer is adjusted to give a digital voltmeter reading of 3.00 V.

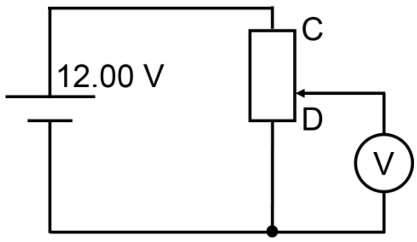


Fig. 7.2

(i) Determine the current through the digital voltmeter given that its resistance is 11.1 kΩ.

$$I_{meter} = \frac{V_{meter}}{R_{meter}}$$

$$I_{meter} = 0.270\ \text{mA}$$

current = ... A [1]

(ii) Deduce the effect on the current through the battery if a voltmeter of lower resistance is used.

Effective resistance of the circuit decreases hence current through battery increases.

....[1]

(d) The student removes the digital voltmeter and connects the lamp in its place.

(i) Explain the significance of the marking '3.00 V, 0.600 W' on the lamp.

For optimum performance at a power of 0.600 W, the lamp needs a p.d. of 3.00 V across it. [1]

(ii) Calculate the resistance of the lamp when it is operating normally.

$$P = \frac{V^2}{R}$$
$$R = 15.0\ \Omega$$

resistance = ... Ω [1]

(iii) A fuse in the lamp is introduced to prevent the lamp from operating above 0.800 W at 3.00 V. Determine the current needed to blow the fuse.

$$P = IV$$
$$I = 0.27 \text{ A}$$

current = ... A [1]

(e) The characteristic *I*−*V* graph in Fig.7.3 is that of a filament lamp.

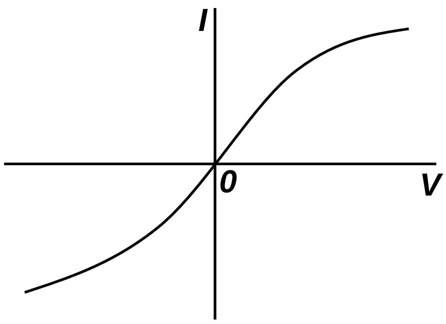


Fig. 7.3

Explain why, as the voltage is increased either positively or negatively from zero, the graph has the form shown in the Fig.7.3.

As p.d. across lamp increases, temperature of lamp increases.

Rise in temperature causes conducting electrons to collide more frequently with lattice ions in the filament.

Resistance of filament lamp increases with temperature.

Since resistance is the ratio of p.d. across lamp to the current through it, hence the graph curves towards the voltage axis.

.... [4]

(f) In order to light up another set of lamps, each having a resistance of 20 Ω, the student sets up another circuit as shown in Fig. 7.4.

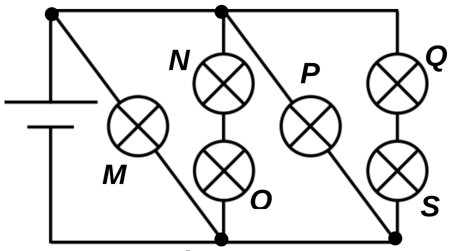


Fig. 7.4

(i) Determine the effective resistance of the circuit.

Since the 4 branches have the same p.d., they are in parallel arrangement.

$$\frac{1}{R} = \frac{1}{20} + \frac{1}{40} + \frac{1}{20} + \frac{1}{40}$$
$$R = 6.66$$

effective resistance = ... Ω [1]

(ii) State and explain which (if any) of the lamps is likely to blow if the battery connected to the circuit is marked 4.50 V and lamps are marked '4.50 V, 0.800 W'. Assume that internal resistance of the battery is negligible.

Consider power delivered to each of the lamps *M* and *P*,

$$P = \frac{V^2}{R}$$

$$P = \frac{4.5^2}{20} = 1.01\ W$$

Consider lamps *N*, *O*, *Q* and *S* individually,

$$P = \frac{2.25^2}{20} = 0.253\ W$$

Since the power supplied to lamps *M* and *P* is more than the suggested power rating, they are likely to blow

....[2]

8 **(a)** Observations from the photoelectric experiment provided the first evidence for the particulate nature of light. Describe two of these observations and how each deviates from predictions of the classical wave theory of light.

Observations:

1) Existence of a threshold frequency below which no photoelectric emission occurs

2) Maximum K.E. of the emitted photoelectrons is independent of the intensity of the radiation

3) Maximum K.E. of the emitted photoelectrons is dependent on the frequency of the electromagnetic radiation.

4) Photoelectric emission takes place instantaneously.

[4]

(b) Two metal plates X and Y are contained in an evacuated container and are connected to a circuit as shown in Fig. 8.1. Graph A shown in Fig. 8.2 shows the current I through the microammeter as a function of the p.d. applied across XY when monochromatic light is allowed to fall on plate X.

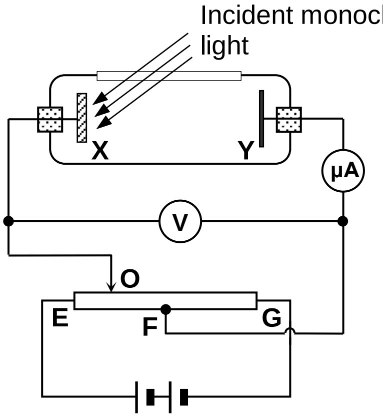


Fig. 8.1

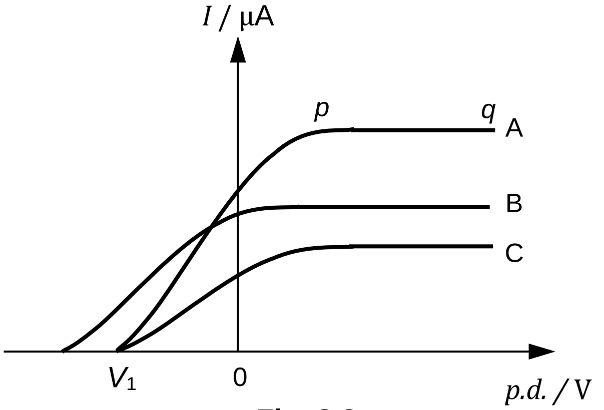


Fig. 8.2

(i) Suggest and explain where the sliding contact **O** should be to give the part of the graph *pq*.

The sliding contact **O** must be in the region **FG**.

The region *pq* of the graph indicates that photoelectric current is independent of the potential difference across XY. This is only possible if **X** is at a lower potential than **Y** so that the emitted electrons are accelerated towards **Y**.

[2]

(ii) Given that the work function of X is 1.3 eV and the wavelength of the light is 550 nm, calculate the value of V_1.

$hf = \text{K.E.}_{max} + \Phi$

$$\frac{hc}{\lambda} = eV_s + \Phi$$

$$\frac{6.63\times10^{-34}\times3.0\times10^{8}}{550\times10^{-9}} = (1.6\times10^{-19})V_s + (1.3\times1.6\times10^{-19})$$

$V_s = 0.96$ V

V_1 = ...V [2]

(iii) Suggest the changes that can be made to the experiment in Fig. 8.1 to produce the lines B and C.

Graph B has a smaller maximum current and larger stopping potential than A.

The larger stopping potential indicates that an incident radiation of higher frequency **OR** incident radiation of lower wavelength **OR** a metal of smaller work function must be used. [2]

AND The lower maximum photocurrent is due to the smaller intensity of incident radiation.

Graph C has a smaller maximum photocurrent but the same stopping potential as A. Since the stopping potential is the same as A, the frequency of the incident radiation must be the same as in A. The lower maximum photocurrent is due to the smaller intensity of incident radiation.

(c) The graph in Fig. 8.3 shows part of the visible region of the spectrum of a hot star far away from Earth.

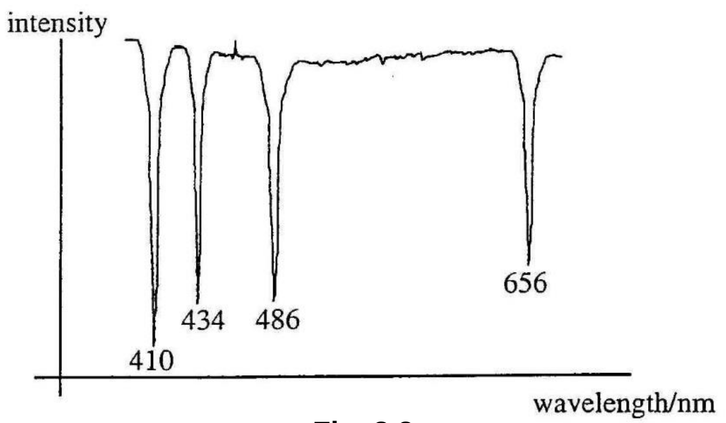


Fig. 8.3

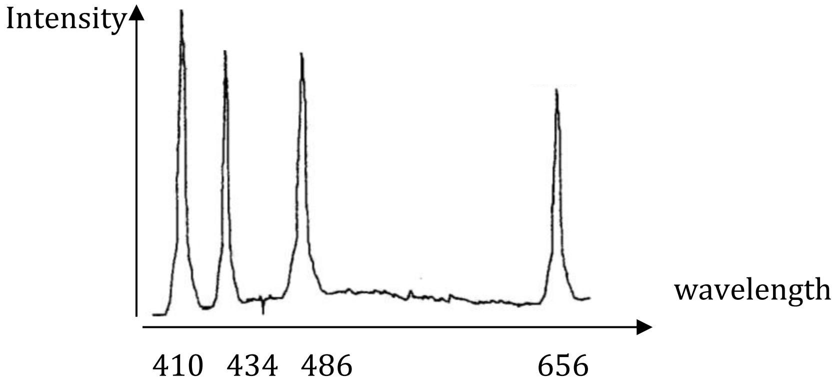
The absorption lines are due to the large number of excited hydrogen atoms on the star.

(i) Explain how absorption lines are produced by the hydrogen atoms.

The energy levels in the hydrogen atom are **discrete**.
When electromagnetic radiation passes through the hydrogen gas, photons of energy corresponding to the exact difference in energy between two energy levels in the atom are absorbed.

This results in lines missing from the spectrum after the radiation passes through the gas. (or mention absorption in the process) [2]

(ii) Sketch a labelled graph of intensity against wavelength for the emission spectrum of hydrogen. [1]



(iii) Fig. 8.4 shows the first six energy levels of a hydrogen atom. Draw arrows to represent the energy transitions that give rise to the emission lines corresponding to those shown in Fig. 8.3. Label the transitions with the corresponding wavelengths. Hence calculate the values of E_2, E_5 and E_6.

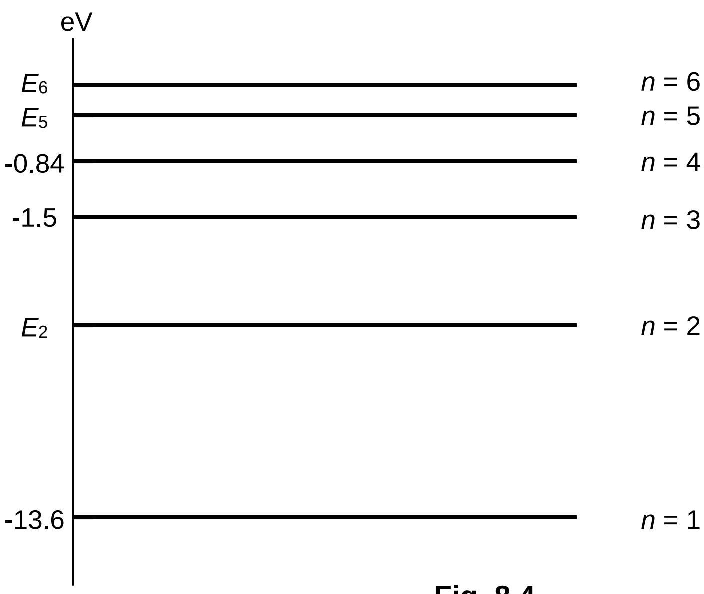
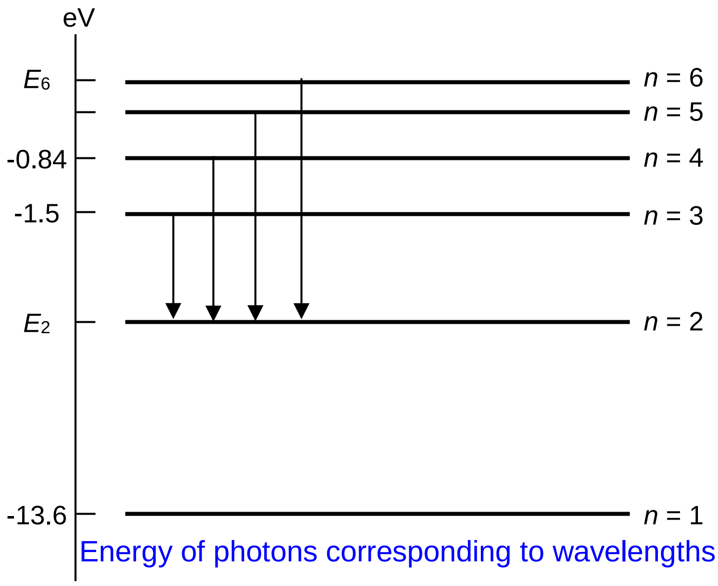


Fig. 8.4



Energy of photons corresponding to wavelengths in figure 6.2a.

λ = 410 nm:

$$E = \frac{hc}{\lambda} = \frac{6.63\times10^{-34}\times3.0\times10^{8}}{410\times10^{-9}} = 4.85 \times 10^{-19}\text{ J} = 3.03\text{ eV}$$

λ = 434 nm:

$$E = \frac{hc}{\lambda} = \frac{6.63\times10^{-34}\times3.0\times10^{8}}{434\times10^{-9}} = 4.58 \times 10^{-19}\text{ J} = 2.86\text{ eV}$$

λ = 486 nm:

$$E = \frac{hc}{\lambda} = \frac{6.63\times10^{-34}\times3.0\times10^{8}}{486\times10^{-9}} = 4.09 \times 10^{-19}\text{ J} = 2.56\text{ eV}$$

λ = 656 nm:

$$E = \frac{hc}{\lambda} = \frac{6.63\times10^{-34}\times3.0\times10^{8}}{656\times10^{-9}} = 3.03 \times 10^{-19}\text{ J} = 1.90\text{ eV}$$

$-1.5 - E_2 = 1.90$ eV
$E_2 = -3.4$ eV

$E_5 - E_2 = 2.86$ eV
$E_5 = 2.86 + (-3.4)$
$E_5 = -0.54$ eV

$E_6 - E_2 = 3.03$ eV
$E_6 = 3.03 + (-3.4)$
$E_6 = -0.37$ eV

E_2 = ... eV

E_5 = ...eV

E_6 = ...eV [6]

(iv) State the region of the electromagnetic spectrum in which radiation corresponding to a transition between $n = 4$ and $n = 3$ would lie.

Infra-red region.

....[1]