HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION

2014 MOCK EXAMINATION

PHYSICS PAPER 1

8.30 am – 11.00 am (2 hours 30 minutes)

This paper must be answered in English

GENERAL INSTRUCTIONS

1. There are **TWO** sections, A and B, in this Paper. You are advised to finish Section A in about 60 minutes.

2. Section A consists of multiple-choice questions in this question paper, while Section B contains conventional questions printed separately in Question-Answer Book **B**.

3. Answers to Section A should be marked on the Multiple-choice Answer Sheet while answers to Section B should be written in the spaces provided in Question-Answer Book **B**. **The Answer Sheet for Section A and the Question-Answer Book for Section B will be collected separately at the end of the examination.**

4. The diagrams in this paper are **NOT** necessarily drawn to scale.

5. The last pages of this question paper contain a list of data, formulae and relationships which you may find useful.

INSTRUCTIONS FOR SECTION A (MULTIPLE-CHOICE QUESTIONS)

1. Read carefully the instructions on the Answer Sheet. After the announcement of the start of the examination, you should first stick a barcode label and insert the information required in the spaces provided. No extra time will be given for sticking on the barcode label after the 'Time is up' announcement.

2. When told to open this book, you should check that all the questions are there. Look for the words **'END OF SECTION A'** after the last question.

3. All questions carry equal marks.

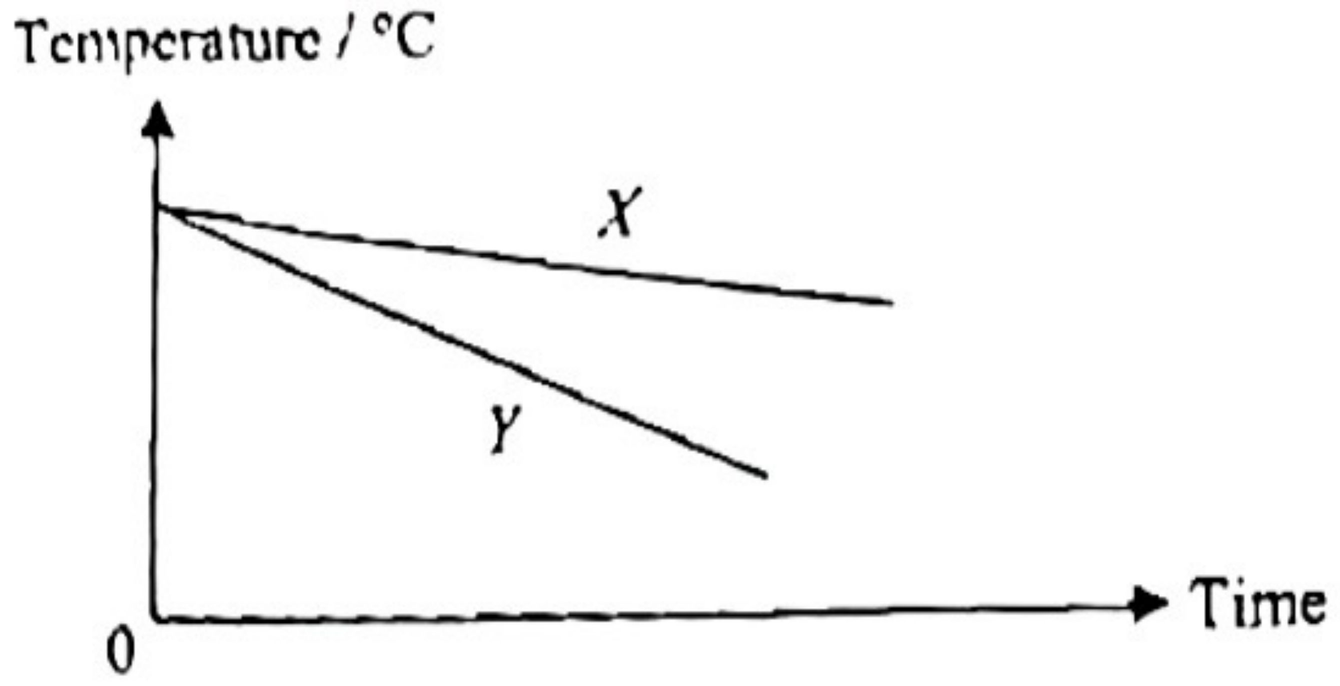
4. **ANSWER ALL QUESTIONS**. You are advised to use an HB pencil to mark all the answers on Answer Sheet, so that wrong marks can be completely erased with a certain rubber. You must mark the answers clearly, otherwise you will lose marks if the answers cannot be captured.

5. You should mark only **ONE** answer for each question. If you mark more than one answer, you will receive **NO MARKS** for that question.

6. No marks will be deducted for wrong answers.

There are 33 questions.

1.



The above figure shows the temperature - time graph of two liquids X and Y at the same initial temperature being cooled in air. Assume that the rates of heat lost to the surroundings of the two liquids are the same. Which of the following deductions is/are correct ?

(1) The heat capacity of X is greater.
(2) The specific heat capacity of X is greater.
(3) If both of the liquids are water, then the mass of X is greater.

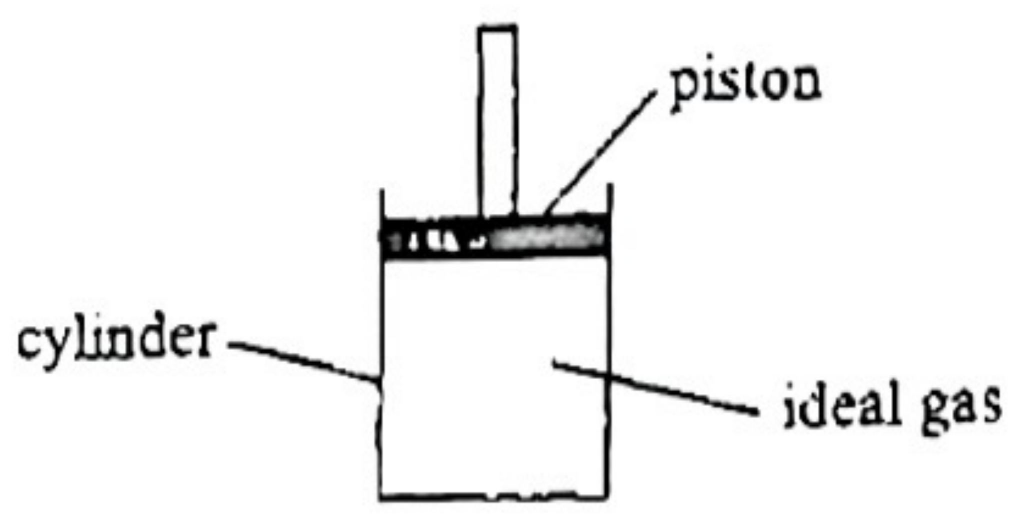
A. (3) only
B. (1) and (2) only
C. (1) and (3) only
D. (1), (2) and (3)

2. In summer when we walk out of the air-conditioned room, the glasses become misty. Which of the following statements concerning the mist formation is/are correct ?

(1) During the formation of mist, latent heat of vaporization is absorbed from the glasses.
(2) During the formation of mist, the potential energy of the water molecules decreases.
(3) Mist formation can only occur above room temperature.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

3



A fixed mass of an ideal gas is contained in a cylinder fitted with a piston which can move freely as shown in the figure. If now the gas is heated under constant pressure, which of the following statements is/are correct ?

(1) The density of the gas would decrease.
(2) Each gas molecule would hit the walls of the cylinder with a greater force.
(3) The frequency of collision of the gas molecules on the piston would increase.

A. (1) only
B. (1) and (2) only
C. (2) and (3) only
D. (1), (2) and (3)

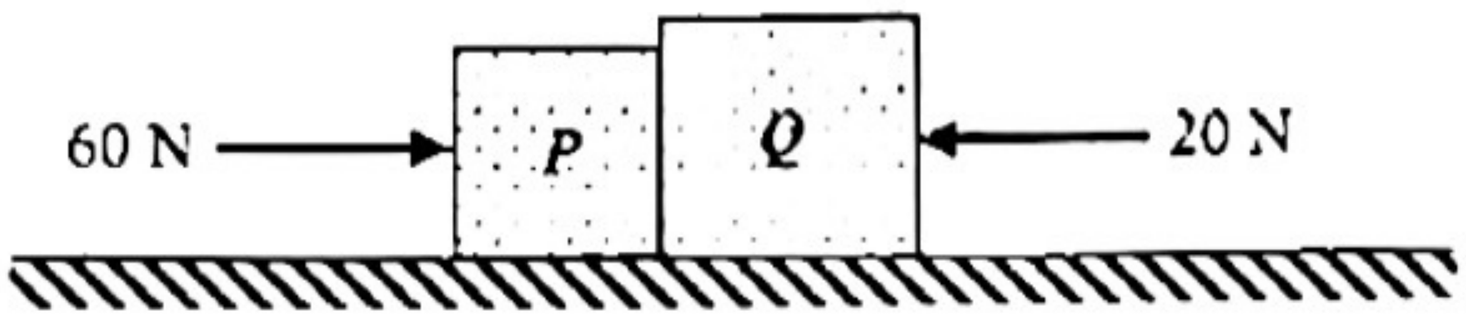
4. A gas vessel contains an ideal gas at a pressure of 250 kPa at room temperature of 25°C. Calculate the number of gas molecules per cubic metre inside the vessel.

A. 6.1×10^{25}
B. 7.2×10^{25}
C. 6.1×10^{26}
D. 7.2×10^{26}

5. John is driving his car with a constant speed of 20 m s^{-1}. At time $t = 0$, he observes a pedestrian rushing out. After a reaction time of 0.8 s, he then applies the brakes to stop his car with uniform deceleration of 2.5 m s^{-2}. What is the total stopping distance of his car ?

A. 16 m
B. 64 m
C. 80 m
D. 96 m

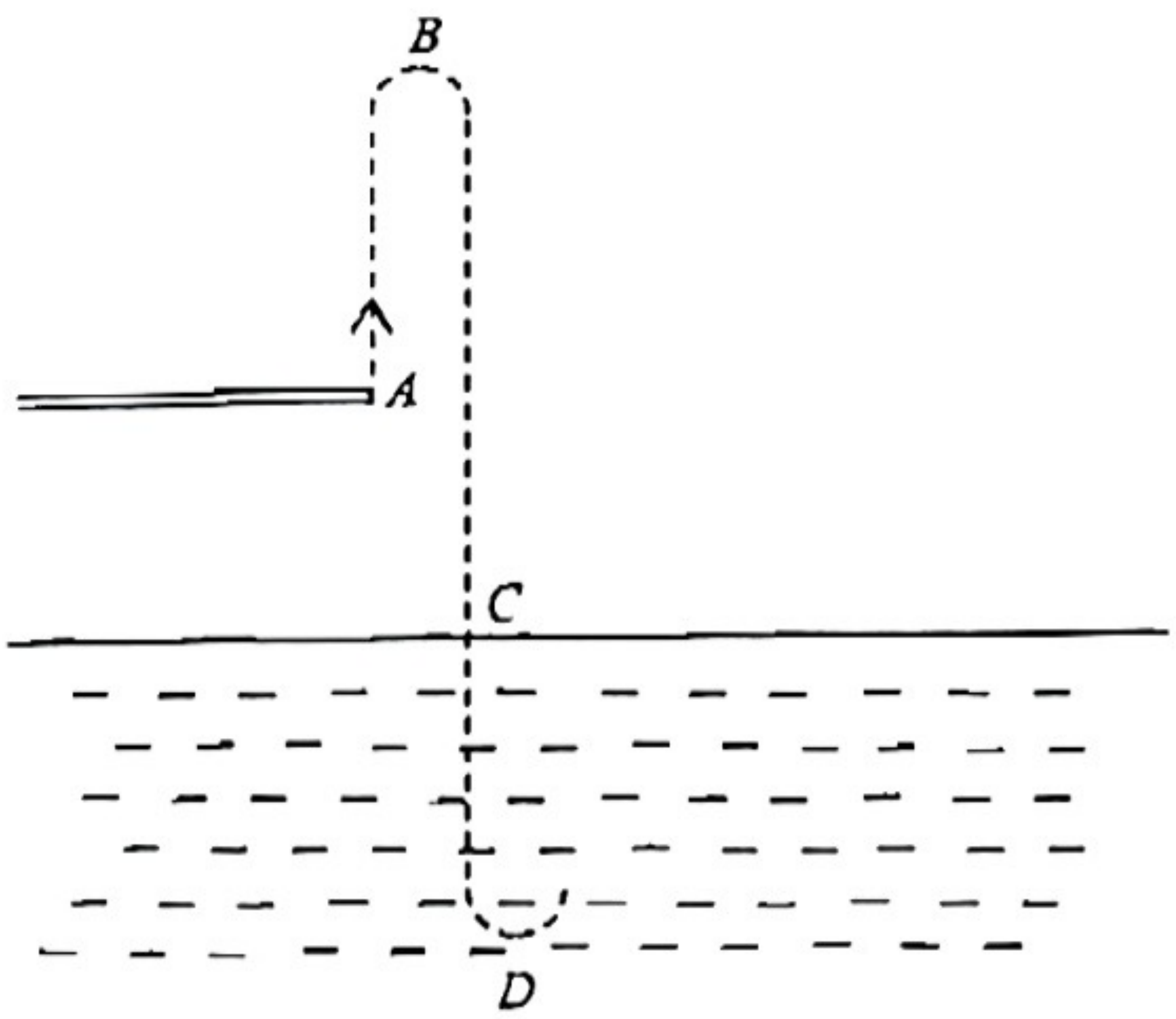
6.



Blocks P and Q of mass $2m$ and $3m$ respectively are in contact on a smooth horizontal floor. Two horizontal forces of 60 N and 20 N act on P and Q respectively as shown in the above figure. Calculate the normal reaction between the two blocks.

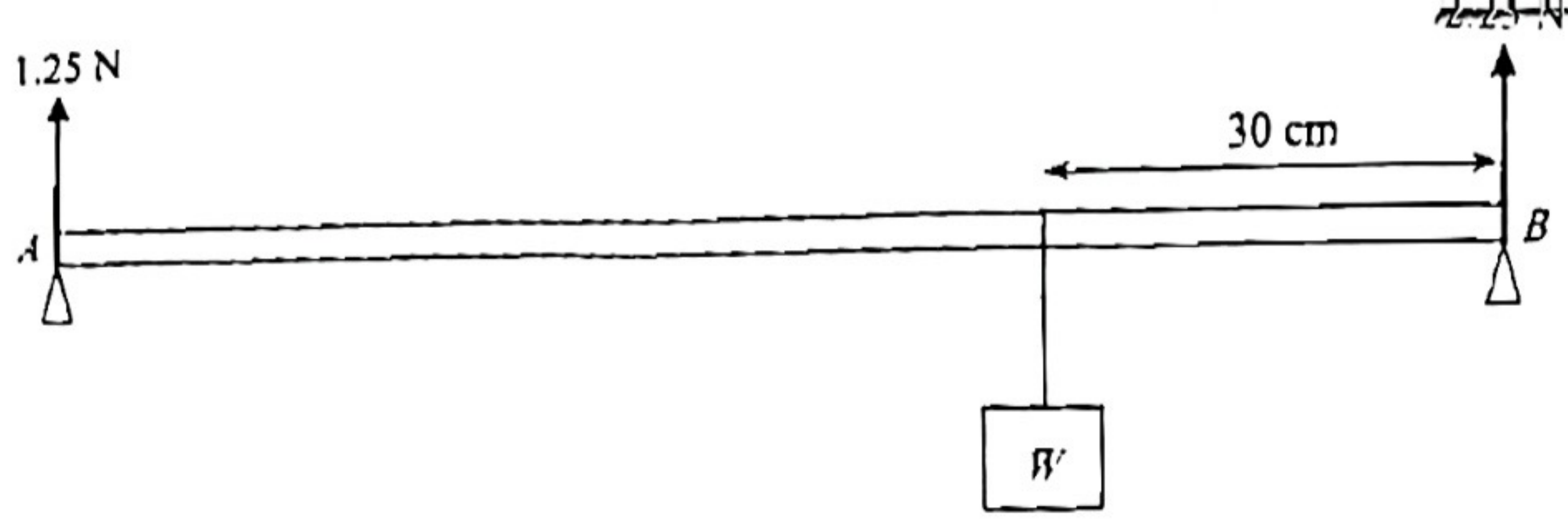
A. 32 N
B. 36 N
C. 44 N
D. 48 N

7.



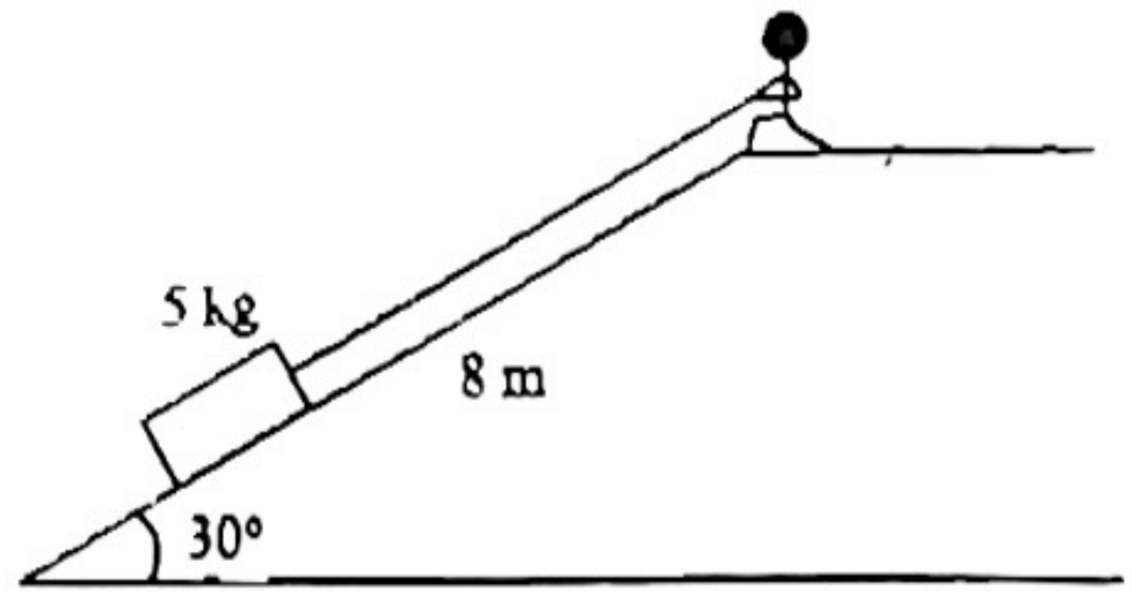
A diver of mass 50 kg jumps up at A from a platform with an initial speed of 5 m s^{-1}. The platform is 3 m above the water surface. The diver rises up to the maximum height B, enters the water at the point C, and then descends to the maximum depth at the point D as shown in the above figure. If point D is at a depth of 2.5 m below the water surface, calculate the average water resistance force when he descends in water from C to D.

A. 740 N
B. 839 N
C. 1210 N
D. 1330 N

8. 

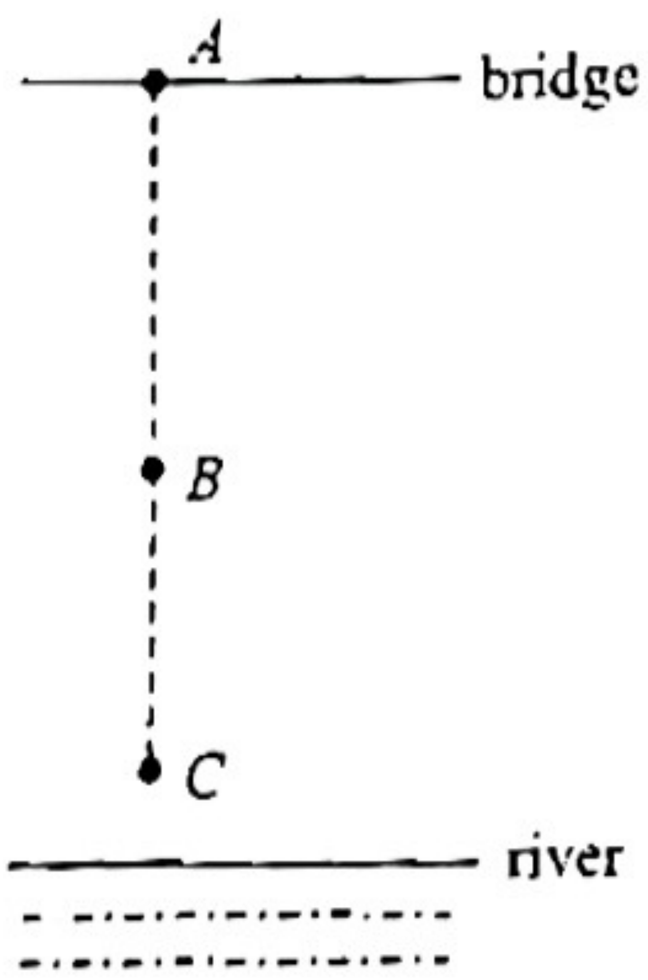
In the above figure, a uniform metre rule is balanced horizontally by two supports at *A* and *B*. The normal reaction forces at *A* and *B* are 1.25 N and 2.25 N respectively. A weight *W* is hanged at 30 cm from *B* as shown. Calculate the weight *W*.

A. 1.5 N
B. 2.5 N
C. 3.0 N
D. 3.5 N

9. 

A man pulls a 5 kg block up a rough inclined plane making an angle of 30° with the horizontal as shown above. The inclined plane is 8 m long and the friction between the block and the inclined plane is 12 N. If the block is pulled from the bottom of the inclined plane to the top in 30 s, find the average output power of the man.

A. 3.20 W
B. 6.54 W
C. 8.26 W
D. 9.74 W

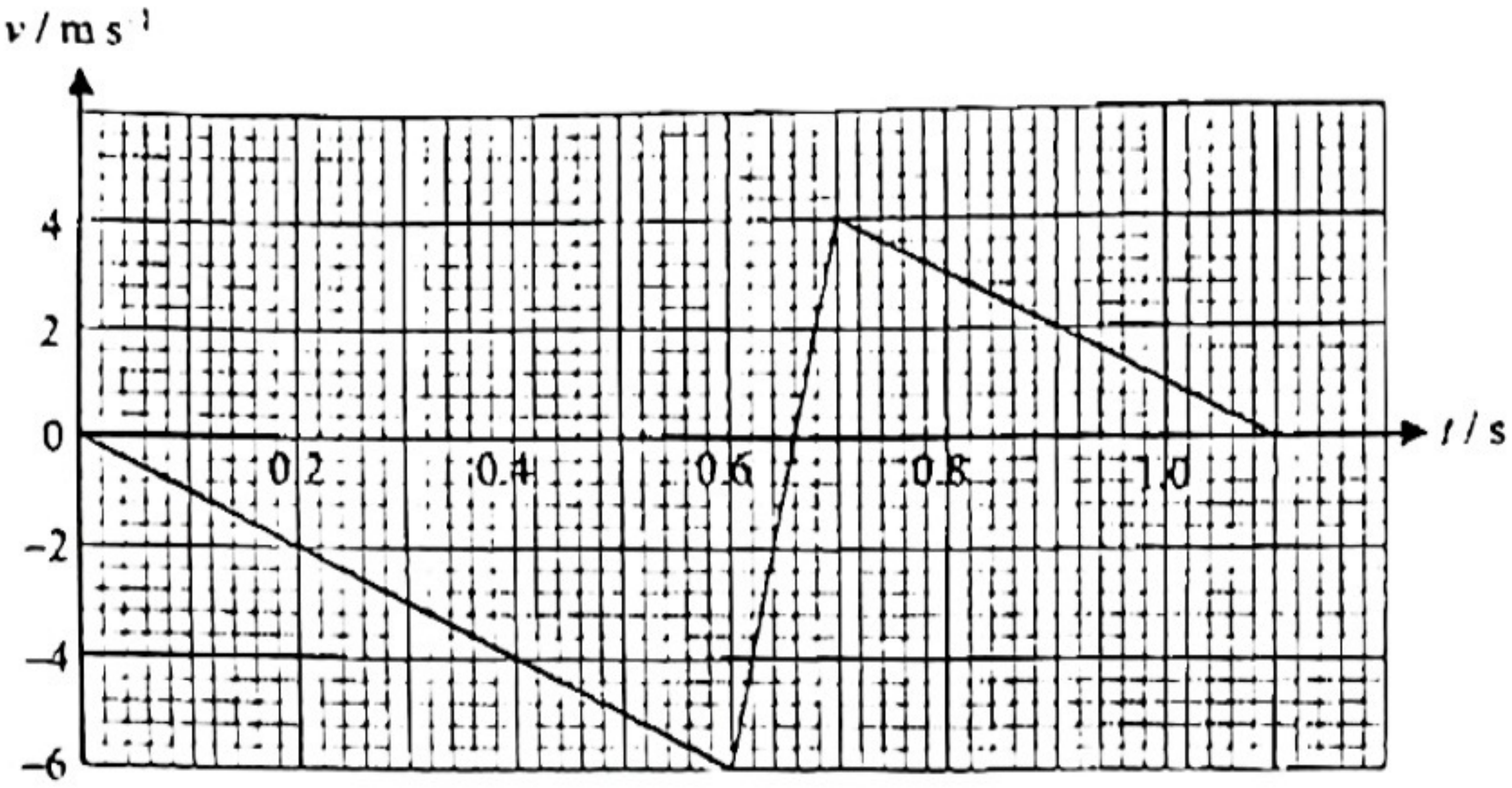
10. 

A boy performs a bungee jump from a bridge above a river. He is tied to the bridge at *A* with an elastic cord. He falls from rest at *A*. When he reaches *B*, the elastic cord starts to stretch. He is momentarily at rest at *C*. Which of the following descriptions about the motion of the boy is/are correct ? (Neglect air resistance.)

(1) The kinetic energy of the boy is increasing from *A* to *B*.
(2) The boy starts to decelerate at the point *B*.
(3) At the point *C*, the acceleration of the boy is zero.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

11.



A ball of mass 0.2 kg is released from rest at a certain height. It hits the ground and rebounds. The velocity-time graph of the ball is shown above. Upward direction is taken as positive. The acceleration due to gravity is taken as 10 m s^{-2}. Which of the following statements is/are correct ?

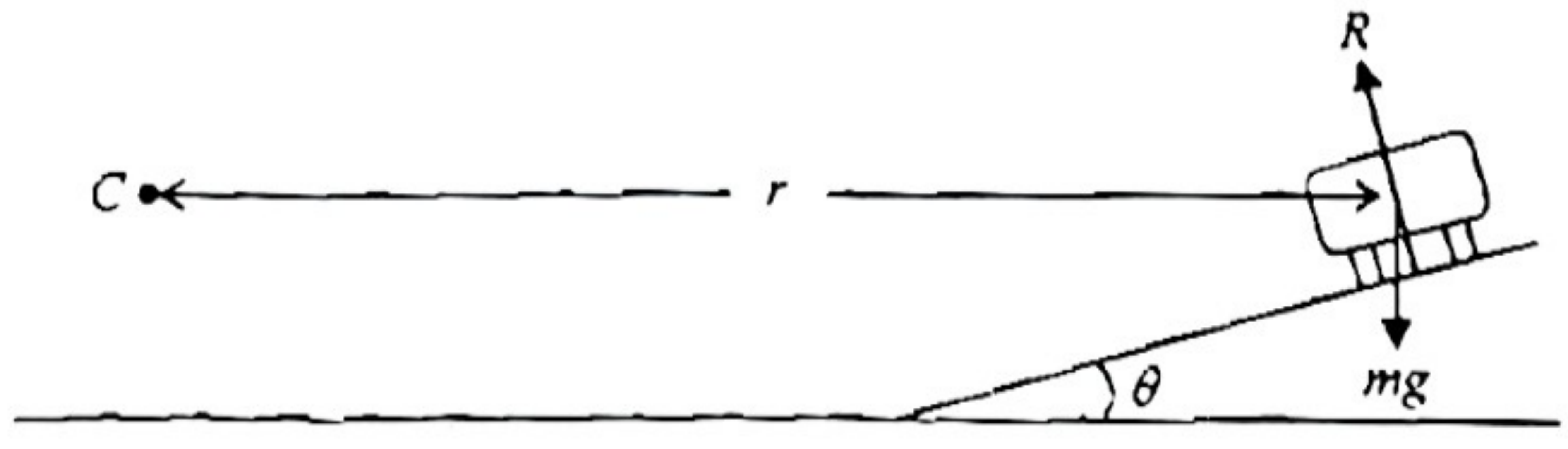
(1) The ball is released at a height of 1.8 m.
(2) The collision of the ball with the ground is an elastic collision.
(3) The magnitude of the average force acting on the ball by the ground during the collision is 20 N.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

12. A small particle is projected horizontally at the top of a table with an initial horizontal velocity of 15 m s^{-1}. The particle performs projectile motion and reaches the ground. If the landing velocity of the particle makes an angle of 30° with the horizontal, what is the height of the table ?

A. 2.87 m
B. 3.82 m
C. 6.24 m
D. 8.60 m

13.



A vehicle of mass m is moving with a constant speed v on an ideal banking road along a horizontal path of radius r. C is the centre of the circular path as shown in the above figure. The angle of inclination of the banked road is θ. Friction on the road surface is assumed negligible. Which of the following statements concerning the motion of the vehicle is/are correct ?

(1) The centripetal force is provided by a component of the weight mg towards the centre of the path.
(2) The normal reaction force R is equal to $mg \cos \theta$.
(3) To travel safely along the circular path, the speed v of the vehicle should be equal to $\sqrt{g r \tan\theta}$.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

14.

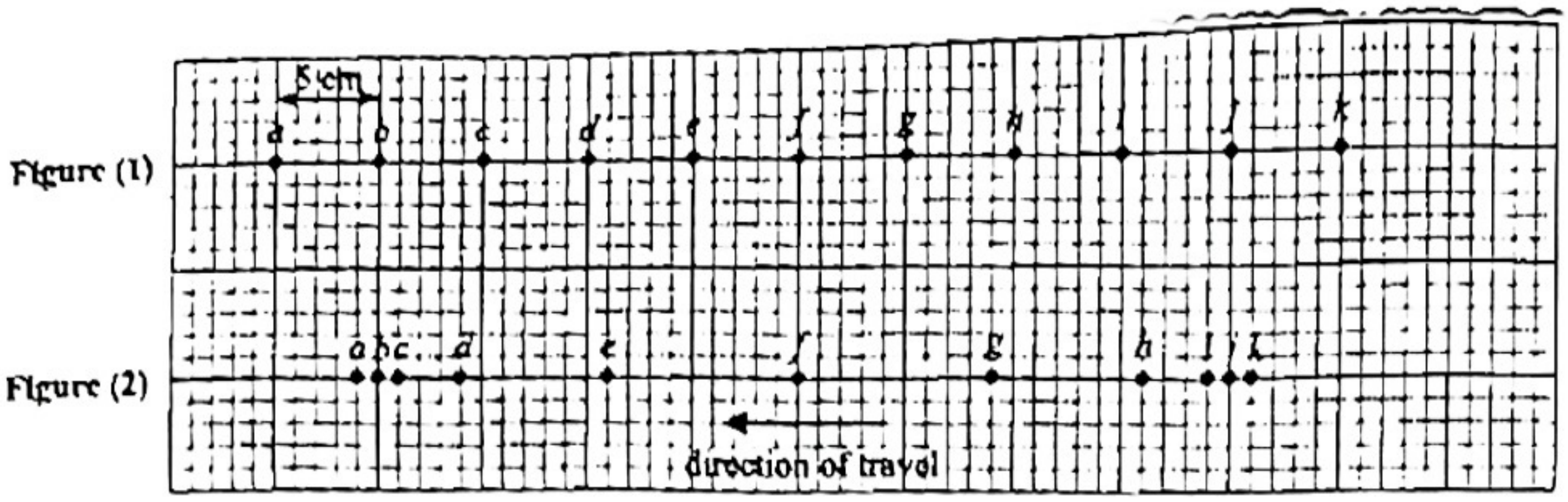
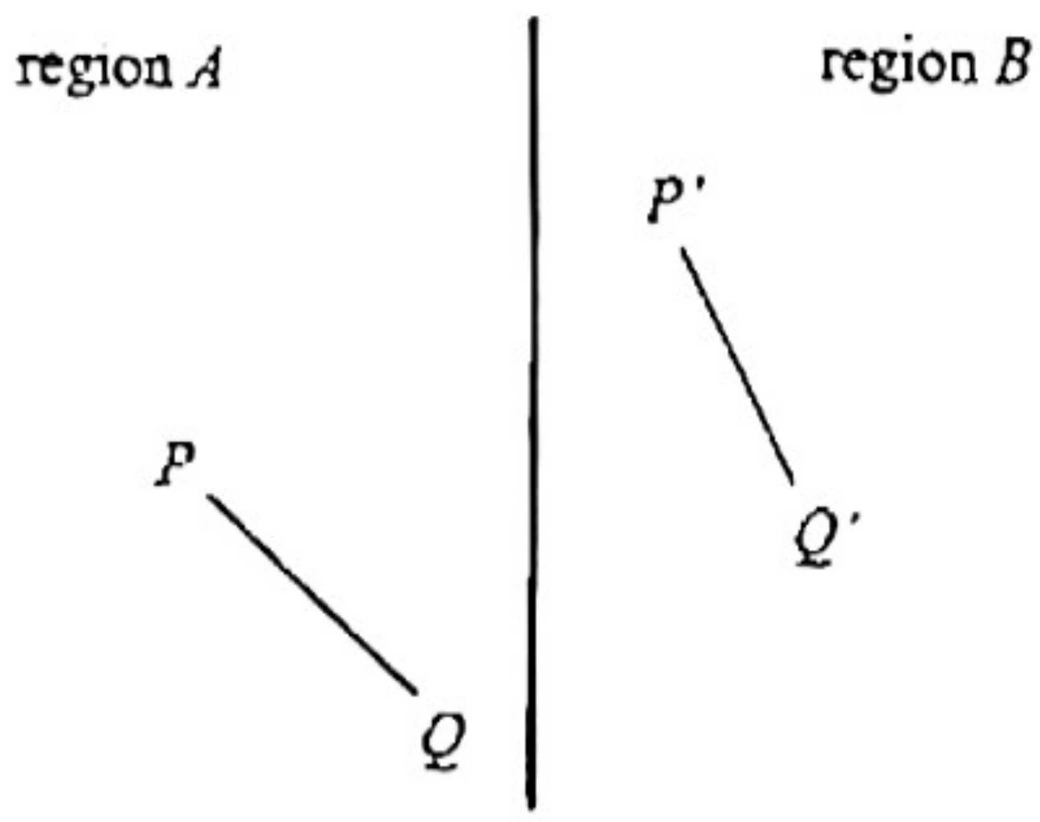


Figure (1) shows the equilibrium positions of particles a to k separated by 5 cm from each other in a medium. A longitudinal wave is travelling from right to left with a speed of 80 cm s^{-1}. At a certain instant, the positions of the particles are shown in Figure (2). Which of the following statements concerning the particles in Figure (2) is/are correct ?

(1) Particle b is moving towards the left.
(2) Particle d is momentarily at rest.
(3) Particles g and i are moving in the same direction.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

15.



The above figure shows two regions in a ripple tank. A series of plane water waves travel from region A to region B. One of the wavefront PQ is shown. After refraction, the wavefront becomes $P'Q'$. Which of the following statements is/are correct ?

(1) Region A is the deep water region and region B is the shallow water region.
(2) After refraction, the wavelength of the water waves decreases.
(3) After refraction, the frequency of the water waves decreases.

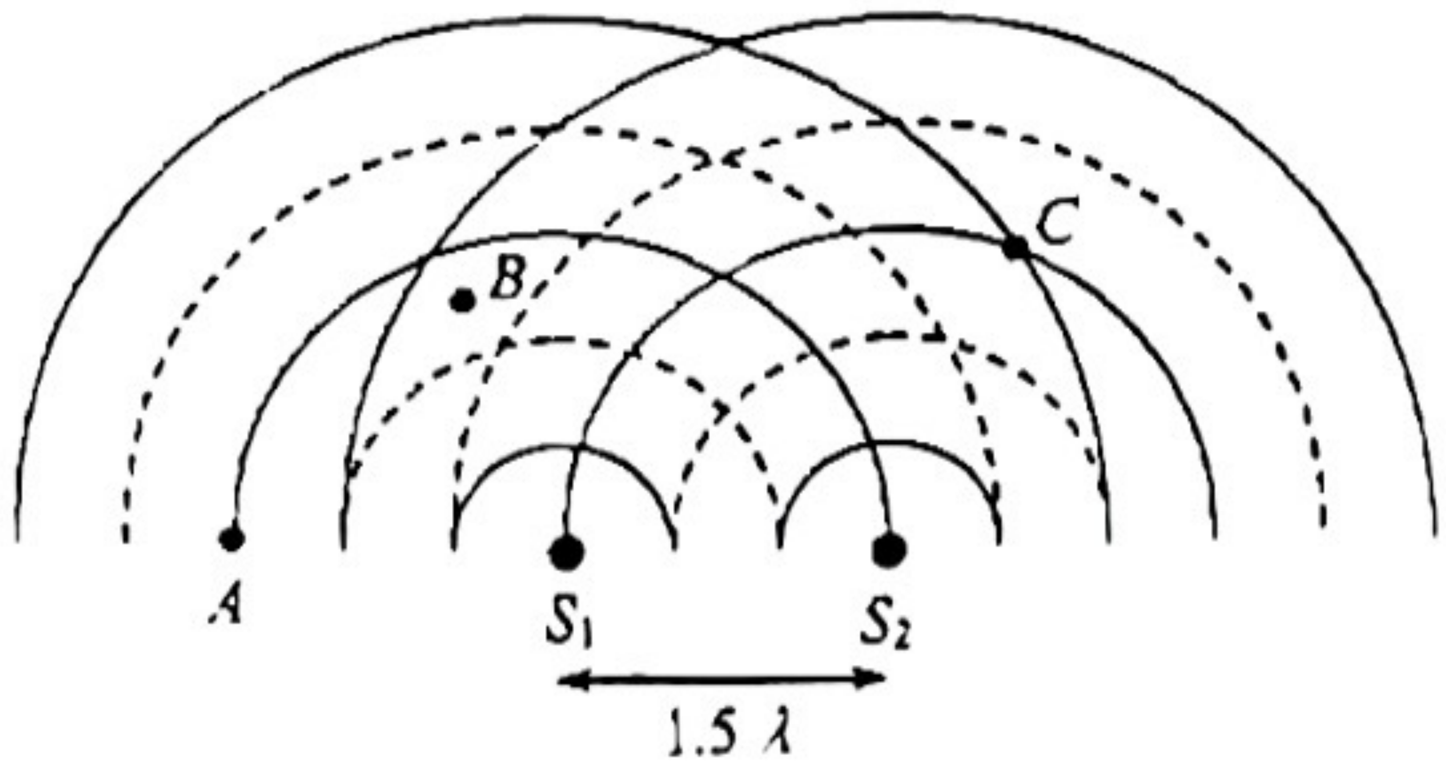
A. (1) only
B. (1) and (2) only
C. (2) and (3) only
D. (1), (2) and (3)

16. A monochromatic light of wavelength 684 nm is incident normally onto a diffraction grating. The first order of bright fringe makes an angle of 20° with the central line. Which of the following deductions are correct ?

(1) The diffraction grating has 500 lines per mm.
(2) The second order occurs at an angle greater than 40°.
(3) There is no third order bright fringe.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

7.

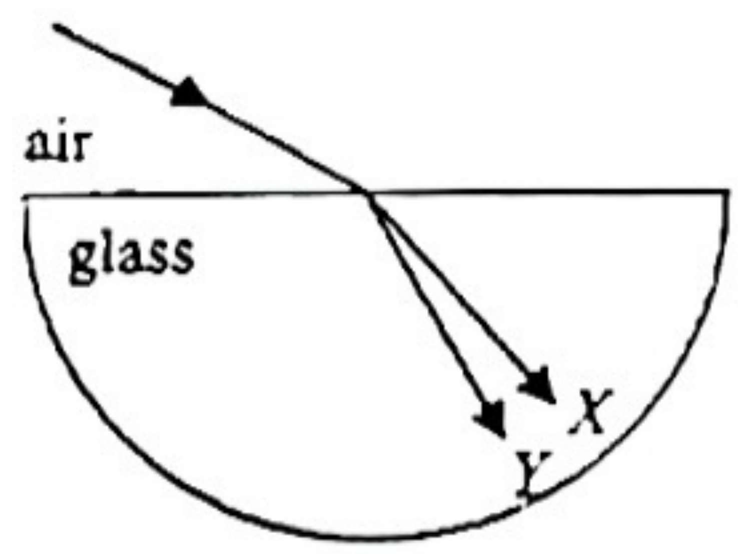


Two point sources S_1 and S_2 are producing circular water waves in a ripple tank. The figure shows the wave pattern at a certain instant. Solid lines represent crests and dotted lines represent troughs. Which of the following statements is/are correct ?

(1) The water particle at A is under destructive interference.
(2) The interference at B is neither constructive nor destructive.
(3) The particle at C is always at the crest.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

8.



Two different coloured lights, X and Y, travel from air to glass. They undergo refraction and split into two different paths in glass as shown. Which of the following descriptions about the two coloured lights is/are correct ?

(1) The speed of X in air is greater than that of Y in air.
(2) The speed of X in glass is greater than that of Y in glass.
(3) The refractive index of glass for X is greater than that for Y.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

9. An object is placed 24 cm in front of a lens. An image with linear magnification of 0.5 is formed. What is the focal length of the lens if the image is

(1) erect ;
(2) inverted ?

	Image is erect	Image is inverted
A.	24 cm	8 cm
B.	12 cm	8 cm
C.	8 cm	12 cm
D.	8 cm	24 cm

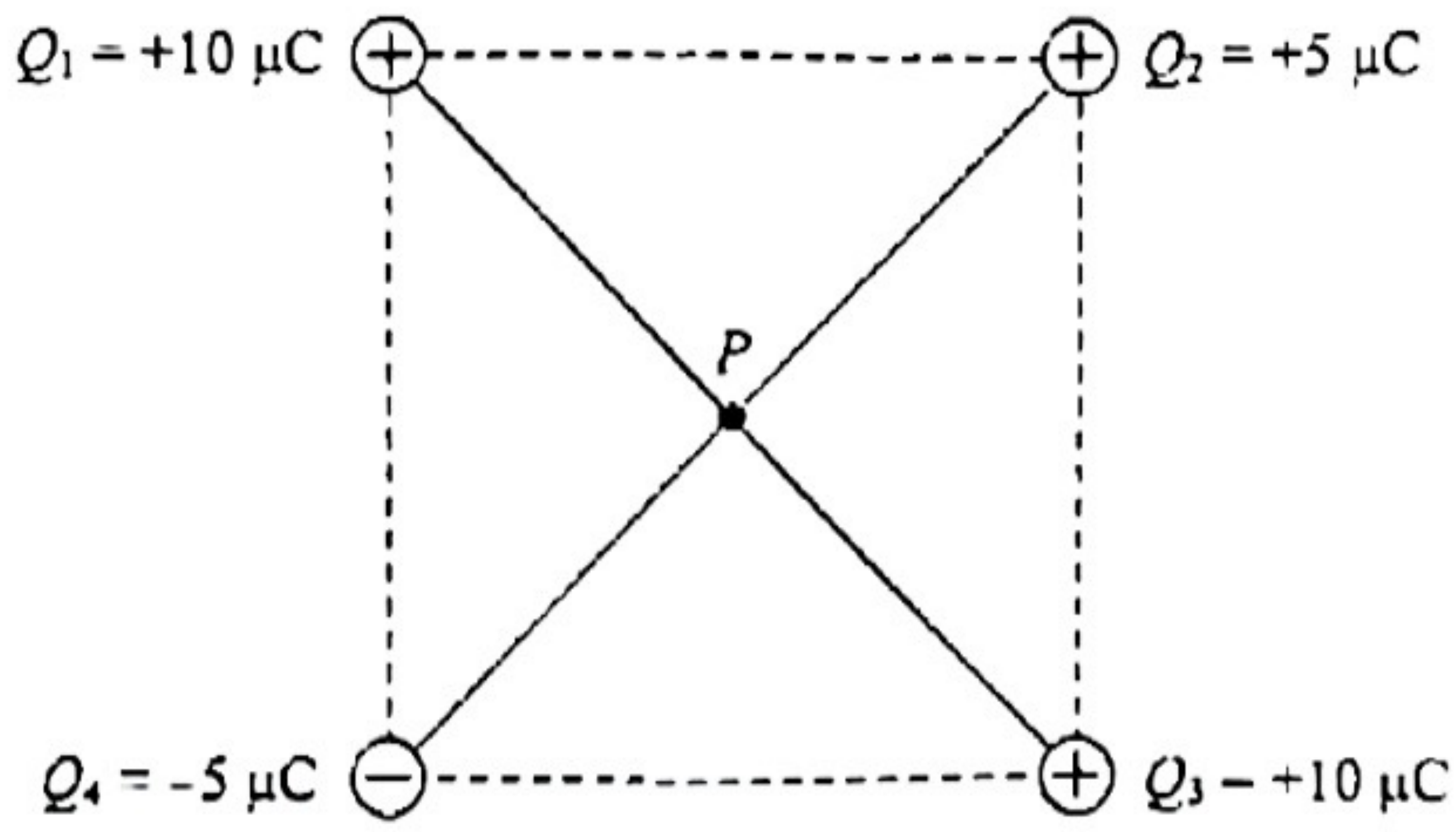
20. Which of the following is **NOT** a correct application of the following electromagnetic waves ?

A. Microwaves are used in satellite communication.
B. Infrared radiation is used in the night-shot function of video camera recorder.
C. Ultraviolet radiation is used to detect survivors buried in earthquake.
D. Gamma radiations are used to kill bacteria in food.

21. A Young's double slit experiment is performed using a monochromatic light source of wavelength 630 nm. The slit separation of the double slit is 0.25 mm. Alternate bright and dark fringes are formed on the screen placed at 1.8 m away from the double slit. What is the separation of the 8th order bright fringe from the central line ?

A. 31.8 mm
B. 36.3 mm
C. 40.8 mm
D. 42.6 mm

22.



As shown in the above figure, there are three positive point charges Q_1, Q_2, Q_3 and one negative point charge Q_4 situated at the four corners of a square. Point P is at the centre of the square. The distance of every charge from the P is 20 mm. Calculate the resultant electric field at the centre P due to the four point charges.

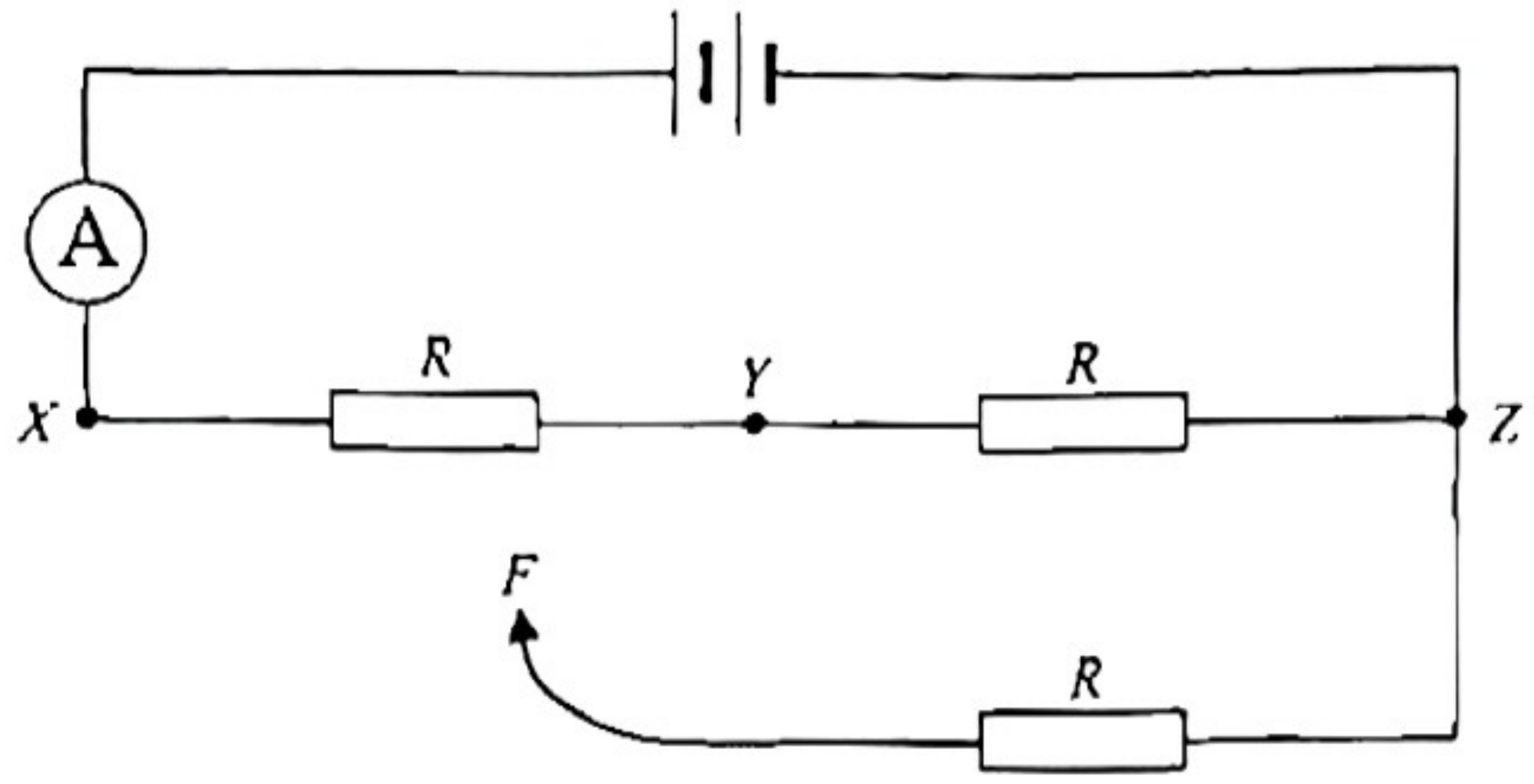
Take $\dfrac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^2 C^{-2}.

A. 1.25×10^8 N C^{-1}
B. 1.75×10^8 N C^{-1}
C. 2.25×10^8 N C^{-1}
D. 4.50×10^8 N C^{-1}

23. Two parallel plates with separation 2.5 cm are connected to a constant voltage supply. A uniform electric field of strength 1.2×10^5 N C^{-1} exists between the two plates. If an electron is released from rest at the negative plate and accelerates towards the positive plate, what is its velocity when it strikes the positive plate ?

A. 2.75×10^7 m s^{-1}
B. 3.25×10^7 m s^{-1}
C. 4.65×10^7 m s^{-1}
D. 6.15×10^7 m s^{-1}

4.



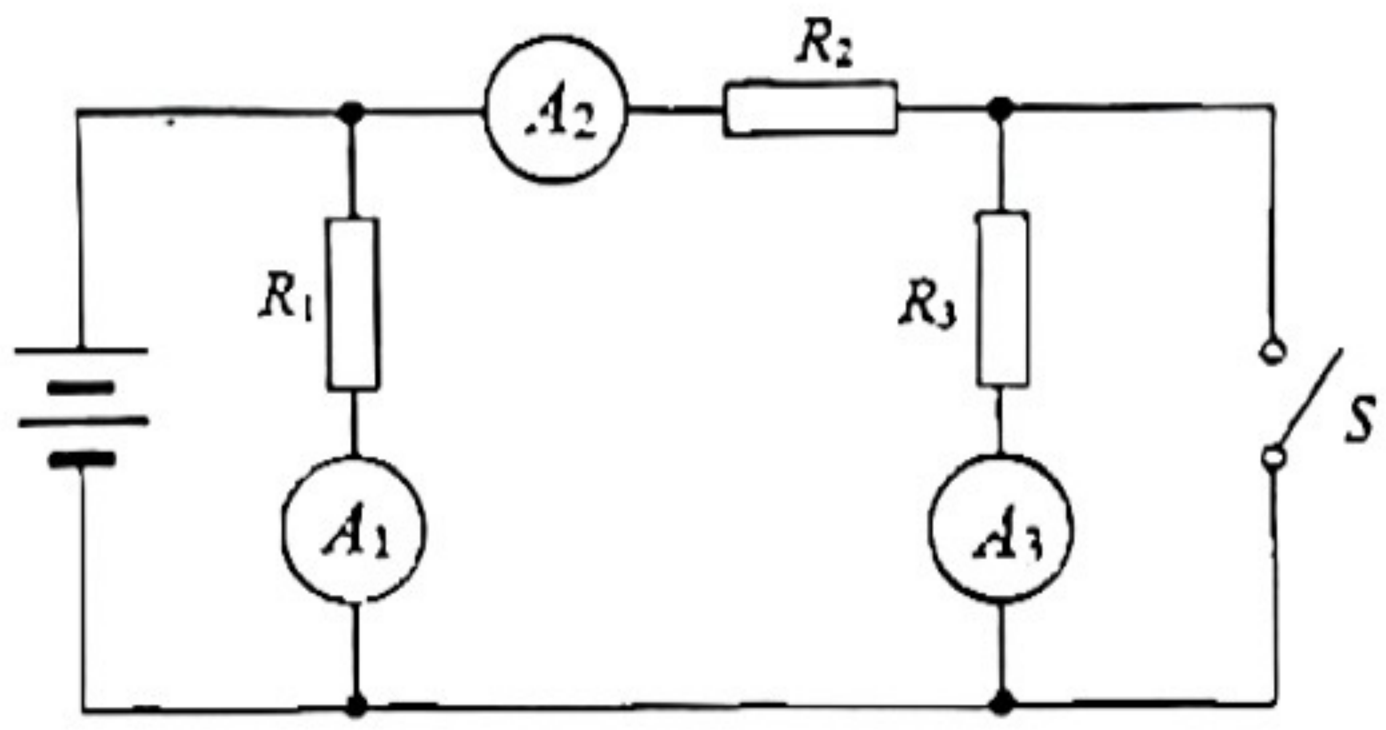
In the above circuit, the three resistors R are identical. The battery has negligible internal resistance. A flying lead F can be connected to different points of the circuit as shown. The following list shows the reading of the ammeter for different connections :

Flying lead F connected to X : reading of ammeter is A_1
Flying lead F connected to Y : reading of ammeter is A_2
Flying lead F connected to Z : reading of ammeter is A_3

Arrange the three ammeter readings in ascending order.

A. $A_1 < A_2 < A_3$
B. $A_2 < A_3 < A_1$
C. $A_3 < A_1 < A_2$
D. $A_3 < A_2 < A_1$

5.



In the above circuit, the three resistors are identical. The internal resistance of the battery is negligible. The ammeters are all ideal. Which of the following statements are correct if the switch S is closed ?

(1) The reading of A_1 remains unchanged.
(2) The reading of A_2 increases.
(3) The power given out by the battery increases.

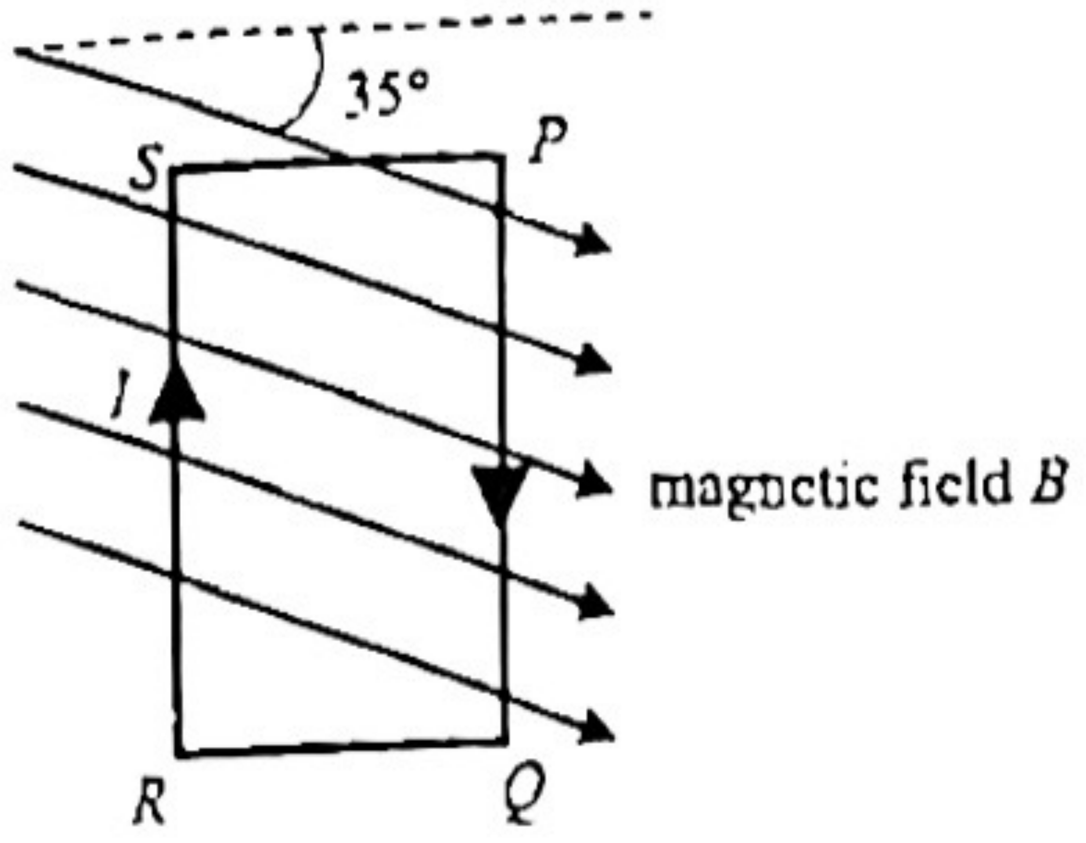
A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

26 Two light bulbs X and Y are of ratings "120 V, 60 W" and "120 V, 120 W" respectively. If they are connected in series to the 240 V mains supply, which of the followings are correct ?

(1) The brightness of X is less than that of Y.
(2) The operating resistance of X is greater than that of Y.
(3) The power given out by X is more than 60 W.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

27.

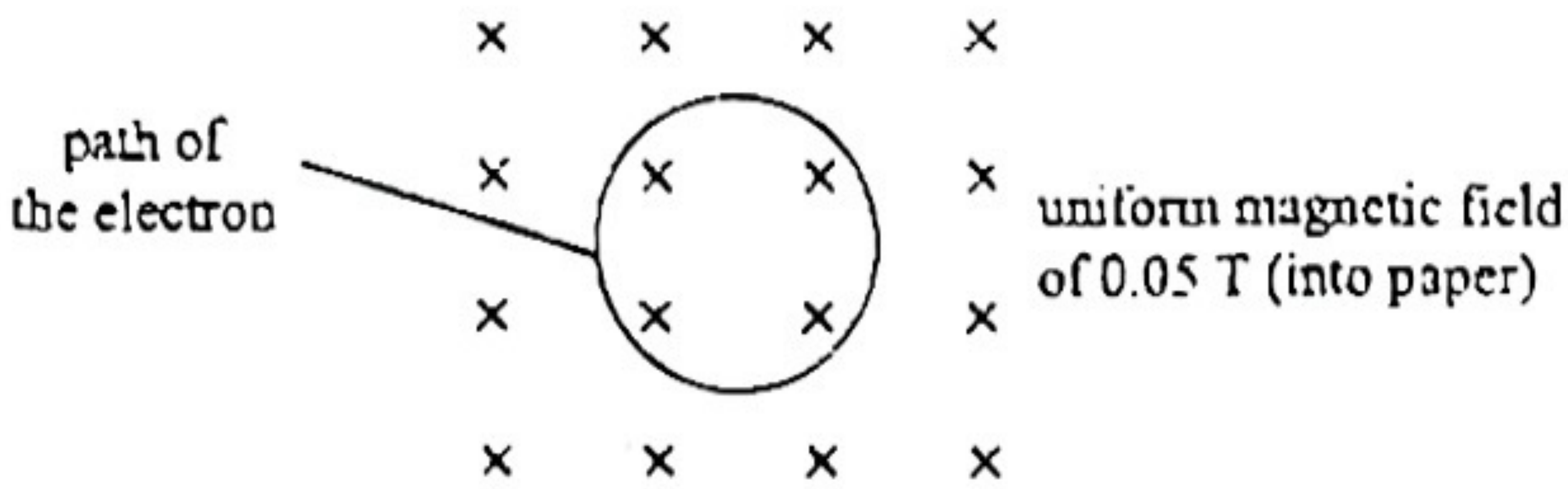


A rectangular loop $PQRS$ is placed in a region of uniform magnetic field of 0.6 T with direction shown in the above figure. The current flowing through the loop is 2 A in the clockwise direction as indicated. The segment PQ has a length of 40 cm. Which of the following statements are correct ?

(1) The direction of the magnetic force acting on the segment PQ is perpendicularly out of paper.
(2) The magnitude of the magnetic force acting on the segment PQ is 0.275 N.
(3) The resultant force acting on the whole loop is zero.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

28.



An electron moves in a circular path of diameter 0.02 m in a plane with a uniform magnetic field of 0.05 T pointing perpendicular into the paper.

Which of the following statements are correct ?

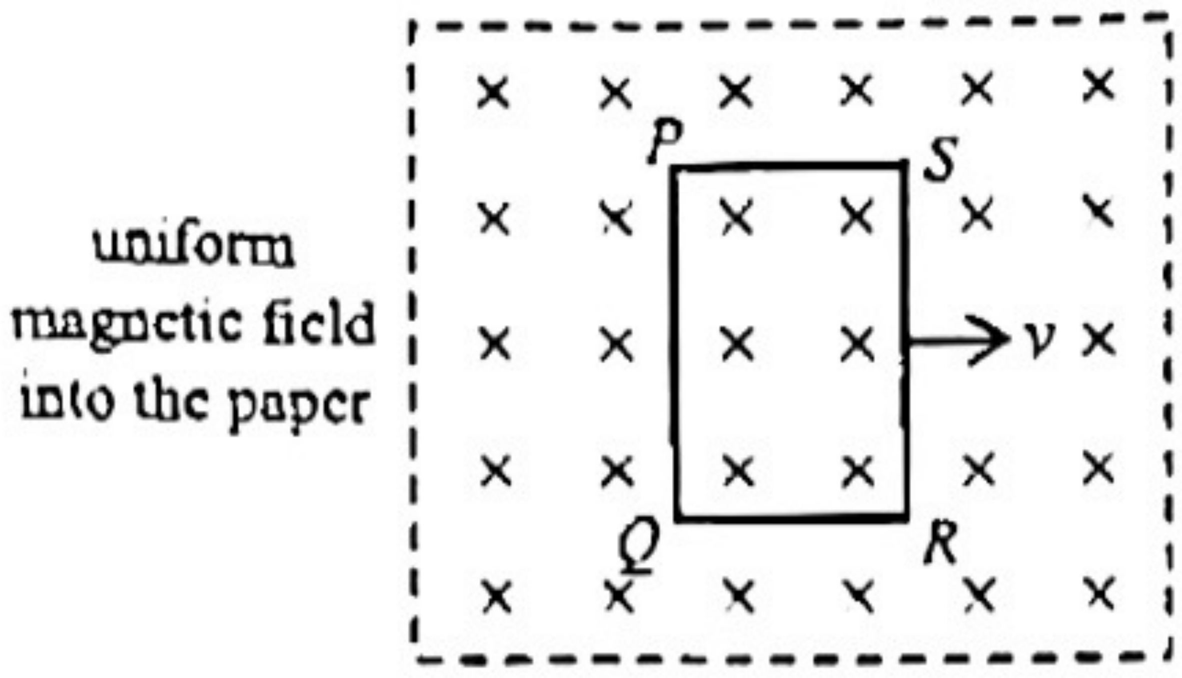
(1) The electron moves in anticlockwise direction.
(2) The speed of the electron is 8.78×10^{7} m s^{-1}.
(3) The period of revolution of the electron is 7.15×10^{-10} s.

A. (1) and (2) only
B (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

29. A long solenoid has a radius of 5 cm and a turn density of 300 m^{-1}. A steady current of 2 A flows through the solenoid. What is the magnetic flux through the solenoid ?

A. 3.64×10^{-6} Wb
B 5.92×10^{-6} Wb
C. 7.26×10^{-6} Wb
D. 8.37×10^{-6} Wb

0.



A rectangular metal frame $PQRS$ is moving with constant velocity inside a region of uniform magnetic field perpendicularly into the paper. Which of the following statements is/are correct when the frame is at the position shown in the above figure ?

(1) The point P is at a higher potential than Q.
(2) An induced current flows in the frame.
(3) An opposing magnetic force acts on the frame.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

1. A radioisotope has an initial activity of 2000 Bq. After 10 minutes, its activity drops to 800 Bq. What is its activity after a further 5 minutes ?

A. 210 Bq
B. 506 Bq
C. 642 Bq
D. 1265 Bq

2

$$W \xrightarrow{\beta} X \xrightarrow{\alpha} Y \xrightarrow{\beta} Z$$

$$P \xrightarrow{\alpha} Q \xrightarrow{\beta} R \xrightarrow{\alpha} S$$

In the above two decay series, X and Q are two isotopes. Which of the following pairs of nuclides are isotopes to each other ?

(1) W and S
(2) Z and P
(3) Z and S

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

3. A star radiates energy at a constant rate of 1.5×10^{26} W by nuclear fusion process. During the fusion process, 0.09% of mass is converted into energy. If the star consists of pure hydrogen and its total mass is 2×10^{28} kg, calculate the lifetime of the star. Given that 1 year = 3.15×10^{7} s

A. 2.68×10^{8} years
B. 3.43×10^{8} years
C. 4.15×10^{8} years
D. 5.92×10^{8} years

END OF SECTION A

List of data, formulae and relationships

Data

molar gas constant	$R = 8.31\ \text{J mol}^{-1}\ \text{K}^{-1}$
Avogadro constant	$N_A = 6.02 \times 10^{23}\ \text{mol}^{-1}$
acceleration due to gravity	$g = 9.81\ \text{m s}^{-2}$ (close to the Earth)
universal gravitational constant	$G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$
speed of light in vacuum	$c = 3.00 \times 10^8\ \text{m s}^{-1}$
charge of electron	$e = 1.60 \times 10^{-19}\ \text{C}$
electron rest mass	$m_e = 9.11 \times 10^{-31}\ \text{kg}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2\ \text{N}^{-1}\ \text{m}^{-2}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\ \text{H m}^{-1}$
atomic mass unit	$u = 1.661 \times 10^{-27}\ \text{kg}$ (1 u is equivalent to 931 MeV)
astronomical unit	$AU = 1.50 \times 10^{11}\ \text{m}$
light year	$ly = 9.46 \times 10^{15}\ \text{m}$
parsec	$pc = 3.09 \times 10^{16}\ \text{m} = 3.26\ \text{ly} = 206265\ \text{AU}$
Stefan constant	$\sigma = 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$
Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$

Rectilinear motion

For uniformly accelerated motion :

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

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

Mathematics

Equation of a straight line	$y = mx + c$
Arc length	$= r\theta$
Surface area of cylinder	$= 2\pi rh + 2\pi r^2$
Volume of cylinder	$= \pi r^2 h$
Surface area of sphere	$= 4\pi r^2$
Volume of sphere	$= \frac{4}{3}\pi r^3$

For small angles, $\sin\theta \approx \tan\theta \approx \theta$ (in radian)

Astronomy and Space Science

$U = -\frac{GMm}{r}$	gravitational potential energy
$P = \sigma A T^4$	Stefan's law
$\left\lvert\frac{\Delta f}{f_0}\right\rvert \approx \frac{v}{c} \approx \left\lvert\frac{\Delta\lambda}{\lambda_0}\right\rvert$	Doppler effect

Energy and Use of Energy

$E = \frac{\Phi}{A}$	illuminance
$\frac{Q}{t} = k\frac{A(T_H - T_C)}{d}$	rate of energy transfer by conduction
$U = \frac{k}{d}$	thermal transmittance U-value
$P = \frac{1}{2}\rho A v^3$	maximum power by wind turbine

Atomic World

$\frac{1}{2}m_e v_{max}^2 = hf - \phi$	Einstein's photoelectric equation
$E_n = -\frac{13.6}{n^2}\text{eV}$	energy level equation for hydrogen atom
$\lambda = \frac{h}{p} = \frac{h}{mv}$	de Broglie formula
$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)

Medical Physics

$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)
$\text{power} = \frac{1}{f}$	power of a lens
$L = 10\log\frac{I}{I_0}$	intensity level (dB)
$Z = \rho c$	acoustic impedance
$\alpha = \frac{I_r}{I_0} = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$	intensity reflection coefficient
$I = I_0 e^{-\mu x}$	transmitted intensity through a medium

A1.	$E = mc\Delta T$	energy transfer during heating and cooling
A2.	$E = l\,\Delta m$	energy transfer during change of state
A3.	$pV = nRT$	equation of state for an ideal gas
A4.	$pV = \frac{1}{3}Nm\overline{c^2}$	kinetic theory equation
A5.	$E_k = \frac{3RT}{2N_A}$	molecular kinetic energy
B1.	$F = m\frac{\Delta v}{\Delta t} = \frac{\Delta p}{\Delta t}$	force
B2.	moment $= F \times d$	moment of a force
B3.	$E_p = m\,g\,h$	gravitational potential energy
B4.	$E_k = \frac{1}{2}mv^2$	kinetic energy
B5.	$P = Fv = \frac{W}{t}$	mechanical power
B6.	$a = \frac{v^2}{r} = \omega^2 r$	centripetal acceleration
B7.	$F = \frac{Gm_1m_2}{r^2}$	Newton's law of gravitation
C1.	$\Delta y = \frac{\lambda D}{a}$	fringe width in double-slit interference
C2.	$d\sin\theta = n\lambda$	diffraction grating equation
C3.	$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$	equation for a single lens

D1.	$F = \frac{Q_1Q_2}{4\pi\varepsilon_0 r^2}$	Coulomb's law
D2.	$E = \frac{Q}{4\pi\varepsilon_0 r^2}$	electric field strength due to a point charge
D3.	$E = \frac{V}{d}$	electric field between parallel plates (numerically)
D4.	$R = \frac{\rho l}{A}$	resistance and resistivity
D5.	$R = R_1 + R_2$	resistors in series
D6.	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$	resistors in parallel
D7.	$P = IV = I^2R$	power in a circuit
D8.	$F = BQv\sin\theta$	force on a moving charge in a magnetic field
D9.	$F = BIl\sin\theta$	force on a current-carrying conductor in a magnetic field
D10.	$B = \frac{\mu_0 I}{2\pi r}$	magnetic field due to a long straight wire
D11.	$B = \frac{\mu_0 NI}{l}$	magnetic field inside a long solenoid
D12.	$\varepsilon = N\frac{\Delta\Phi}{\Delta t}$	induced e.m.f.
D13.	$\frac{V_s}{V_p} = \frac{N_s}{N_p}$	ratio of secondary voltage to primary voltage in a transformer
E1.	$N = N_0 e^{-kt}$	law of radioactive decay
E2.	$t_{\frac{1}{2}} = \frac{\ln 2}{k}$	half-life and decay constant
E3.	$A = kN$	activity and the number of undecayed nuclei
E4.	$E = mc^2$	mass-energy relationship

Hong Kong Diploma of Secondary Education Examination

2014

Mock Examination

PHYSICS PAPER 1

SECTION B : Question-Answer Book B

This paper must be answered in English

Please stick the barcode label here

Candidate Number

Question No.	Marks
1	7
2	8
3	12
4	7
5	7
6	5
7	8
8	12
9	9
10	9

INSTRUCTIONS FOR SECTION B

(1) After the announcement of the start of the examination, you should first write you Candidate Number in the space provided on Page 1 and stick barcode labels in the spaces provided.

(2) Refer to the general instructions on the cover of the Question Paper for Section A

(3) Answer **ALL** questions.

(4) Write your answers in the spaces provided in this Question-Answer Book. Do not write in the margins. Answers written in the margins will not be marked.

(5) Graph paper and supplementary answer sheets will be provided on request. Write your candidate number, mark the questions box and stick a barcode label on each sheet, and fasten them with string **INSIDE** this Question-Answer Book.

(6) No extra time will be given to candidates for sticking on the barcode labels or filling in the question number boxes after the 'Time is up' announcement.

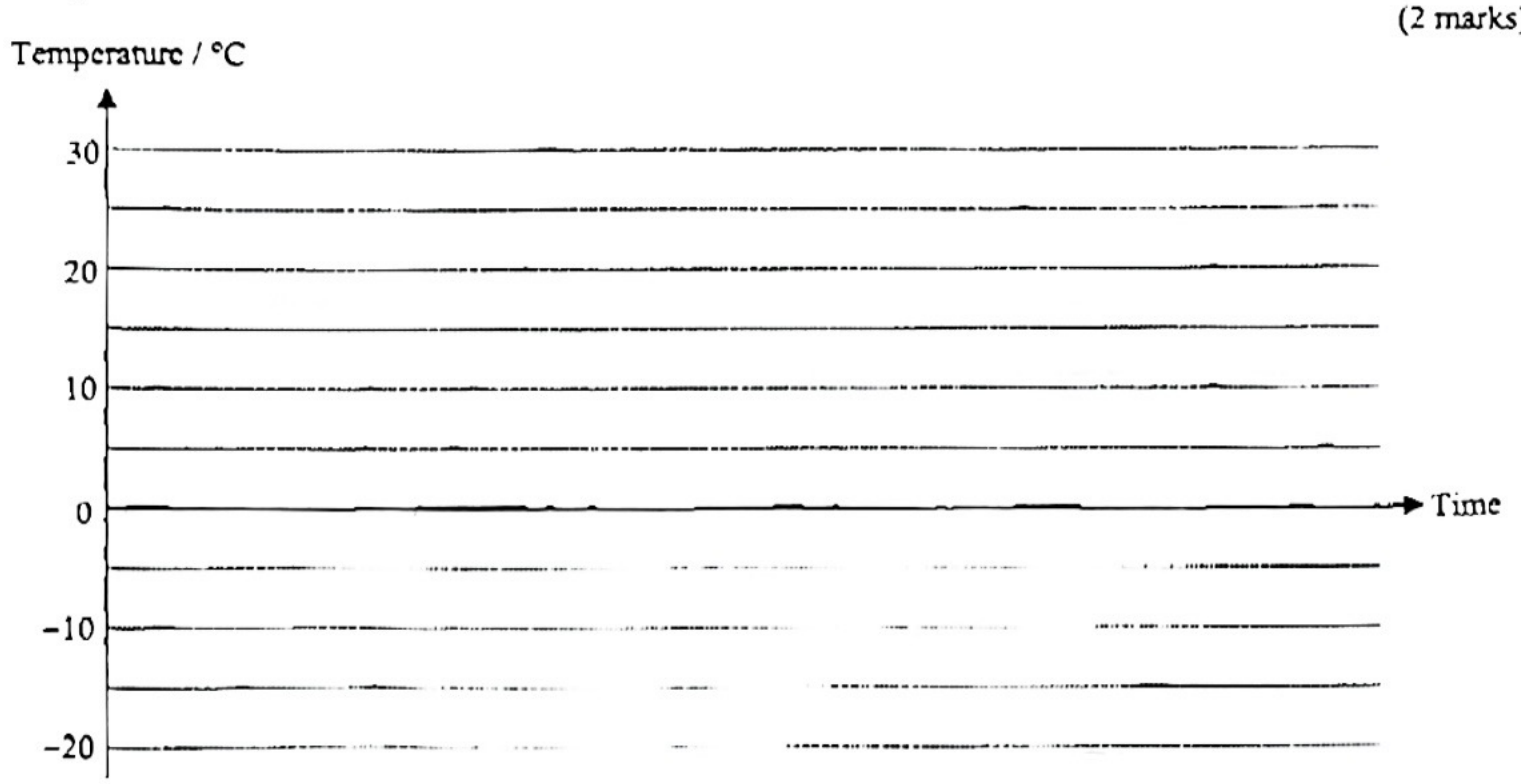
Section B : Answer ALL questions. Write your answers in the spaces provided

1 A piece of ice is taken out from the freezer of a refrigerator. The temperature of the freezer is kept at a constant temperature of −15°C. The piece of ice is put in a beaker and the beaker is placed in the laboratory. The room temperature inside the laboratory is kept at a constant temperature of 25°C.

Given : specific heat capacity of ice = 2200 J kg^{-1} °C^{-1}
specific heat capacity of water = 4200 J kg^{-1} °C^{-1}
specific latent heat of fusion of ice = 334 000 J kg^{-1}

(a) Sketch on the below graph to show the time variation of the temperature of the ice until its temperature becomes steady.

(2 marks)



(b) Suppose another piece of ice is taken out from the freezer. The mass of the ice is found to be 0.1 kg.

(i) Calculate the total amount of heat absorbed by the ice when it changes to 0°C of water. (2 marks)

....

....

(ii) If the piece of ice at −15°C is put into a polystyrene cup containing water of mass 0.5 kg at an initial temperature of 60°C, using the above result, calculate the final temperature of the mixture. Assume no heat exchange with the surroundings (2 marks)

....

....

....

(iii) After the temperature of the mixture becomes steady, the total mass of the mixture is found to be slightly less than 0.6 kg, which is the total initial mass of the ice and water. Suggest a possible reason for this. (1 mark)

....

....

2.

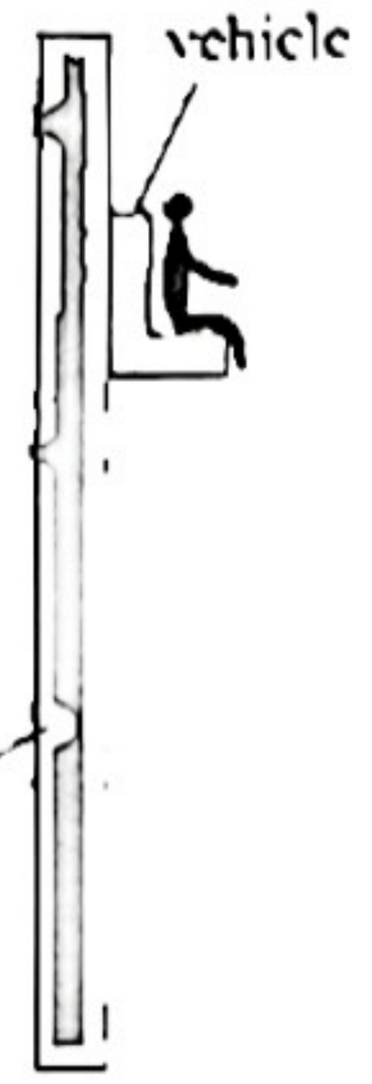


Figure (a)

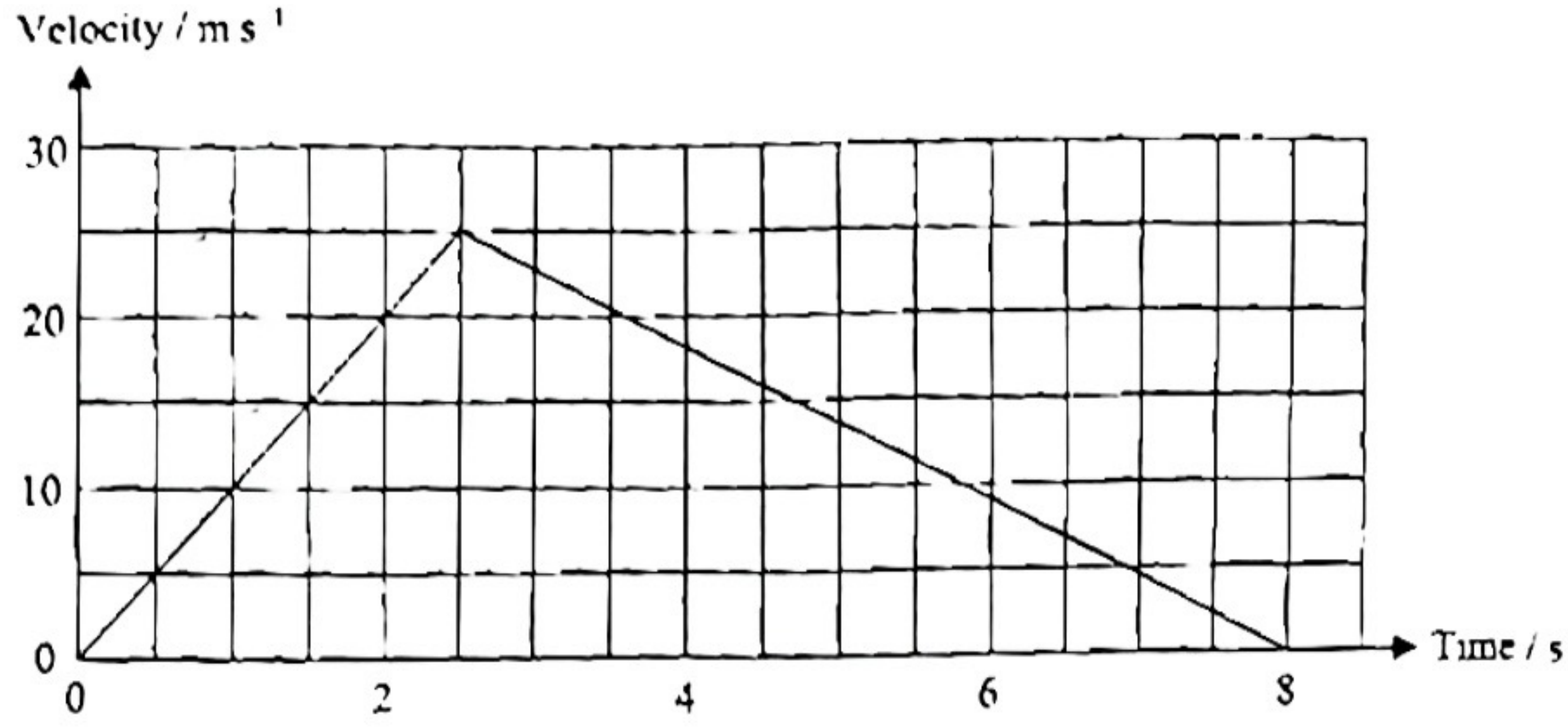


Figure (b)

Figure (a) above shows the "Mega Drop" in an amusement park. The vehicle carrying passengers is lifted up by an electric motor. Once it reaches the top of the tower, the vehicle remains at rest for a while. It is then released and falls under gravity. When the vehicle gets close to the ground, it decelerates downward and finally stops at the ground. Figure (b) shows the variation of the velocity of the vehicle with time as the vehicle is released at $t = 0$ s. Downward direction is taken as positive. The acceleration due to gravity is assumed to be 10 m s^{-2}

(a) When the passenger is at rest, he experiences an upward supporting force acting on him by the seat. State which force forms an action and reaction pair with this supporting force. (1 mark)

....

....

(b) For safety purpose, the passenger is fixed with a wide elastic belt. State two reasons that why a thin rigid wire is not suitable in this situation. (2 marks)

....

....

....

....

(c) Calculate the height of the passenger above the ground when the vehicle is just released. (2 marks)

....

....

....

(d) If the mass of the passenger is 80 kg, calculate the magnitude of the supporting force F acting on him by the seat during the time interval of deceleration (3 marks)

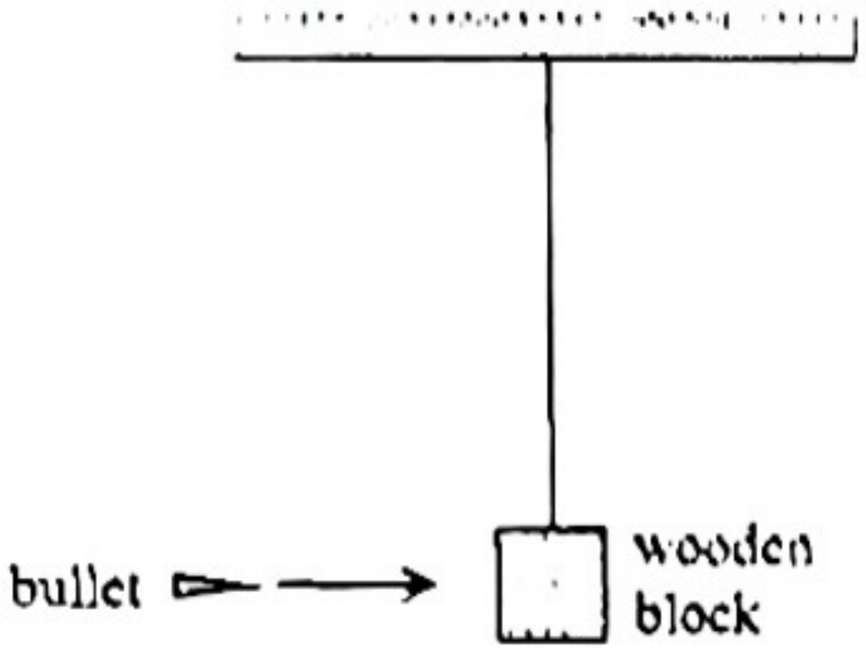
....

....

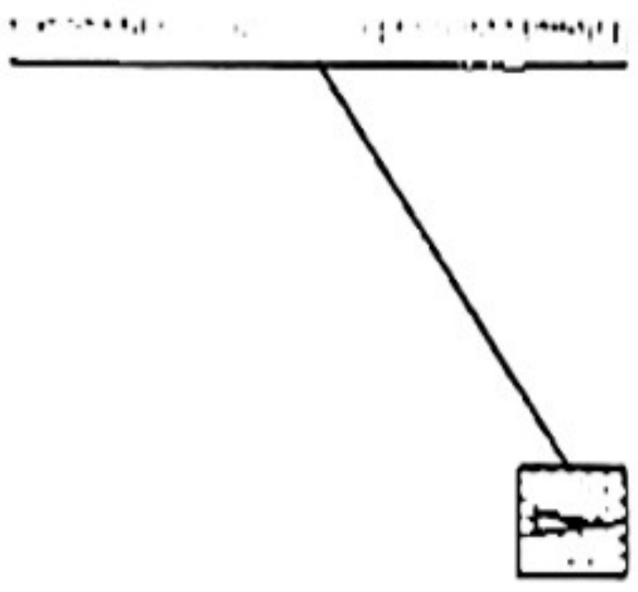
....

....

Answers written in the margins will not be marked.



A wooden block of mass 1.24 kg is hanging freely in the air from a light string of length 20 cm. A bullet of mass 10 g travelling at a speed of 200 m s^{-1} hits the block and becomes embedded in it. The block then swings upwards as shown in the figure below.



(a) Calculate the common velocity of the wooden block and the bullet after the hitting. (2 marks)

....

....

....

(b) Calculate the maximum height above its original position that the block can rise after the hitting by the bullet. (2 marks)

....

....

....

(c) If the embedment of the bullet into the wooden block takes a time of 5 ms, calculate the force acting on the block by the bullet during the impact. (2 marks)

....

....

....

(d) At the maximum height, the wooden block is momentarily at rest. Draw and label all the forces acting on the block at this position. (2 marks)

Answers written in the margins will not be marked.

(e) Comment on the following two statements : (2 marks)

Statement (1) : "During the hitting of the bullet on the wooden block, the total mechanical energy is conserved."

....

....

....

....

Statement (2) : "After the hitting by the bullet, the wooden block rises up. During this motion, the momentum of the wooden block is conserved."

....

....

....

....

(f) If the bullet hits the wooden block with the same initial speed but now it rebounds backwards instead of embedding into the block, describe and explain how the maximum height reached by the block would be affected. (2 marks)

....

....

....

....

....

....

....

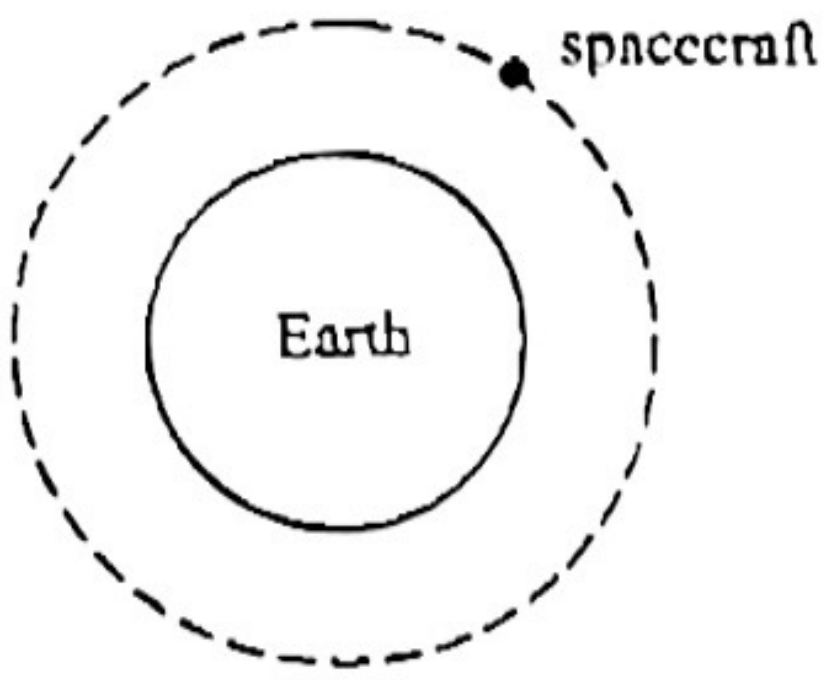
....

....

....

Answers written in the margins will not be marked.

6. A spacecraft is sent to a circular orbit at a height of 750 km above the Earth's surface. When the spacecraft reaches the orbit, the engine is shut off. Given that the radius of the Earth is 6380 km.



(a) Calculate the strength of the gravitational field g at the circular orbit. (2 marks)

....

....

....

....

(b) Explain whether the weight has work done on the spacecraft or not. (1 mark)

....

....

....

....

(c) Determine the speed of the spacecraft in the circular orbit. (2 marks)

....

....

....

....

....

(d) How many number of revolutions does the spacecraft take in 24 hours ? (2 marks)

....

....

....

....

....

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

5.

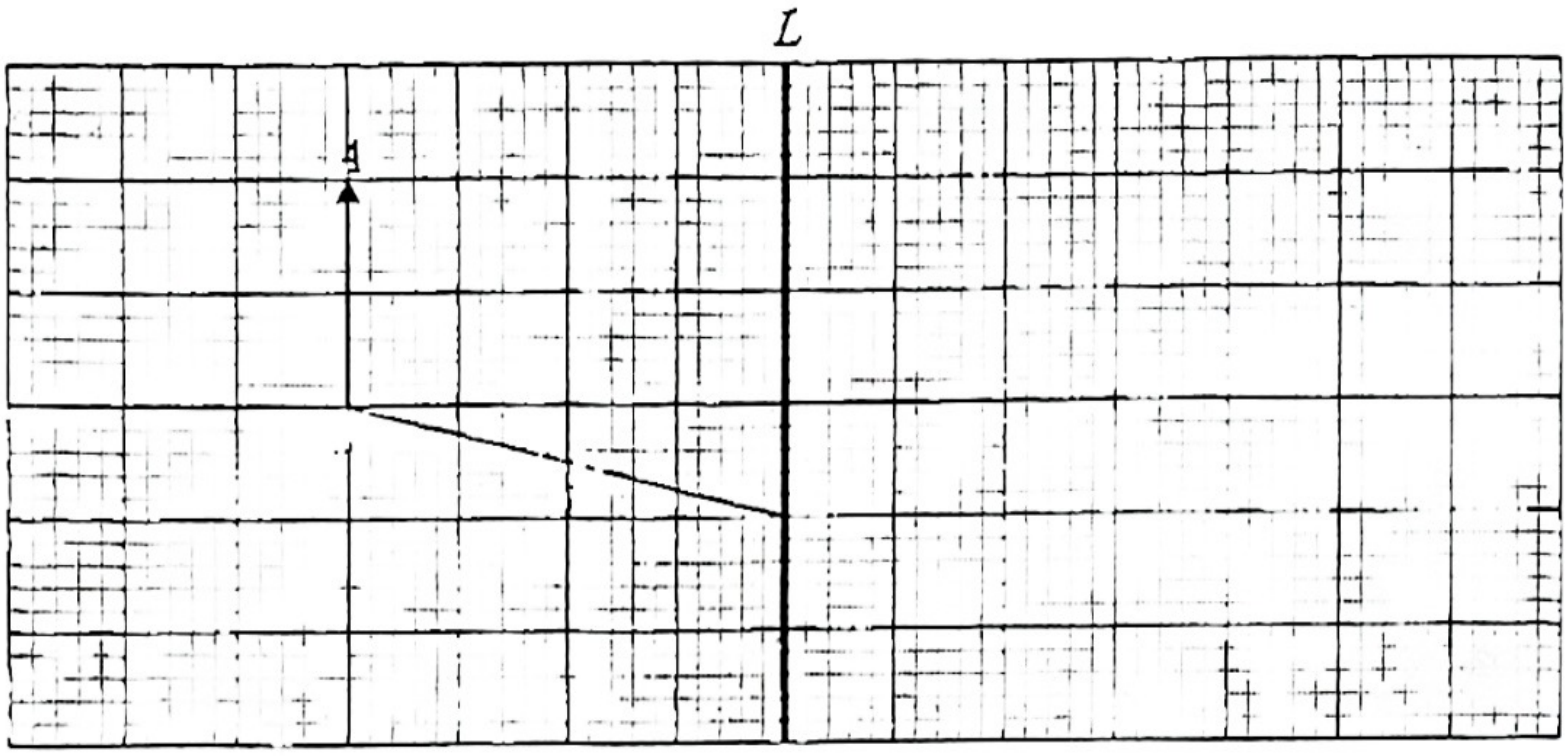
A lens L is used to observe the image of a baby. The image in the lens is shown in the above figure.

(a) State the type of lens that has been used. Explain your answer. (2 marks)

....

....

(b) The figure below shows the object AB representing the baby and the lens L.



(i) If the magnification of the image is 0.6, draw the position of the image in the figure. (1 mark)

(ii) Complete the light ray p in the above figure. (1 mark)

(iii) Mark the position of the principal focus F by drawing a suitable light ray in the above figure. (1 mark)

(c) What would be the change of size of the image if the lens is moved slightly towards the baby ? (1 mark)

....

....

(d) State an application of this type of lens. (1 mark)

....

....

Answers written in the margins will not be marked.

6 You are provided with the following list of apparatus :

- a signal generator
- two identical loudspeakers
- a microphone
- a CRO

Describe how you should use the apparatus to conduct an experiment to demonstrate the interference of sound waves.

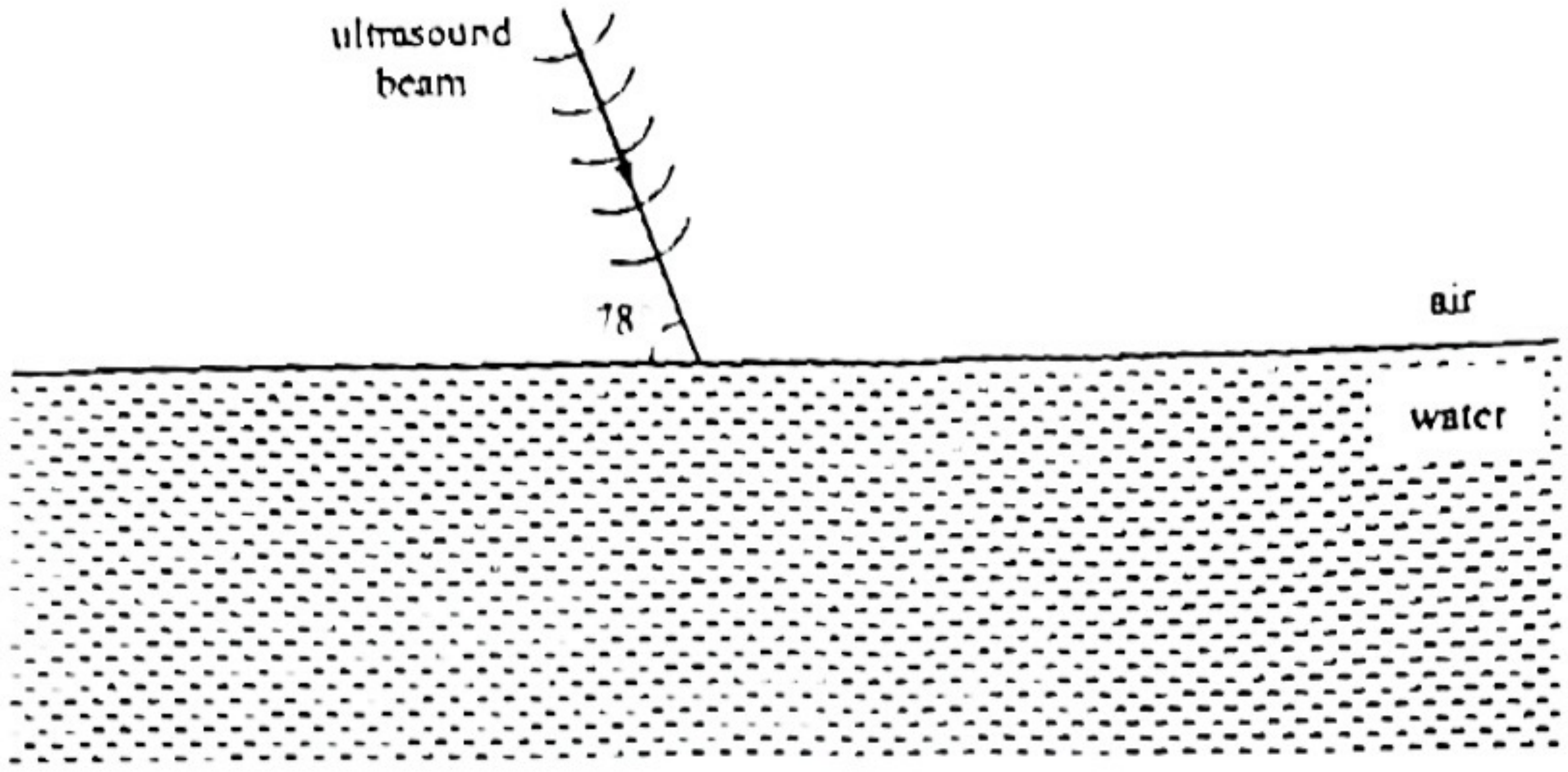
The description should include the adjustment on the CRO. Describe the result that would be expected.

(5 marks)

Answers written in the margins will not be marked

Answers written in the margins will not be marked.

7.



A beam of ultrasound with frequency 30000 Hz travels from air to water as shown in the above figure. Given that speeds of sound in air and water are 340 m s^{-1} and 1500 m s^{-1} respectively.

(a) Calculate the angle refraction in water as the ultrasound enters the water from air. (2 marks)

....

....

....

(b) Explain whether it is possible for the ultrasound to undergo total internal reflection at certain angles of incidence when it travels from air to water. (2 marks)

....

....

....

(c) Ultrasound is used in sonar system to detect submarines under water.

(i) Suppose a submarine is vertically beneath the water surface at a depth of 240 m. A ship sends a pulse of ultrasound from the water surface to detect the submarine. Calculate the time taken for the echo of the ultrasound to reflect back to the ship. (2 marks)

....

....

....

(ii) Explain why radar is not used in such an application. (1 mark)

....

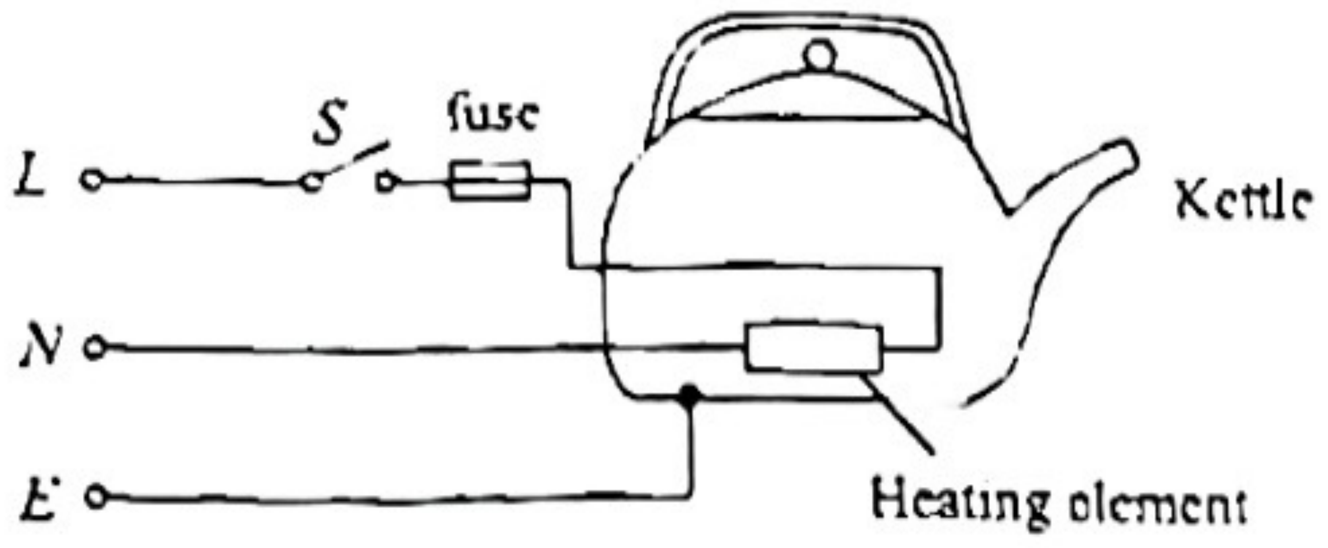
....

(iii) Explain why audible sound is not suitable to be used in sonar system. (2 marks)

....

....

Answers written in the margins will not be marked.



The above Figure shows an electric kettle of rating "220 V 2800 W". The kettle contains water of mass 1.8 kg at an initial temperature of 25°C.

(a) The connecting cable of the kettle consists of Earth wire E. What is the function of the Earth wire ? (2 marks)

....

....

....

(b) For safety purpose, a fuse should be installed to the kettle. Among the following fuse values : 10-A, 15-A, 20-A, which one is the most suitable ? Explain why the other two fuses are not suitable. (3 marks)

....

....

....

....

....

....

(c) The heater is placed at the bottom of the heater.

(i) Explain how the convection of water is set up. (2 marks)

....

....

....

....

....

(ii) State the advantage of placing the heater at the bottom to give convection. (1 mark)

....

....

....

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

(d) Now the kettle is switched on. Assume that there is 20% of heat lost to the surrounding air and the kettle, what is the mass of water boiled off from the kettle after 10 minutes ?

Given : specific heat capacity of water = 4200 J kg^{-1} °C^{-1}

specific latent heat of vaporization of water = 2.26×10^6 J kg^{-1} (2 marks)

....

....

....

....

....

....

....

....

(e) During boiling, air bubbles are formed. Suppose an air bubble is formed at the bottom of the heater. It then rises to the water surface. During the rise, the temperature of air inside the bubble remains unchanged. The pressure at the water surface is lower than that at the bottom. Using Kinetic Theory, explain the change of volume as the air bubble rises up to the water surface. (2 marks)

....

....

....

....

....

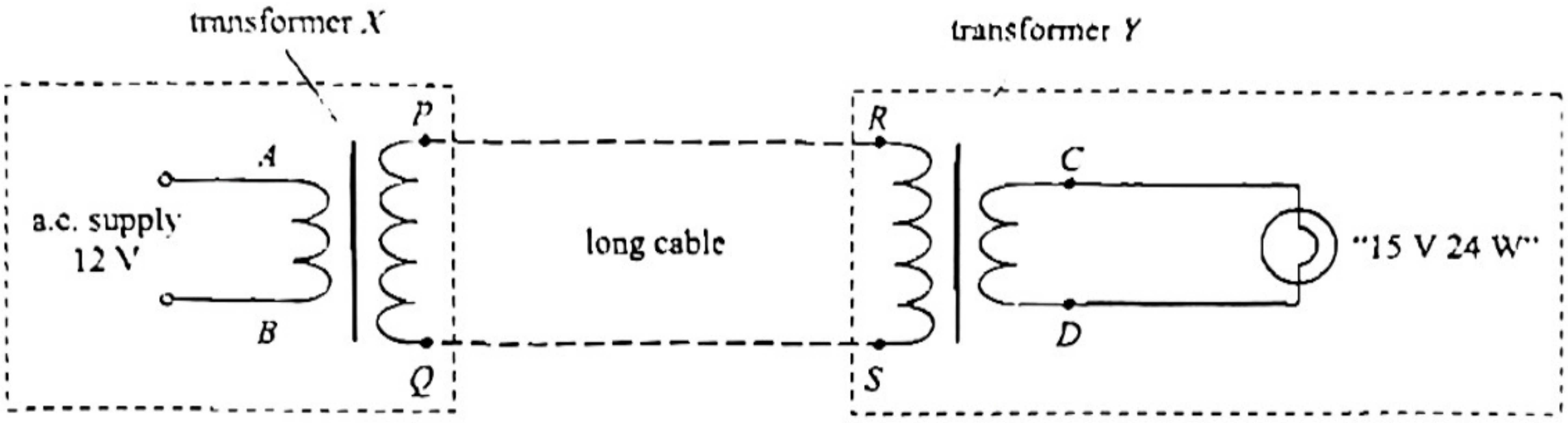
....

....

....

....

Answers written in the margins will not be marked.



The above figure shows the power transmission of a lighting system. An a.c. supply of 12 V is connected to *AB* of transformer *X* as shown. The a.c. voltage is then stepped up by transformer *X* and then transmitted through a long cable. Each wire of the cable, *PR* and *QS*, has a resistance of 10 Ω. At the end of the cable, the voltage is then stepped down by transformer *Y* to give the normal working of a lighting system. The rating values of the lighting system is "15 V 24 W". The two transformers are assumed to be ideal. Turns ratio of the transformer *Y* is 200 : 50.

(a) Calculate the voltage across *RS*. (1 mark)

....

....

(b) Calculate the current through the long cable. (2 marks)

....

....

(c) Calculate the power loss in the long cable. Hence determine the efficiency of this lighting system. (2 marks)

....

....

....

(d) Calculate the voltage across *PQ*. (1 mark)

....

....

(e) For the transformer *X*, if the number of turn in the secondary coil is 340, what is the number of turn in the primary coil ? (1 mark)

....

....

(f) Explain how the use of high voltage can increase the efficiency of power transmission through the long cable. (2 marks)

....

....

....

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

10. Polonium-218 (Po-218) has a half-life of 3.08 minutes. It decays by emitting an α particle as shown in the following nuclear equation :

$$^{218}_{84}\text{Po} \longrightarrow {}^{214}_{82}\text{Pb} + {}^{4}_{2}\text{He}$$

Given that the mass of one mole of Po-218 is 218 g.

(a) If each alpha particle carries an energy of 5.2 MeV, calculate the mass defect in the above nuclear reaction Express your answer in kg. Neglect the energy carried by the daughter nucleus. (2 marks)

....

....

....

....

(b) Calculate the decay constant of Po-218. State the physical meaning of the decay constant. (2 marks)

....

....

....

....

....

(c) A sample consists of pure Po-218. It has an activity of 25 MBq. Calculate the mass of the sample. (3 marks)

....

....

....

....

....

(d) Give TWO reasons that Po-218 is not suitable to be used as medical tracer. (2 marks)

....

....

....

....

....

END OF PAPER

Answers written in the margins will not be marked.

Hong Kong Diploma of Secondary Education Examination

2014

Mock Examination

PHYSICS PAPER 2

Question-Answer Book

(1 hour)

This paper must be answered in English

Please stick the barcode label here.

Candidate Number									

INSTRUCTIONS

(1) After the announcement of the start of the examination, you should first write you Candidate Number in the space provided on Page 1 and stick barcode labels in the spaces provided.

(2) This paper consists of **FOUR** sections, Section A, B, C and D. Each section contains eight multiple-choice questions and one structured question which carries 10 marks. Attempt **ALL** question in any **TWO** sections.

(3) Write your answers in the spaces provided in this Question-Answer Book. Do not write in the margins. Answers written in the margins will not be marked. For multiple-choice questions, blacken the appropriate circle with an HB pencil. You should mark only **ONE** answer for each question. If you mark more than one answer, you will receive **NO MARKS** for that question.

(4) Graph paper and supplementary answer sheets will be provided on request. Write your candidate number, mark the questions box and stick a barcode label on each sheet, and fasten them with string **INSIDE** this Question-Answer Book.

(5) The diagrams in this paper are NOT necessarily drawn to scale.

(6) The last pages of this Question-Answer Book contain a list of data, formulae and relationship which you may find useful.

(7) No extra time will be given to candidates for sticking on the barcode labels or filling in the question number boxes after the 'Time is up' announcement.

Section A : Astronomy and Space Science

Q.1 : Multiple-choice questions

1.1 Arrange the following astronomical bodies in ascending order of their typical sizes :

(1) stellar cluster
(2) star
(3) galaxy
(4) satellite
(5) planet

A. (4), (5), (2), (1), (3)
B. (5), (4), (1), (2), (3)
C. (4), (5), (2), (3), (1)
D. (4), (2), (5), (1), (3)

A B C D
○ ○ ○ ○

1.2 Galileo has made some important astronomical discoveries through the observation by telescope. Which of the followings is NOT one of his discoveries ?

A. Celestial bodies are not perfect sphere.
B. The Earth is not the centre of the orbit of every celestial body.
C. The orbits of the planets are not circular.
D. Venus shows complete cycle of phases.

A B C D
○ ○ ○ ○

1.3 The famous Halley's Comet (哈雷彗星) can be observed at the Earth periodically. The last time that it can be observed is in the year of 1986. The next time to be observed is in 2061. What is the length of the major axis of this comet ?

A. 2.7×10^{12} m
B. 3.6×10^{12} m
C. 5.3×10^{12} m
D. 6.8×10^{12} m

A B C D
○ ○ ○ ○

1.4 The luminosity of the Sun is 3.9×10^{26} W. What is the brightness of the Sun observed at the Earth ?

A. 1380 W m^{-2}
B. 1950 W m^{-2}
C. 2380 W m^{-2}
D. 4780 W m^{-2}

A B C D
○ ○ ○ ○

1.5 A space capsule of mass 500 kg is projected with the velocity of escape from a planet's surface. When the object is at distance r from the planet's centre, its gravitational potential energy is equal to -2.56×10^{9} J. What is its speed at this position ? (Take the potential energy to be zero at infinity.)

A. 2260 m s^{-1}
B. 3200 m s^{-1}
C. 4530 m s^{-1}
D. 6400 m s^{-1}

A B C D
○ ○ ○ ○

1.6 Star X has an angular shift of 0.16 arcsecond when it is viewed from the two opposite extremes of the Earth's orbit over a time interval of 6 months. Estimate the distance of star X from the Earth. Express the answer in light year.

A. 20 ly
B. 29 ly
C. 41 ly
D. 58 ly

A B C D
○ ○ ○ ○

1.7 A star is about 6 kpc from the centre of a spiral galaxy and its rotational speed about the centre is 320 km s^{-1}. Assume that most of the mass of this galaxy is concentrated at the centre. Estimate the mass of this galaxy.

A. 2.01×10^{41} kg
B. 2.85×10^{41} kg
C. 4.03×10^{41} kg
D. 5.69×10^{41} kg

A B C D
○ ○ ○ ○

1.8

A star is moving at a velocity of 650 km s^{-1} making an angle of 40° to the line of sight from the Earth as shown. If the star emits a spectral line of wavelength 524.65 nm, what would be the apparent wavelength of this spectral line observed at the Earth ?

A. 523.78 nm
B 523.92 nm
C 525.52 nm
D 525.58 nm

A B C D
○ ○ ○ ○

Q.1 : Structured question

The table below shows some information on three stars X, Y and Z.

	Absolute magnitude M	Apparent magnitude m	Spectral class
Star X	− 2.0	+ 4.0	B
Star Y	+ 10.0	+ 3.0	B
Star Z	2.0	+ 1.0	K

(a) From the above table :

(i) state which star appears to be the brightest as observing from the Earth ; (1 mark)

(ii) State which star is the farthest away from the Earth ; (1 mark)

(iii) State and explain which star in the table is a white wharf. (2 marks)

(b) Calculate the ratio of $\frac{L_X}{L_Y}$ where L_X , L_Y are the luminosity of the stars X and Y respectively. (2 marks)

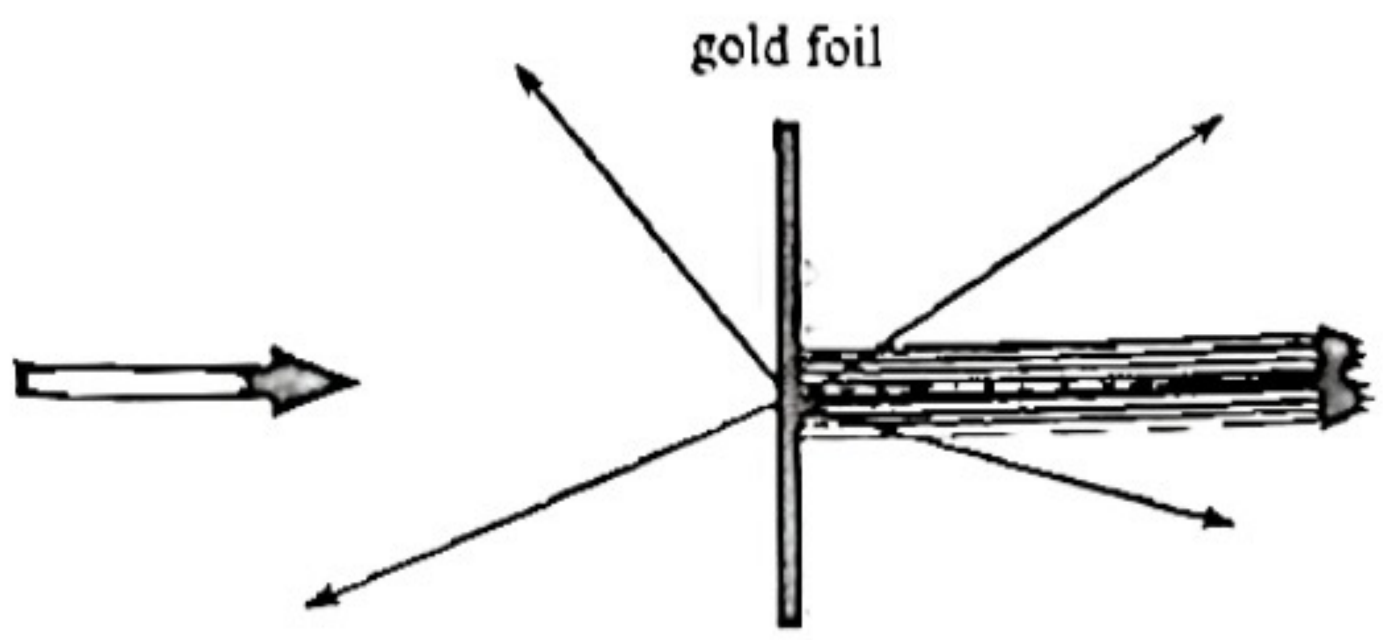
(c) Write down the ratio of the brightness of the star X between its absolute magnitude M and apparent magnitude m. Hence calculate the distance of the star X from the Earth. (2 marks)

(d) Suppose the surface temperatures of stars X and Z are 15000 K and 3600 K respectively. Calculate the ratio $\frac{R_X}{R_Z}$ where R_X and R_Z are the radii of stars X and Z respectively. (2 marks)

Section B : Atomic World

Q.2 : Multiple-choice questions

2.1



In Rutherford scattering experiment, alpha particles are used to bombard a thin gold foil. Which of the following statements about this experiment is/are correct ?

(1) The alpha particles are scattered in random directions.
(2) The size of the nucleus of the gold atom relative to that of the gold atom can be estimated.
(3) The internal structure of the nucleus of the gold atom can be known.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

A B C D
○ ○ ○ ○

2.2 A beam of monochromatic light is incident on a metal of work function 2 eV. The maximum speed of the photoelectrons emitted is found to be 4.8×10^{5} m s^{-1}. Calculate the wavelength of the monochromatic light.

A. 4.26×10^{-7} m
B. 4.68×10^{-7} m
C. 5.34×10^{-7} m
D. 6.19×10^{-7} m

A B C D
○ ○ ○ ○

2.3 In an experiment to investigate the photoelectric effect, a beam of monochromatic light is incident onto a metal plate to emit photoelectrons. The maximum kinetic energy of the photoelectrons emitted is

A. independent of the intensity of the incident light.
B. independent of the type of metal.
C. directly proportional to the frequency of the incident light.
D. directly proportional to the intensity of the incident light.

A B C D
○ ○ ○ ○

2.4 A proton has a mass of 1.67×10^{-27} kg and it carries a charge with the same magnitude as that of an electron. In order to give protons the de Broglie wavelength of 2.5×10^{-12} m, what should be the accelerated voltage for the protons that are starting from rest ?

A. 132 V
B. 256 V
C. 542 V
D. 695 V

A B C D
○ ○ ○ ○

2.5 A beam of monochromatic green light is incident onto the cathode of a photocell. Photoelectrons are emitted at the cathode. The anode can be made positive to accelerate the photoelectrons to give the saturation, or made negative to give the stopping potential. If now the green light is replaced by yellow light with the same intensity, what would be the effect on :

(1) the saturation current
(2) the stopping potential

	Saturation current	Stopping potential
A.	unchanged	increase
B.	unchanged	decrease
C.	increase	increase
D.	increase	decrease

A B C D
○ ○ ○ ○

2.6 Two small point objects emitting red light of wavelength 650 nm are observed by a human eye. The distance of the two objects from the eye is 2.4 m. If the diameter of the pupil of the eye is 2.8 mm, calculate the minimum separation of the two objects that can be resolved by the eye.

A. 0.34 mm
B. 0.48 mm
C. 0.68 mm
D. 0.96 mm

A B C D
○ ○ ○ ○

2.7 Which of the followings correctly describe(s) the function of the electromagnetic lens system used in a Transmission Electron Microscope (TEM) ?

(1) The electromagnetic lens system accelerates the electron beam to a high enough speed.
(2) The electromagnetic lens system works with a principle similar to a concave lens of an optical system.
(3) The electromagnetic lens system allows the electrons with a small range of well-defined energy to pass through.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

A B C D
○ ○ ○ ○

2.8 Which of the following may be the possible applications of nanotechnology ?

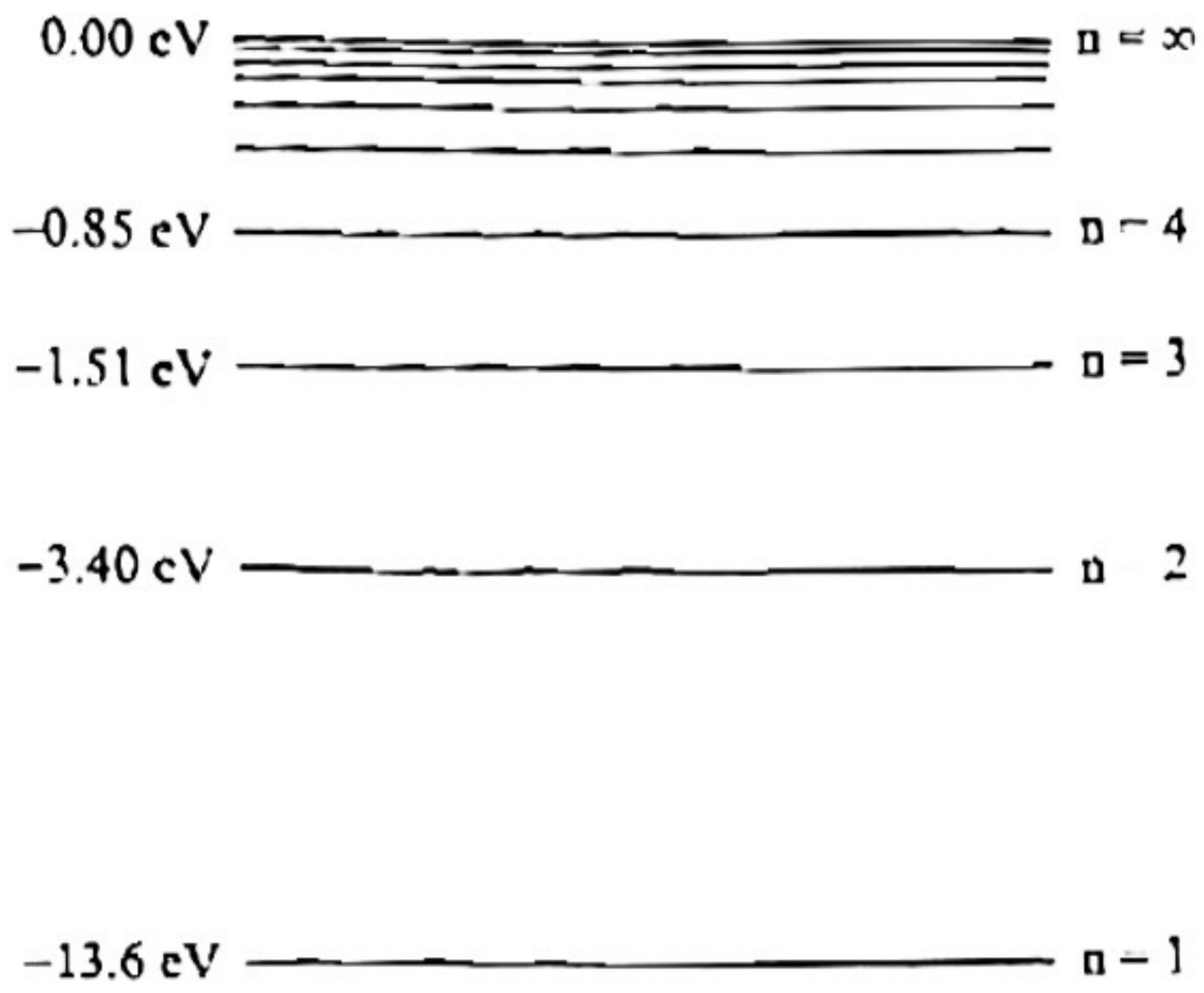
(1) cosmetic products
(2) drugs
(3) paint

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

A B C D
○ ○ ○ ○

Q.2 : Structured question

The Figure below shows some of the energy levels for a hydrogen atom.



(a) Explain what is meant by ionization energy of an atom. Hence state the ionization energy of hydrogen atom. (2 marks)

(b) Suppose an electron with kinetic energy of 12 eV makes collision with a hydrogen atom.

(i) What type of collision would occur ? (1 mark)

(ii) What happen to the hydrogen atom ? (1 mark)

(iii) After collision, the hydrogen atom would emit a photon. Calculate the wavelength of this photon. State the type of electromagnetic waves it belongs to. (2 marks)

(iv) Calculate the final speed of the electron after collision. (1 mark)

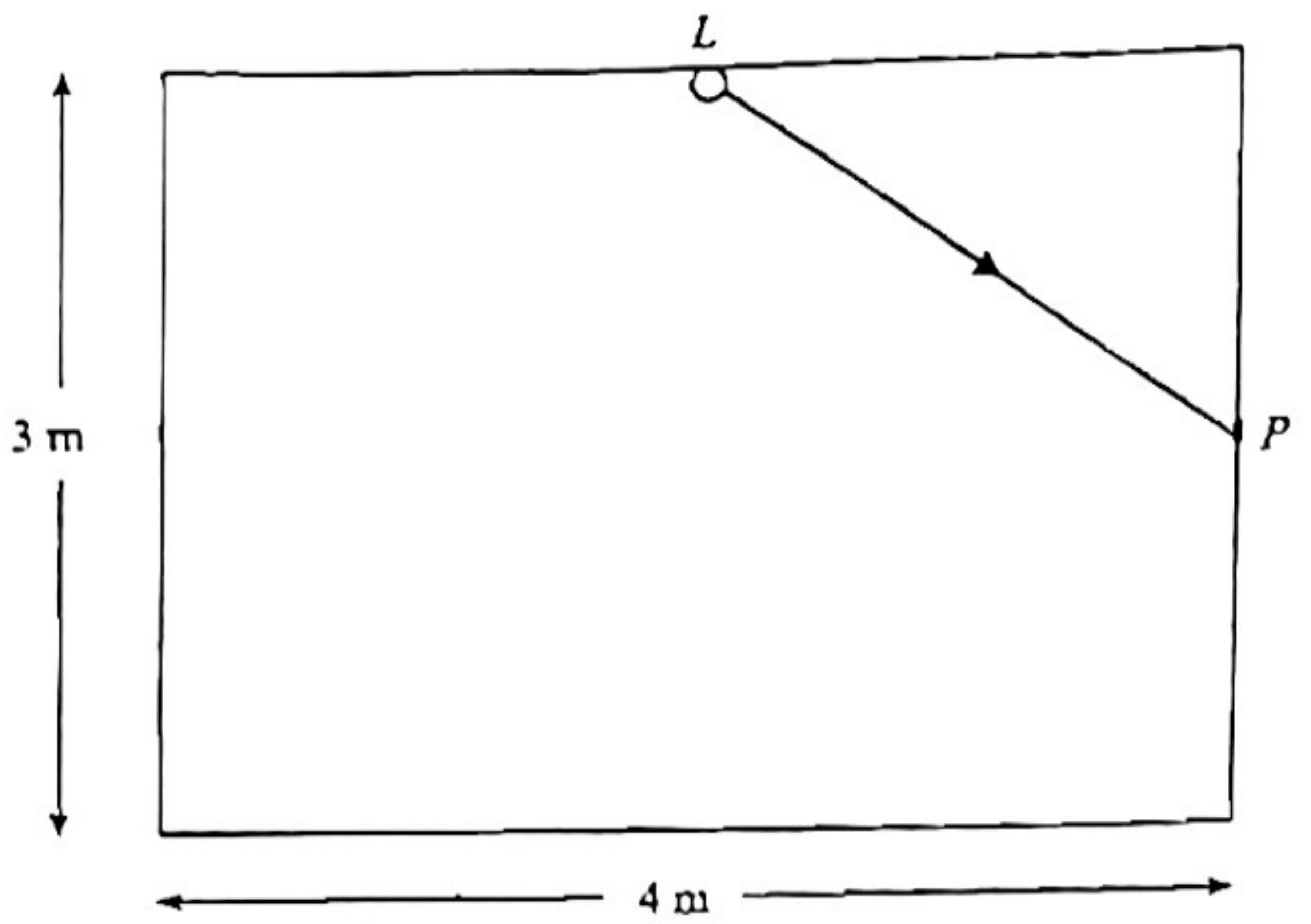
(c) If a photon with energy 12 eV makes collision with a hydrogen atom, explain what would happen. (2 marks)

(d) If a hydrogen atom is excited to the energy level of $n = 4$, list out the possible energy of photons within the visible light spectrum that may be emitted. (1 mark)

Section C : Energy and Use of Energy

Q.3 : Multiple-choice questions

3.1



A rectangular room has a height of 3 m and a width of 4 m as shown in the above figure. A small lamp acting as a point light source is hanged at the middle of the ceiling and it gives out a steady luminous flux of 2500 lm. Calculate the illuminance at the point P which is exactly at the middle of the side wall.

A. 19.1 lx
B. 23.9 lx
C. 25.5 lx
D. 38.3 lx

A B C D
○ ○ ○ ○

3.2 An air conditioner has a power rating of 1.5 kW. It is installed in an insulated room to extract heat. The room contains air 30 m^3 of air at 40°C. The air-conditioner takes 180 s to lower the temperature to 25°C. Calculate the coefficient of performance (COP) of the air-conditioner.

Given : density of air = 1.2 kg m^{-3} ; specific heat capacity of air = 1000 J kg^{-1} K^{-1}

A. 1.8
B. 2.0
C. 2.2
D. 2.4

A B C D
○ ○ ○ ○

3.3 A small house has the shape of a cube, with each side of 8 m. The total area of the windows at the house is 20 m^2. Apart from the bottom, the other five surfaces can conduct heat into the house. When the house is under sunlight, the average temperature difference between the interior and the exterior of the house is 15°C.

Given : U-value of the building material of the house = 13.5 W m^{-2} K^{-1}
U-value of the window material = 2.5 W m^{-2} K^{-1}

Estimate the Overall Thermal Transfer value (OTTV) of the house.

A. 192 W m^{-2}
B. 194 W m^{-2}
C. 198 W m^{-2}
D. 205 W m^{-2}

A B C D
○ ○ ○ ○

3.4 Which of the following factors would affect the U-value of a building material ?

(1) the thickness of the building material
(2) the area of the building material
(3) the temperature difference across the building material

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

A B C D
○ ○ ○ ○

3.5 Which of the followings is NOT a disadvantage of Electric Vehicles ?

A. Electric Vehicles take a long time to recharge the batteries.
B. Electric Vehicles travel relatively shorter distance for each full-charging.
C. The price of Electric Vehicles is usually higher than the similar model of petrol vehicles.
D. Electric Vehicles are usually noisier than the petrol vehicles.

A B C D
○ ○ ○ ○

3.6 A wind farm installs a total of 30 wind turbines. Each turbine has 2 blades, each of length 18 m. When steady wind blows normally on the blades of the turbine at an average velocity of 12.5 m s^{-1}, the turbine rotates to drive the generator to give out electricity. If the efficiency of the turbine is 32%, find the total electrical power output by the wind farm. Given that the density of air is 1.2 kg m^{-3}

A. 0.38 MW
B. 2.86 MW
C. 11.5 MW
D. 22.9 MW

A B C D
○ ○ ○ ○

3.7 The solar constant is 1370 W m^{-2}. On reaching the ground, about 60% of solar energy is absorbed by the atmosphere. If a solar panel with area 2.5 m^2 is used to collect the solar energy for generation of electrical power, and the efficiency of the conversion is only 16%, how long does it take to give out a total electrical energy of 1 kWh ?

A. 3.04 hours
B. 4.56 hours
C. 6.84 hours
D. 8.42 hours

A B C D
○ ○ ○ ○

3.8 Many countries are now preparing to replace incandescent light bulbs by compact fluorescent bulbs. Which of the followings is/are the advantages of this action ?

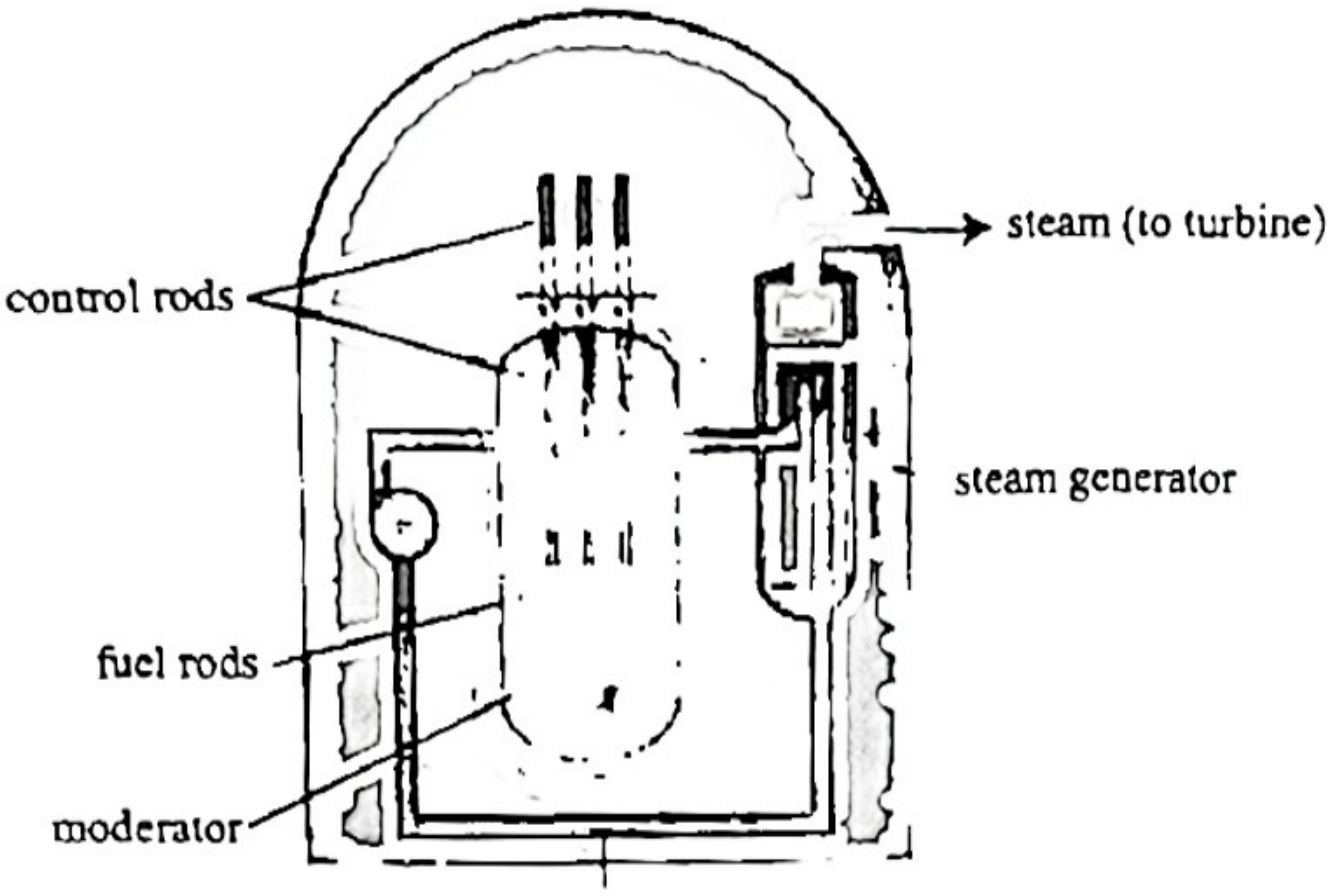
(1) Compact fluorescent bulbs are more energy efficient than incandescent light bulbs.
(2) Compact fluorescent bulbs are less expensive than incandescent light bulbs.
(3) Compact fluorescent bulbs cause less pollution problem to the environment.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

A B C D
○ ○ ○ ○

Q.3 : Structured question

The figure below shows a fission reactor used to generate electrical energy by the fission of uranium-235.



(a) Explain the term nuclear binding energy. (1 mark)

(b) The following equation is one of the fission reactions of Uranimum-235.

$$^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{89}_{36}Kr + ^{145}_{56}Ba + 2\,^{1}_{0}n$$

In the above reaction, there is a mass defect of 3.46×10^{-28} kg.

(i) Calculate the energy released in each fission of U-235. Give your answer in MeV. (1 mark)

(ii) Explain whether the two daughter nuclides, $^{89}_{36}Kr$ and $^{145}_{56}Ba$, have greater or smaller nuclear binding energy per nucleon than the mother nuclide $^{235}_{92}U$. (2 marks)

(iii) For a nuclear power plant to generate a power of 500 MW, calculate the mass of pure U-235 needed in 1 second. Given that the mass of 1 mole of U-235 is 0.235 kg. (2 marks)

(c) Explain the function of the following two components in the above fission reactor.

(i) Control rods (1 mark)

(ii) Moderator (1 mark)

(d) Someone suggests that hydro-electric power station can give the similar power output as a nuclear power plant.

(i) Suppose a hydro-electric power station has a dam to store water and release at a height of 15 m. The overall efficiency of power generation is 45%. Calculate the mass flow rate required to generate the same power of 500 MW as the above nuclear power plant. (1 mark)

(ii) Other than the extremely high capital cost of building a hydroelectric power station, state ONE adverse effect of building hydro-electric power station to the environment. (1 mark)

Section D : Medical Physics

Q.4 : Multiple-choice questions

4.1 The power of Mary's eye lens can vary from 40 D to 42 D. Her far point is normal and she can see distant objects clearly. Which of the following statements concerning Mary's eye are correct ?

(1) The lens-to-retina distance of Mary's eye is 2.5 cm.
(2) The near point of Mary is 50 cm.
(3) Mary should wear spectacles made of concave lens to correct her eye defect.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

A B C D
○ ○ ○ ○

4.2 Which of the following concerning the light sensitive cells in human eyes are correct ?

(1) Rods and cones can transmit signal to give the same detail of the object.
(2) Only the rods can function to transmit light at very dim environment.
(3) Rods cannot transmit colour signals to our brain.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

A B C D
○ ○ ○ ○

4.3 A machine produces a noise of 90 dB. If the background noise from the environment is 85 dB, what would be the total sound level ?

A. 90.5 dB
B. 91.2 dB
C. 92.5 dB
D. 95.0 dB

A B C D
○ ○ ○ ○

4.4 Which of the following concerning the ultrasound scan is NOT correct ?

A. Ultrasound can hardly enter bone from soft tissue.
B. A-scan displays images of the amplitude of the ultrasound echoes.
C. B-scan displays images of the brightness of the ultrasound echoes.
D. Higher frequency of ultrasound can penetrate deeper into the human bodies.

A B C D
○ ○ ○ ○

4.5 The following table shows the speed of sound in muscle and bone and their corresponding densities.

Tissue	Speed of sound in tissue / m s^{-1}	Density / kg m^{-3}
Muscle	1580	1076
Bone	3050	2560

Calculate the intensity reflection coefficient of ultrasound at the interface between muscle and bone.

A. 0.028
B. 0.359
C. 0.413
D. 0.625

A B C D
○ ○ ○ ○

4.6 Both the coherent and incoherent bundles in an endoscope are made of optical fibres. Which of the following statements is/are correct ?

(1) All the light entering an optical fibre from one end can undergo total internal reflection to reach the other end.
(2) The direction of light transmission in coherent bundles is opposite to that in incoherent bundles.
(3) Both the coherent and incoherent bundles can transmit images for observation.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

A B C D
○ ○ ○ ○

4.7 The intensity of an X-ray beam is 80 W cm^{-2}. After penetrating through 6 cm of a certain body tissue, the intensity is reduced to 50 W cm^{-2}. What is the half-value thickness of the body tissue ?

A. 4.25 cm
B. 5.68 cm
C. 6.42 cm
D. 8.85 cm

A B C D
○ ○ ○ ○

4.8 Artificial contrast medium is sometimes used in X-ray radiographic imaging to highlight a soft tissue organ. Which of the following is/are the properties of an artificial contrast medium ?

(1) An artificial contrast medium should be non-toxic.
(2) An artificial contrast medium should be digestible and absorbed in the human body.
(3) An artificial contrast medium should have a linear attenuation coefficient much lower than that of the soft tissue.

A. (1) only
B (2) only
C. (1) and (3) only
D. (2) and (3) only

A B C D
○ ○ ○ ○

Q.4 : Structured question

Nowadays, hospitals have installed different equipments for the examination of the human bodies of patients.

(a) Billy was suspected to have a liver disease. He was arranged by the hospital to have an ultrasound examination.

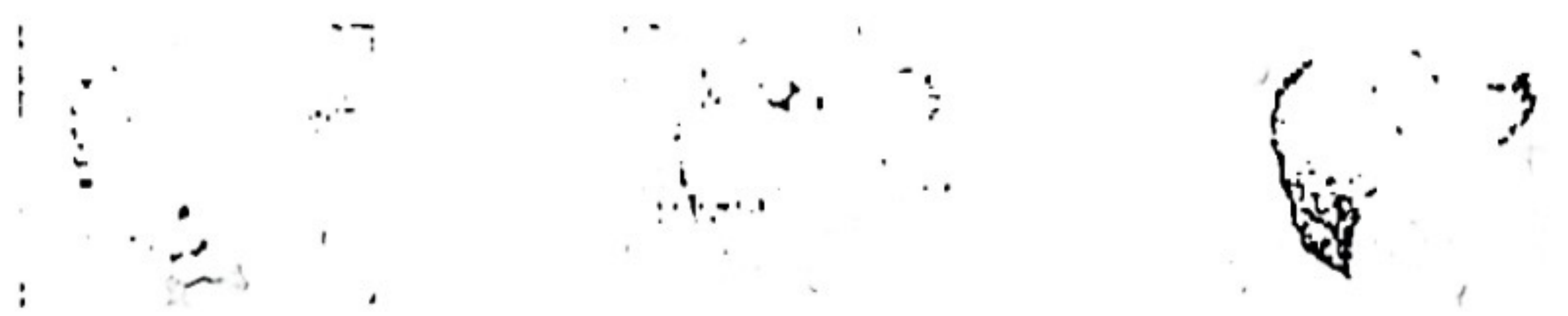
(i) State TWO reasons that ultrasound scanning is suitable in the examination of the liver disease. (2 marks)

(ii) Before the examination, the doctor applied a thin layer of coupling gel to the skin of Billy. State its function and explain why it is necessary to do so. (2 marks)

(iii) Explain why X-ray radiographic imaging is not suitable for examination in this case. (1 mark)

(iv) Computed tomography (CT) can also give accurate diagnosis. Other than expensive, state a reason why the doctor did not suggest Billy to have CT for the liver examination. (1 mark)

(b) For further examination, the doctor recommended Billy to have a Radionuclide Imaging (RNI). In the examination process of RNI, Technetium-99m is used to combine with a substance so that this compound can be easily absorbed by liver. This compound was taken by Billy orally and a series of images were then recorded by a gamma camera outside the body at different times as shown below.



1 hour after intake — 3 hours after intake — 6 hours after intake

(i) What information can be obtained from the RNI images ? (1 mark)

(ii) The half-life of technetium-99m is 6 hours. Calculate the decay constant of technetium-99m. Hence determine the time taken for the technetium-99m inside the body to drop to 0.1% of the initial amount. Give your answer in 2 significant figures. (2 marks)

(iii) Actually the time taken is much shorter than the above calculated value. Suggest a reason for this discrepancy. (1 mark)

END OF PAPER

Section A

Answers

1. C	6. C	11. A	16. D	21. B	26. C	31. B
2. B	7. D	12. B	17. A	22. C	27. B	32. B
3. B	8. B	13. B	18. B	23. B	28. C	33. B
4. A	9. D	14. C	19. A	24. D	29. B	
5. D	10. A	15. B	20. C	25. D	30. A	

Solution

1. C

Absolute value of the slope of the graph = $\frac{P}{mc} \propto \frac{1}{mc}$ (as the power is the same for both liquid)

✓ (1) As the absolute value of the slope of X is smaller, the heat capacity mc is greater.

✗ (2) Although the value of mc for X is greater, but the mass m may not be the same, thus the relation of specific heat capacity c cannot be determined

✓ (3) If both of them are water, then their specific heat capacity c must be the same, thus the mass m of X is greater

2. B

✗ (1) Mist formation is the condensation of vapour into liquid, thus latent heat of vaporization should be released to the glasses.

✓ (2) The molecular potential energy liquid is lower than that of vapour.

✗ (3) Mist formation can occur at temperatures even below the room temperature.

3. B

✓ (1) As the pressure is constant, volume of gas increases as the temperature increases. Thus the gas molecules become more separated and the density decrease.

(2) As the temperature increases, kinetic energy and average speed of gas molecules increase. Thus, the momentum of each gas molecule increases. Each gas molecule then hit the wall with a greater force due to its greater momentum.

✗ (3) The gas molecules hit the walls of the cylinder more violently as temperature increases, thus the molecules must hit the walls of the cylinder less frequently to give the same pressure

4. A

In 1 m^3, the number of mole of gas molecules n is found by : $PV = nRT$

$\therefore (250 \times 10^3)(1) = n(8.31)(25 + 273) \quad \therefore n = 100.95$

Number of gas molecules in 1 m^3 = $100.95 \times 6.02 \times 10^{23} = 6.1 \times 10^{25}$

5. D

Thinking distance :

$\ell = 20 \times 0.8 = 16$ m

Braking distance s

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

$(0) = (20)^2 + 2(-2.5)s \quad \therefore s = 80$ m

Total stopping distance : $D = \ell + s = 16 + 80 = 96$ m

6. C

Assume the normal reaction force between P and Q is R.

As the force 60 N is greater than 20 N, the system would move to the right with constant acceleration a.

Consider block P : $60 - R = 2ma$

Consider block Q : $R - 20 = 3ma$

Adding the two equations together

$\therefore 60 - 20 = 5ma \quad \therefore ma = 8$

$R - 20 = 3 \times 8$

$R = 44$ N

7. D

Consider the motion of the diver from A to D :

KE at A + PE at A relative to D = Work done against water resistance F

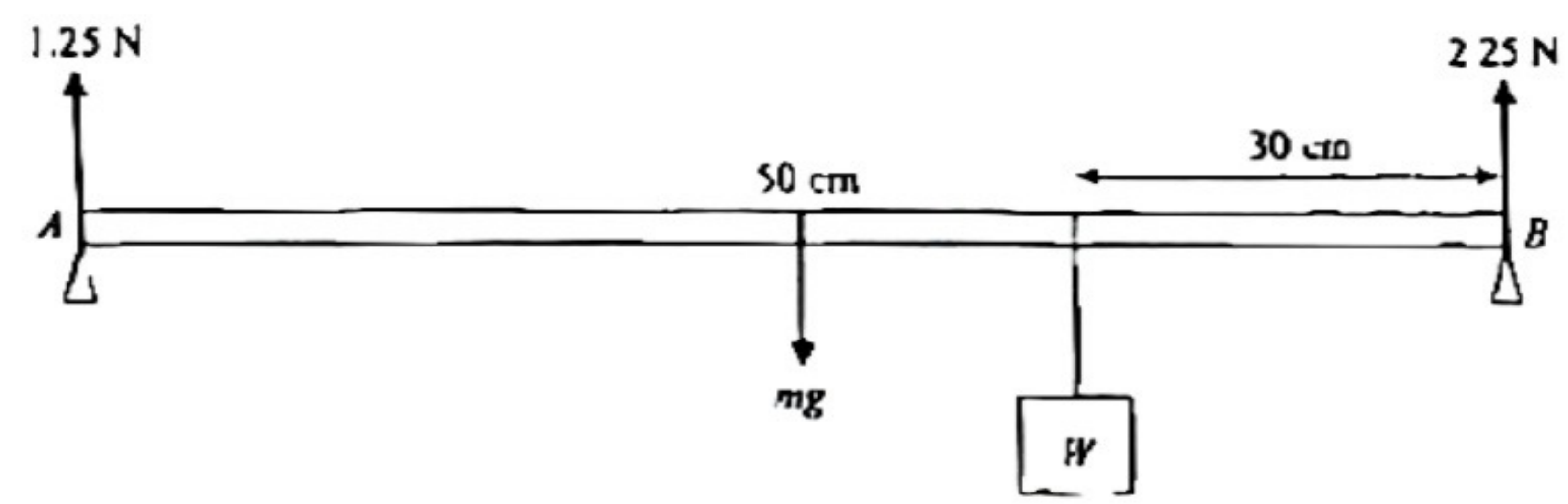
$\frac{1}{2}(50)(5)^2 + (50)(9.81)(3 + 2.5) = F(2.5)$

$F = 1330$ N

8. B

Note that the length of a metre rule is 100 cm.

Since the metre rule is uniform, the centre of gravity must be at the middle, that is, at the 50 cm mark



Take moment at the middle of the metre rule (mg has no moment about this point)

Moments of 1.25 N and W are clockwise and moment of 2.25 N is anticlockwise about the middle

$1.25 \times 50 + W \times 20 = 2.25 \times 50$

$W = 2.5$ N

9. D

$P = \frac{W}{t}$ $\therefore W = Pt$

Work done by the man = gain of PE of the block + work done against friction

$\therefore Pt = mgh + fs$

$\therefore P(30) = (5)(9.81)(8 \sin 30°) + (12)(8)$

$\therefore P = 9.74$ W

OR

Applied force by the man : $F = mg \sin\theta + f$

$= (5)(9.81) \sin 30° + (12)$

$= 36.525$ N

Work done by the man $= Fs = (36.525)(8) = 292.2$ J

Power output by the man $P = \frac{W}{t} = \frac{(292.2)}{(30)} = 9.74$ W

10. A

✓ (1) From A to B, the boy is under free fall and accelerates under the gravity.
Thus his kinetic energy is increasing.

(2) At the point B, the elastic cord starts to stretch.
Since the elastic force depends on the extension of the elastic cord,
thus when the cord starts to stretch, the elastic force is smaller than the weight of the boy.
Therefore the resultant force is still pointing downwards and the boy still accelerates downwards at B

✗ (3) At C, although the velocity of the boy is zero, his velocity is changing that later he bounces up.
Thus the acceleration of the boy at C is not zero.
The acceleration of the boy at C is upwards.

11. A

(1) Height = area of the graph from 0 to 0.6 s

$= \frac{1}{2} \times 6 \times 0.6$

$= 1.8$ m

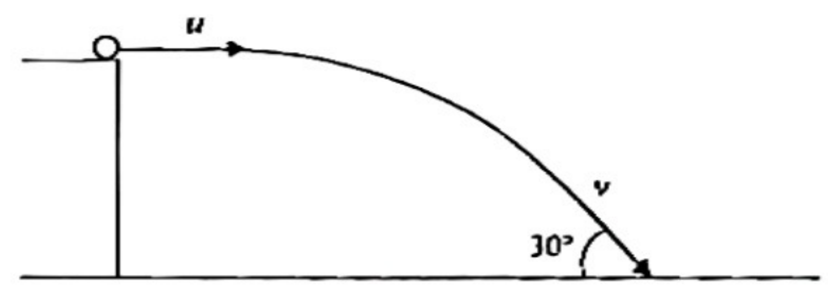
(2) Since the speed after collision is 4 m s^{-1}, smaller than the speed 6 m s^{-1} just before collision,
thus there is loss of kinetic energy during the collision, therefore, the collision is not elastic.

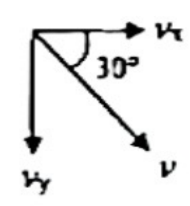
(3) Average force acting on the ball by the ground is the normal reaction.

$\therefore R - mg = \frac{mv - mu}{t}$

$\therefore R - (0.2)(10) = \frac{(0.2)(4) - (0.2)(-6)}{(0.1)}$ $\therefore R = 22$ N

12. B





Resolve the landing velocity v into 2 components

Horizontal component : $v_x = u = 15$ m s^{-1}

By $\tan\theta = \frac{v_y}{v_x}$ $\therefore \tan 30° = \frac{v_y}{(15)}$ $v_y = 8.66$ m s^{-1}

By $v_y^2 = u_y^2 + 2ay$

$\therefore (8.66)^2 = 2(9.81)y$

$\therefore y = 3.82$ m

13. B

✗ (1) As the weight is in vertical direction, it cannot have a horizontal component towards the centre.
Centripetal force is provided by the horizontal component of the normal reaction, $R \sin\theta$.

✗ (2) As the acceleration is horizontal, forces must be resolved into vertical and horizontal components.
In vertical direction, there is no acceleration, thus the vertical forces are balanced.
Therefore, $R\cos\theta = mg$ but $R \neq mg\cos\theta$

(3) $R\sin\theta = \frac{mv^2}{r}$ and $R\cos\theta = mg$

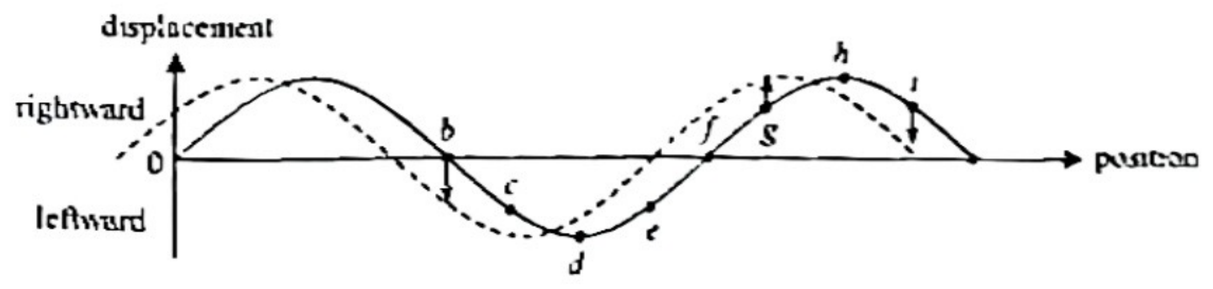
$\therefore \tan\theta = \frac{v^2}{gr}$

$\therefore v = \sqrt{gr\tan\theta}$

14. C

In Figure (2), particles b and j are at the compression C and particle f is at the rarefaction R.

Draw the displacement - position graph for the particles in Figure (2) as shown below

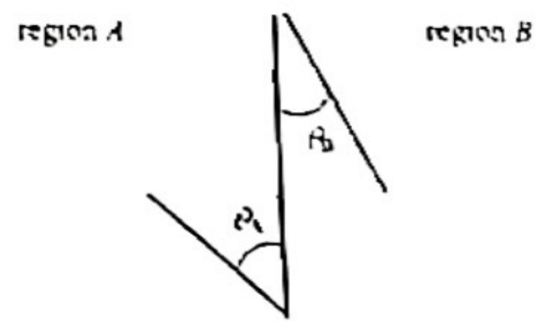


✓ (1) As shown in the figure, particle b is moving towards the negative direction, that is, leftwards.

✓ (2) As shown in the figure, particle d is at the extreme position and is momentarily at rest.

✗ (3) Particles g and i should be moving in opposite directions.

15. B



(1) The angle that the wavefront made with the interface is the incident angle and the refracted angle.
From the figure, $\theta_A > \theta_B$
During refraction, $\because \sin\theta \propto v \propto \lambda$
$\therefore v_A > v_B$ $\therefore$ region A is the deep water region

(2) After refraction, the wavelength in region B is smaller as $\lambda \propto v$.

✗ (3) The frequency must remain unchanged during refraction.

16. D

✓ (1) By $d \sin\theta = n\lambda$ $\therefore d \sin 20^\circ = (1)(684 \times 10^{-9})$ $\therefore d = 2 \times 10^{-6}$ m

$p = \frac{1}{d} = \frac{1}{2 \times 10^{-6}} = 500\,000$ lines per m $= 500$ lines per mm

✓ (2) By $\sin\theta_2 = 2 \sin\theta_1 = 2 \sin 20^\circ$ $\therefore \theta_2 = 43.2^\circ > 40^\circ$

✓ (3) By $\sin\theta_3 = 3 \sin\theta_1 = 3 \sin 20^\circ = 1.03 > 1$ $\therefore \theta_3$ does not exist $\therefore$ No third order

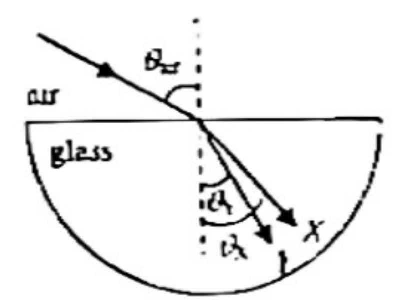
17. A

✓ (1) As the separation between the two sources S_1 and S_2 is 1.5λ, the path difference at A is 1.5λ.
Thus, destructive interference occurs at A.

✗ (2) The path difference at $B = 2\frac{1}{4}\lambda - 1\frac{1}{4}\lambda = 1\lambda$ thus, constructive interference occurs at B

✗ (3) The interference at C is constructive, thus C is oscillating up and down, it may be at crest or trough.

18. B



(1) The two colours should have the same speed in air.

(2) During refraction, $\sin\theta \propto v$. As the refracted angle $\theta_X > \theta_Y$ $\therefore v_X > v_Y$.
Thus, the speed of colour X in glass in greater than that of Y in glass.

(3) Both of the two coloured lights have the same incident angle but different refracted angle.
By $n = \sin\theta_{air} / \sin\theta_{glass}$, as the refracted angle in glass for colour X is greater,
the refractive index of glass for X should be smaller.

19. A

Since $u = 24$ cm and $m = 0.5$

$\therefore v = m u = 0.5 \times 24 = 12$ cm

(1) If the image is erect, it must be virtual, $v = -12$ cm

$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} = \frac{1}{(24)} + \frac{1}{(-12)}$ $f = -24$ cm

It is a concave lens with focal length 24 cm.

(2) If the image is inverted, it must be real, thus $v = +12$ cm

$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} = \frac{1}{(24)} + \frac{1}{(12)}$ $f = +8$ cm

It is a convex lens with focal length 8 cm.

20. C

To detect survivors buried under ground, infrared radiation should be used.

21. B

$\Delta y = \frac{\lambda D}{a} = \frac{(630 \times 10^{-9})(1.8)}{(0.25 \times 10^{-3})} = 4.536 \times 10^{-3}$ m $= 4.536$ mm

Note that the bright fringe at the central line is the zero order bright fringe.

Separation of the 8th order bright fringe from the central line $= 8 \times 4.536 = 36.3$ mm

22. C

The electric fields due to Q_1 and Q_3 have the same magnitude and in opposite directions,
thus, they balance each other

The electric fields due to Q_2 and Q_4 at P are both pointing to Q_4,
thus, they should add up together to give the resultant electric field E.

$E = \frac{Q}{4\pi\varepsilon_0 r^2} \times 2 = (9 \times 10^9) \times \frac{(5 \times 10^{-6})}{(20 \times 10^{-2})^2} \times 2 = 2.25 \times 10^6$ N C^{-1}

23. B

$V = E d = (1.2 \times 10^5) \times (2.5 \times 10^{-2}) = 3000$ V

$q V = \frac{1}{2} m v^2$ $\therefore (1.6 \times 10^{-19})(3000) = \frac{1}{2}(9.11 \times 10^{-31}) v^2$ $v = 3.25 \times 10^7$ m s^{-1}

OR

$F = q E = (1.6 \times 10^{-19})(1.2 \times 10^5) = 1.92 \times 10^{-14}$ N

$a = \frac{F}{m} = \frac{(1.92 \times 10^{-14})}{(9.11 \times 10^{-31})} = 2.11 \times 10^{16}$ m s^{-2}

$v^2 = u^2 + 2as = 0 + 2(2.11 \times 10^{16})(2.5 \times 10^{-2})$ $\therefore v = 3.25 \times 10^7$ m s^{-1}

24 D

Flying lead F connected to X : equivalent resistance is R_X

$$R_X = \frac{2R \times R}{2R + R} = 0.667\,R$$

Flying lead F connected to Y : equivalent resistance is R_Y.

$$R_Y = R + \frac{R}{2} = 1.5\,R$$

Flying lead F connected to Z : equivalent resistance is R_Z.

$R_Z = R + R = 2\,R$ (the lower resistor is shorted)

Equivalent resistance in descending order : $R_Z > R_Y > R_X$

The greater the equivalent resistance of the circuit, the smaller the current is.

Current in ascending order : $A_3 < A_2 < A_1$

25 D

✓ (1) Since the voltage across the resistor R_1 remains unchanged, the current is unchanged.

✓ (2) When the switch S is closed, the resistor R_1 is shorted
and thus the resistance in this branch reduces from $2R$ to $1R$, thus the current increases

✓ (3) As the total equivalent resistance of the circuit decreases, current delivered by the battery increases, and thus power given out by the battery also increase

26. C

✗ (1) In series, the power is proportional to the resistance by $P = I^2 R$
$\therefore P \propto R$ as I is the same.
Since $R_X > R_Y$ $\therefore P_X > P_Y$ $\therefore X$ should be brighter than Y

(2) By $R = \frac{V_r^2}{P_r}$
$\therefore R_X = 240\,\Omega$ and $R_Y = 120\,\Omega$. $R_X > R_Y$

(3) $R_X = 2\,R_Y$ $\therefore V_X = 240 \times \frac{2}{3} = 160\text{ V}$

Since the applied voltage of 160 V across X is greater than the rated voltage of 120 V,
X would be brighter than normal and the power would be greater than 60 W

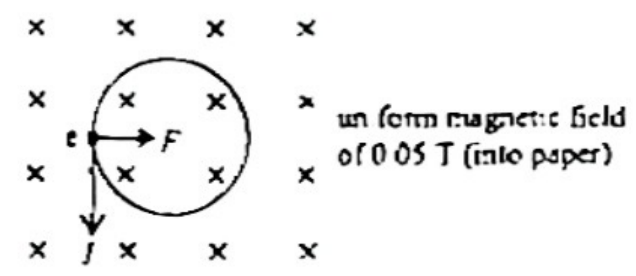
27. B

(1) Consider the effective component of the magnetic field in horizontal direction.
By use of the Left hand rule, direction of the magnetic force is perpendicularly out of paper

(2) $F = BIl = (0.6\cos 35^\circ) \times (2) \times (0.40) = 0.393\text{ N}$

(3) Resultant force acting on a loop placing in a uniform magnetic field must always be zero, as the forces on two sides must be equal and opposite that they would balance.

28 C



(1) Consider an arbitrary point as shown.
Since the magnetic force provides the centripetal force,
thus the magnetic force is directed towards the center
By using Left hand rule, the direction of current I is point downwards
Since the electron carries negative charge, thus the direction of velocity is opposite to the current
Therefore, the electron moves upwards at this point
The circular motion should be in clockwise direction

(2) $Bqv = \frac{mv^2}{r}$

$$\therefore v = \frac{Bqr}{m} = \frac{(0.05)(1.6 \times 10^{-19})(0.01)}{(9.11 \times 10^{-31})} = 8.78 \times 10^{7}\text{ m s}^{-1}$$

(3) $$T = \frac{2\pi r}{v} = \frac{2\pi(0.01)}{(8.78 \times 10^{7})} = 7.15 \times 10^{-10}\text{ s}$$

29. B

$B = \mu_0 n I = (4\pi \times 10^{-7})(300)(2) = 7.54 \times 10^{-4}\text{ T}$

$\Phi = BA = (7.54 \times 10^{-4})(\pi \times 0.05^2) = 5.92 \times 10^{-6}\text{ Wb}$

30 A

✓ (1) By using Right hand rule, the induced e.m.f. is from Q to P, thus P is at a higher potential.

✗ (2) E.m.f. are induced on both sides PQ and RS, they cancel each other and thus no current flows.

✗ (3) Since no current flows, thus there is no opposing magnetic force acting on the frame

31. B

By $A = A_0 e^{-kt}$

After 10 minutes :

$(800) = (2000)\,e^{-k(10)}$ $\therefore k = 0.0916\text{ min}^{-1}$

After a further 5 minutes :

$A = (800)\,e^{-(0.0916)(5)} = 506\text{ Bq}$

OR

$A = (2000)\,e^{-(0.0916)(15)} = 506\text{ Bq}$

32. B

Since X and Q are isotopes, they have the same atomic number.

assume an arbitrary value of atomic number for them, say, 50

$${}_{49}W \xrightarrow{\beta} {}_{50}X \xrightarrow{\alpha} {}_{48}Y \xrightarrow{\beta} {}_{49}Z$$

$${}_{52}P \xrightarrow{\alpha} {}_{50}Q \xrightarrow{\beta} {}_{51}R \xrightarrow{\alpha} {}_{49}S$$

Note that after α decay, atomic number decreases by 2. After β decay, atomic number increases by 1

✓ (1) Both W and S have same atomic number.

× (2) Z and P have different atomic number

✓ (3) Both Z and S have the same atomic number

33. B

Total energy that can be radiated :

$E = mc^2 = (2\times10^{[illegible]}\times0.09\%)\times(3\times10^{8})^2 = 1.62\times10^{[illegible]}$ J

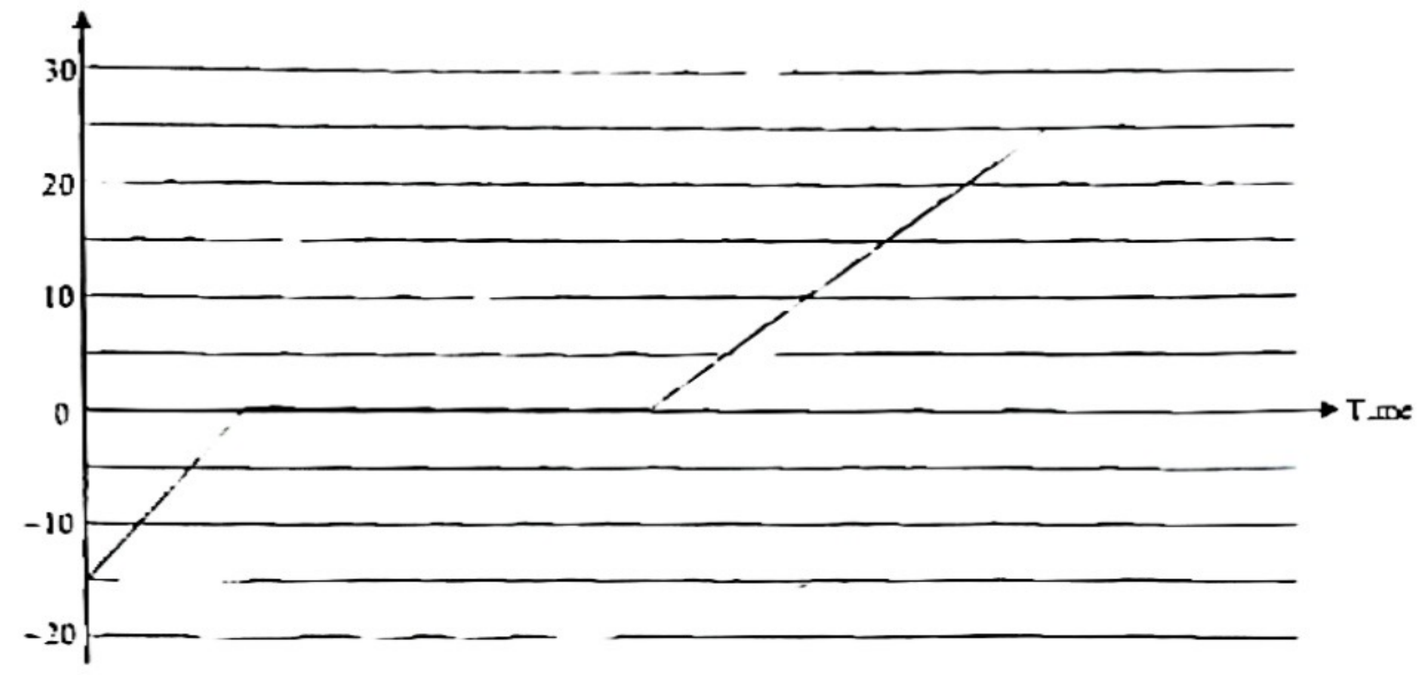
By $E = Pt$

$(1.62\times10^{[illegible]}) = (1.5\times10^{[illegible]})\,t$

$\therefore t = 1.08\times10^{[illegible]}\text{ s} = \dfrac{1.08\times10^{[illegible]}}{3.15\times10^{7}} = 3.43\times10^{[illegible]}$ year

Section B

1. (a)



< start from −15°C, rise to 0°C and stay constant for some time to melt > [1]

< after melting, temperature rises to 25°C, the room temperature, and then stay constant > [1]

(during the change of temperature, curve is accepted)

(b) (i) Heat absorbed $= mc\Delta T + ml_f$ [1]

$= (0.1)(2200)(15) + (0.1)(334000)$

$= 36700$ J [1]

(ii) $(36700) + (0.1)(4200)(\theta - 0) = (0.5)(4200)(60 - \theta)$ [1]

$\therefore \theta = 35.4$°C [1]

(iii) Some water may evaporate and escape to the surrounding air [1]

2. (a) The force acting on the seat by the passenger [1]

OR

The normal reaction force acting on the seat by the passenger [1]

(b) ① A thin wire would increase the pressure acting on the passenger due to the small area of contact [1]

② A rigid wire would increase the force acting on the passenger due to the short impact time [1]

(c) Height = total area of the graph $= \frac{1}{2}\times(25)\times(8)$ [1]

$= 100$ m [1]

(d) a = slope $= -\dfrac{(25)}{(8-2.5)} = -4.545\text{ m s}^{-2}$ [1]

$F - mg = ma$ [1]

$\therefore F = (80)(10) - (80)(4.545)$

$\therefore F = 1160$ N < accept 1100 N to 1200 N > [1]

3. (a) $m_1 u = (m_1 + m_2) v$

$(0.01)(200) = (0.01 + 1.24) v$ [1]

$\therefore v = 1.6 \text{ m s}^{-1}$ [1]

(b) $\frac{1}{2} M v^2 = M g h$

$\frac{1}{2}(1.6)^2 = (9.81) h$ [1]

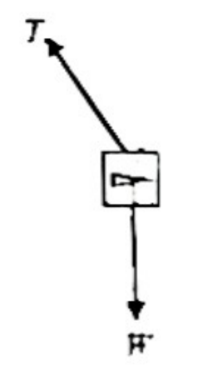
$\therefore h = 0.130 \text{ m}$ <accept 0.13 m> [1]

(c) $F = \frac{mv - mu}{t}$

$= \frac{(1.24)(1.6) - (0)}{(5 \times 10^{-3})}$ [1]

$= 397 \text{ N}$ <accept 396.8 N> [1]

(d)



< Tension T correctly marked > [1]

< Weight W or mg correctly marked > [1]

(e) Statement (1):

The statement is false. Since the collision is inelastic, there is loss of kinetic energy after the collision [1]

Statement (2):

The statement is false. Since there is external net force acting on the block, its momentum is not conserved. [1]

(f) If the bullet rebounds backwards, its change of momentum increases. [1]

By the Law of conservation of momentum, the block gains a greater momentum.

Thus the block would rise to a greater height. [1]

4. (a) $g = \frac{GM_E}{r^2}$ $\therefore g \propto \frac{1}{r^2}$ $\therefore \frac{g}{(9.81)} = \frac{(6380)^2}{(6380 + 750)^2}$ [1]

$\therefore g = 7.85 \text{ N kg}^{-1}$ [1]

OR

$GM_E = gR^2 = (9.81)(6380 \times 10^3)^2 = 3.993 \times 10^{14}$ [1]

$g = \frac{GM_E}{r^2} = \frac{(3.993 \times 10^{14})}{[(6380 + 750) \times 10^3]^2} = 7.85 \text{ N kg}^{-1}$ [1]

4. (b) The weight has no work done on the spacecraft

since the direction of the weight is always perpendicular to the motion of the spacecraft. [1]

(c) $mg = \frac{mv^2}{r}$

$\therefore (7.85) = \frac{\quad}{(6380 + 750) \times 10^3}$ [1]

$v = 7480 \text{ m s}^{-1}$ <accept 7470 to 7490 m s^{-1}> [1]

(d) $T = \frac{2\pi r}{v}$

$= \frac{2\pi(6380 + 750) \times 10^3}{(7480)}$ [1]

$= 5989 \text{ s}$

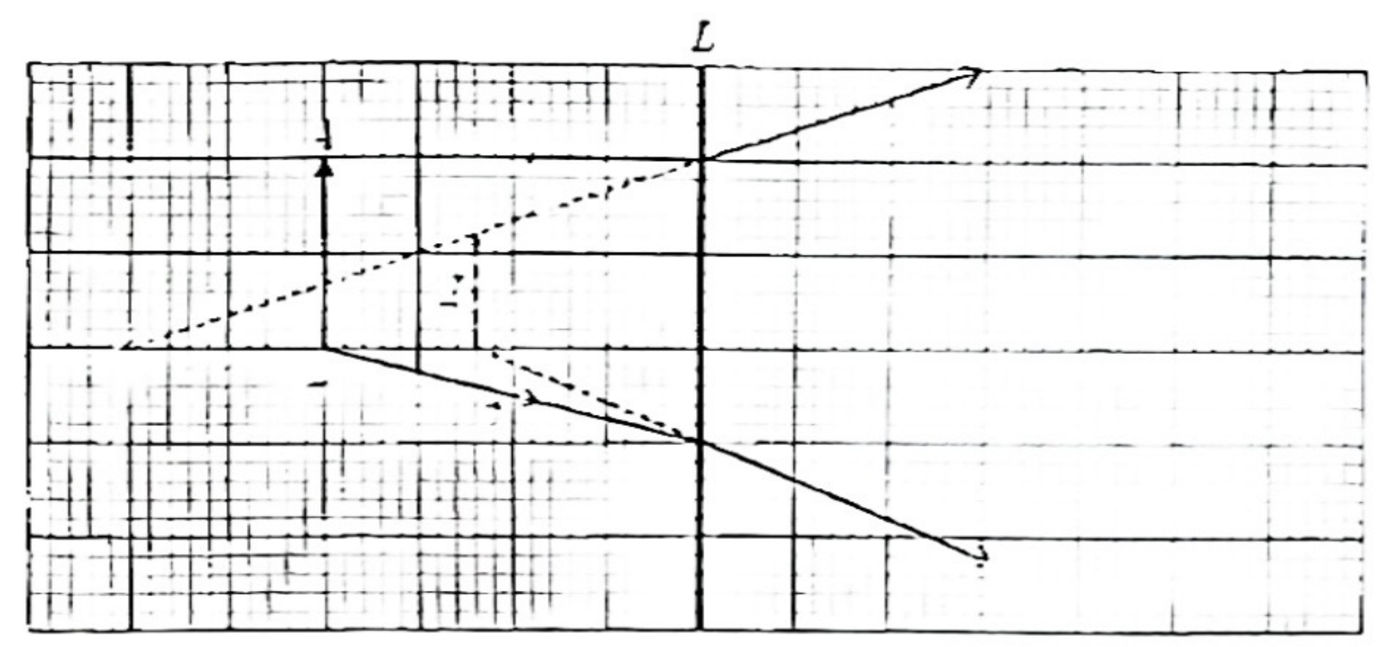
Number of revolutions in 24 h $= \frac{24 \times 3600}{5989}$

$= 14.4$ <accept 14.0 to 14.8> [1]

5. (a) It is a concave lens (OR diverging lens) [1]

since the image is erect and diminished. [1]

(b)



(i) < The size and the position of the image I is correctly marked > [1]

(ii) < The refracted ray of p is correctly drawn > [1]

(iii) < The position of the F is correctly marked > [1]

(c) The size of the image would increase. [1]

(d) Any ONE of the following: [1]

* peep-hole lens
* spectacles for short sighted eyes

6. Connect the two loudspeakers to the signal generator and place them apart with a suitable separation [1]

Adjust the frequency of the signal generator to give an audible sound note [1]

Connect the microphone to the CRO and move the microphone in front of the two loudspeakers. [1]

The time-base and the y-gain of the CRO should be adjusted to give a clear waveform of the sound note. [1]

As the microphone is moved, alternate maxima and minima can be observed on the CRO [1]

7. (a) $\dfrac{\sin(90^\circ - 78^\circ)}{\sin r} = \dfrac{340}{1500}$ [1]

$\therefore r = 66.5^\circ$ [1]

(b) Yes, ultrasound travels faster in water than in air. [1]

From air to water, it is refracted away from the normal

and total internal reflection is possible if the incident angle is large enough [1]

(c) (i) $t = \dfrac{2d}{v} = \dfrac{2 \times 240}{1500}$ [1]

$= 0.32$ s [1]

(ii) Radar uses microwaves that are easily absorbed by water [1]

(iii) Audible sound has longer wavelength, [1]

it would diffract around the submarine and does not reflect to give the echo. [1]

8. (a) The Earth wire is to prevent someone touching the kettle from electric shock [1]

when the live wire accidentally touches the metal case of the kettle. [1]

(b) Rated current of the kettle $= \dfrac{2800}{220} = 12.7$ A

$\therefore$ 15-A fuse is the most suitable [1]

The 10-A fuse is not suitable as it would blow in normal working as the rated current exceeds 10 A. [1]

The 20-A fuse is not suitable as the heater may be damaged by excessive current. [1]

(c) (i) Water at the bottom is heated, becomes less dense and rises up [1]

Cooler water being denser sinks to the bottom to give convection currents. [1]

(ii) The water can be heated more quickly and uniformly. [1]

(d) $P t \times (1 - 20\%) = m c \Delta T + m_s l_v$

$\therefore (2800)(10 \times 60) \times (1 - 20\%) = (1.5)(4200)(100 - 25) + m_s(2.26 \times 10^6)$ [1]

$m_s = 0.344$ kg [1]

(e) As the bubble rises up, the average speed of the gas molecules remains unchanged. [1]

The volume of the bubble has to increase

so that the frequency of collision on the bubble's inner surface decreases to give smaller pressure [1]

9. (a) Voltage across $RS = 15 \times \dfrac{200}{50} = 60$ V [1]

(b) By $P = VI$

$\therefore (24) = (60) I$ [1]

$I = 0.4$ A [1]

OR

Current in the lighting system $= \dfrac{24}{15} = 1.6$ A [1]

Current in the cable $= 1.6 \times \dfrac{50}{200} = 0.4$ A [1]

(c) $P_{loss} = I^2 R = (0.4)^2 (10 + 10) = 3.2$ W [1]

$\eta = \dfrac{P_{out}}{P_{in}} = \dfrac{(24)}{(24 + 3.2)} \times 100\% = 88.2\%$ [1]

(d) Voltage across $PQ = 0.4 \times (10 + 10) + 60 = 68$ V [1]

(e) $N_P = 340 \times \dfrac{12}{68} = 60$ [1]

(f) By $P = VI$, using high voltage V to transmit power can reduce the current I through the cable. [1]

The power loss, which is equal to $I^2 R$, can then be reduced to increase the efficiency of power transmission. [1]

10. (a) $\Delta m = \dfrac{5.2}{931}$ u [1]

$= \dfrac{5.2}{931} \times 1.661 \times 10^{-27}$ kg $= 9.28 \times 10^{-30}$ kg [1]

OR

$E = \Delta m c^2$

$\therefore (5.2 \times 10^6 \times 1.6 \times 10^{-19}) = \Delta m \times (3 \times 10^8)^2$ [1]

$\therefore \Delta m = 9.24 \times 10^{-30}$ kg [1]

(b) $k = \dfrac{\ln 2}{3.08 \times 60} = 3.75 \times 10^{-3}$ s^{-1} [1]

Decay constant is the probability (OR chance) of decay of a nucleus (OR atom) in unit time [1]

(c) By $A = kN$

$\therefore (25 \times 10^6) = (3.75 \times 10^{-3}) N$ [1]

$\therefore N = 6.67 \times 10^9$ [1]

Mass $= \dfrac{6.67 \times 10^9}{6.02 \times 10^{23}} \times 0.218 = 2.42 \times 10^{-15}$ kg <accept 2.42×10^{-12} g> <accept 2.40 to 2.44> [1]

10. (d) ① The half-life of Po218 is too short that there is not enough time for the diagnosis to carry out [1]

② Po-218 emits α particles that the penetrating power is not large enough to pass through the human body. [1]

OR

Po-218 emits α particles that have strong ionizing power to give large harmful effect on human body [1]

Section A : Astronomy and Space Science

1.1 A

(4) Satellite has the smallest size as it moves around a planet.

(5) Planet is smaller than star as it moves around a star

(2) Star, like the Sun, forms the centre of a solar system

(1) Stellar cluster consists of a number of nearby stars grouped together

(3) Galaxy consists of hundreds of billions of stars

1.2 C

✓ A. The observation that the surface of the Moon is rough and uneven, and the observation that there are sunspots on the Sun's surface, lead to the conclusion that celestial bodies are not perfect spheres.

B. Since there are satellites moving around Jupiter, not every celestial body moves around the Earth, thus, the Earth may not be at the centre of every orbit.

× C. Galileo has not found evidence for non-circular orbits, the discovery of elliptical orbits was by Kepler.

✓ D. Venus shows complete cycle of phases at different times, similar to that of Moon.

1.3 C

Period of Halley's Comet : $T = 2061 - 1986 = 75$ years

By Kepler's third law of planetary motion : $T^2 = a^3$ < T in year and a in AU >

$\therefore (75)^2 = a^3$ $\therefore a = 17.8$ AU

Semi-major axis is 17.8 AU.

Major axis = $17.8 \times 2 = 35.6$ AU = $35.6 \times 1.5 \times 10^{11}$ m = 5.3×10^{12} m

1.4 A

The distance of the Sun from the Earth is 1 AU, by definition. 1 AU is equal to 1.5×10^{11} m

$$b = \frac{L}{4\pi d^2} = \frac{(3.9 \times 10^{26})}{4\pi (1.5 \times 10^{11})^2} = 1380 \text{ W m}^{-2}$$

1.5 B

When an object is projected with the velocity of escape, its total mechanical energy must be just equal to zero

$\therefore KE + PE = 0$ $\therefore KE = -PE = -(-2.56 \times 10^9) = 2.56 \times 10^9$ J

$\therefore \frac{1}{2}(500)v^2 = 2.56 \times 10^9$ $\therefore v = 3200$ m s^{-1}

1.6 C

Parallax : $p = \frac{1}{2} \times 0.16'' = 0.08''$

Distance : $d = \frac{1}{p} = \frac{1}{0.08} = 12.5$ pc $= 12.5 \times 3.26$ ly $= 41$ ly

1.7 B

$$\frac{GMm}{r^2} = \frac{mv^2}{r}$$

$$M = \frac{v^2 r}{G} = \frac{(320\times10^3)^2(6\times10^3\times3.09\times10^{16})}{(6.67\times10^{-11})} = 2.85\times10^{41}\ \text{kg}$$

1.8 A

Radial velocity : $v_r = v\cos\theta = 650\times\cos 40^\circ = 498\ \text{km s}^{-1}$

By Doppler effect : $\frac{v_r}{c} = \frac{\Delta\lambda}{\lambda_o}$ $\quad\therefore \frac{498\times10^3}{3\times10^8} = \frac{\Delta\lambda}{524.65}$ $\quad\Delta\lambda = 0.87\ \text{nm}$

Since the star is approaching towards the Earth, it gives blue shift and the apparent wavelength must be shorter.

Apparent wavelength : $\lambda' = 524.65 - 0.87 = 523.78\ \text{nm}$

Q1. (a) (i) Star Z < The apparent magnitude is the smallest. > [1]

(ii) Star X < The difference of $m - M$ is the greatest. > [1]

(iii) White dwarf has high temperature and low luminosity, that is, high absolute magnitude [1]

Thus, star Y is a white dwarf [1]

(b) Difference of absolute magnitudes : $\Delta M = (-10.0) - (-2.0) = 12$ [1]

For the difference of absolute magnitude by 1, ratio of luminosities is $\sqrt[5]{100}$

$$\frac{L_X}{L_Y} = (\sqrt[5]{100})^{12} = 6.31\times10^4$$ [1]

< Note that as the absolute magnitude of X is smaller than that of Y, luminosity of X is greater than that of Y >

(c) Ratio of the brightness $= (\sqrt[5]{100})^{4-(-2)} = (\sqrt[5]{100})^6$ [1]

For the same star, luminosity L is same

By $b = \frac{L}{4\pi d^2}$

$b \propto \frac{1}{d^2}$ $\quad (\sqrt[5]{100})^6 = \left(\frac{d}{10}\right)^2$ $\quad\therefore d = 158\ \text{pc}$ [1]

(d) By Stefan's Law : $L = 4\pi R^2 \sigma T^4$

Since stars X and Z have the same absolute magnitude, they have the same luminosity L [1]

$\therefore R^2 \propto \frac{1}{T^4}$

$\therefore \left(\frac{R_X}{R_Z}\right)^2 = \left(\frac{T_Z}{T_X}\right)^4 = \left(\frac{3600}{15000}\right)^4$ $\quad\therefore \frac{R_X}{R_Z} = 0.0576$ [1]

Section B : Atomic World

2.1 B

× (1) The alpha particles are not scattered in random directions
They are repelled away according to how close they are to the nucleus
If the scattering is random, then the alpha particles would be scattered evenly to all directions of 360°

(2) By considering the kinetic energy of the alpha particles,
the closest distance that an alpha particle can approach can be estimated,
and this gives information about the size of the nucleus, being much smaller than that of the atom

(3) Although the nucleus is known to be very tiny, the internal structure is not known
The proton and neutron are not discovered in this experiment

2.2 B

By $E = \phi + K_{max}$

$$\frac{hc}{\lambda} = \phi + \frac{1}{2} m v_{max}^2$$

$$\frac{(6.63\times10^{-34})(3\times10^8)}{\lambda} = (2\times1.6\times10^{-19}) + \frac{1}{2}(9.11\times10^{-31})(4.8\times10^5)^2$$

$\therefore \lambda = 4.68\times10^{-7}\ \text{m}$

2.3 A

✓ A. The maximum kinetic energy of the photoelectrons is not affected by the intensity of the incident light

× B Different types of metal have different work function ϕ
By Einstein's photoelectric equation : $E = \phi + K_{max}$
For the same energy of photon, K_{max} is affected by ϕ.

C. By Einstein's photoelectric equation : $hf = \phi + K_{max}$
Although the maximum kinetic energy K_{max} increases if the frequency f increases,
but they not proportional.

D. The intensity of the incident light would affect the number of photoelectrons emitted only,
but not affecting the maximum kinetic energy of the photoelectrons.

2.4 A

By $\lambda = \frac{h}{p}$ $\quad\therefore (2.5\times10^{-12}) = \frac{(6.63\times10^{-34})}{p}$

$\therefore p = 2.652\times10^{-22}\ \text{kg m s}^{-1}$

By $eV = \frac{1}{2}mv^2 = \frac{(mv)^2}{2m} = \frac{p^2}{2m}$

$$\therefore (1.6\times10^{-19})V = \frac{(2.652\times10^{-22})^2}{2(1.67\times10^{-27})}$$

$\therefore V = 132\ \text{V}$

2.5 D

Since the frequency f of yellow light is lower than that of green light,

by $E = hf$, energy E of each photon of yellow light is smaller

By Einstein's photoelectric equation :

$$E = \phi + eV_s$$

the stopping potential V_s should decrease.

Since the intensity I is the same, for the same area A of the cathode,

by $P = IA$,

the power P of light incident onto the cathode surface is the same.

By $P = \frac{N}{t}E$,

as E is smaller for yellow light, the number of photons per time $\frac{N}{t}$ would be greater,

thus more photoelectrons would be emitted per time and the saturation current would increase.

2.6 C

By Rayleigh criterion ,

$$\theta = \frac{1.22\lambda}{d}$$

$$\therefore \theta = 1.22 \times \frac{650 \times 10^{-9}}{2.8 \times 10^{-3}} = 2.832 \times 10^{-4} \text{ rad}$$

By $\theta = \frac{a}{L}$

$$\therefore a = L\theta = (2.4) \times (2.832 \times 10^{-4}) = 6.8 \times 10^{-4} \text{ m} = 0.68 \text{ mm}$$

2.7 B

× (1) Electrons are accelerated by electric field in the part of electron source
Magnetic field has no work done on electrons and cannot change the kinetic energy of electrons.

× (2) The electromagnetic lens system should work like a convex lens to focus the electrons.
Note that convex lens can converge light beam but concave lens would diverge light beam

(3) The lens system must allow electrons with a certain kinetic energy to pass through,
so that the electrons can have a certain de Broglie wavelength to give a certain resolving power

2.8 D

✓ (1) Cosmetic products may contain nanoparticles to help cleaning up dirt on our skin.

✓ (2) Drugs may contain nanoparticles that can be delivered into the human body faster and easier

✓ (3) Paint may contain nanoparticles to have anti-bacterial and detoxicating abilities

Q2 (a) Ionization energy of an atom is the minimum energy required to remove an electron from the atom [1]

Ionization energy = 13.6 eV [1]

(b) (i) Inelastic collision would occur. [1]

(ii) The hydrogen atom would be excited to the first excitation state. < OR excited to the second energy level > [1]

(iii) $[(-3.40) - (-13.6)] \times 1.6 \times 10^{-19} = \frac{(6.63 \times 10^{-34}) \times (3 \times 10^{8})}{\lambda}$ [1]

$\lambda = 1.22 \times 10^{-7}$ m

It belongs to ultra-violet radiation. [1]

(iv) Loss of kinetic energy of the electron during collision = $(-3.40) - (-13.6) = 10.2$ eV

$\therefore (12 - 10.2) \times 1.6 \times 10^{-19} = \frac{1}{2}(9.11 \times 10^{-31})v^2$

$\therefore v = 7.95 \times 10^{5} \text{ m s}^{-1}$ [1]

(c) The photon would not be absorbed < "inelastic collision occur" is not accepted > [1]

since there is no difference of energy levels exactly equal to 12 eV. [1]

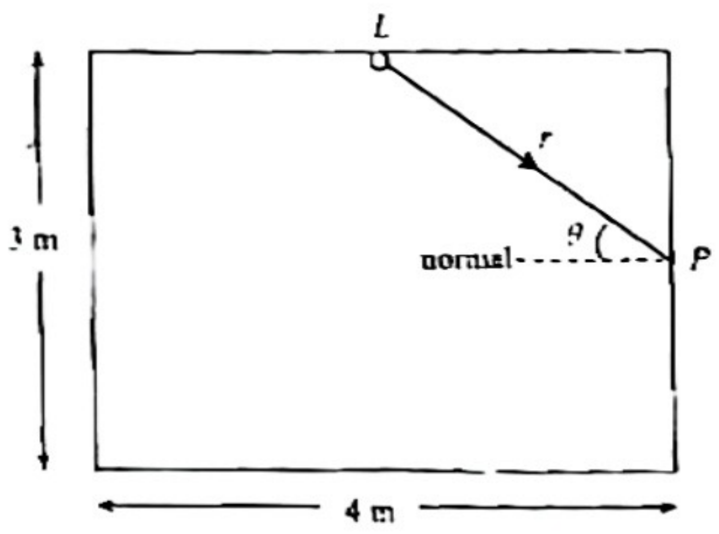
(d) From $n = 4$ to $n = 2$: $\Delta E = (-0.85) - (-3.40) = 2.55$ eV

From $n = 3$ to $n = 2$: $\Delta E = (-1.51) - (-3.40) = 1.89$ eV

< both 2 values are correct > [1]

Section C : Energy and Use of Energy

3.1 C



Distance from L to P : $r = \sqrt{(1.5)^2 + (2)^2} = 2.5$ m

Angle that the incident light made with the normal : $\tan\theta = \dfrac{1.5}{2}$ $\therefore \theta = 36.87°$

Illuminance : $E = \dfrac{\Phi}{4\pi r^2}\cos\theta = \dfrac{(2500)}{4\pi(2.5)^2}\cos 36.87° = 25.5$ lx (lux)

3.2 B

Mass of air $= 30 \times 1.2 = 36$ kg

Heat extracted from the air : $Q_C = m c \Delta T = (36)(1000)(40 - 25) = 540\ 000$ J

Electrical energy used : $W = P t = (1.5 \times 10^3)(180) = 270\ 000$ J

$\text{COP} = \dfrac{Q_C}{W} = \dfrac{540000}{270000} = 2$

3.3 A

Total area of the building material $= 8 \times 8 \times 5 - 20 = 300$ m^2

Rate of heat transfer through the building material $= U A \Delta T = (13.5)(300)(15) = 60750$ W

Total area of the window $= 20$ m^2

Rate of heat transfer through the window material $= U A \Delta T = (2.5)(20)(15) = 750$ W

$\text{OTTV} = \dfrac{Q/t}{A} = \dfrac{60750 + 750}{300 + 20} = 192$ W m^{-2}

3.4 A

✓ (1) By $U = k/d$, U-value depends on thermal conductivity k and the thickness d only.

✗ (2) By $Q/t = U A \Delta T$, although the area affects the rate of heat conduction, they are proportional. Thus U-value does not depend on the area A of the building material.

✗ (3) By $Q/t = U A \Delta T$, the temperature difference ΔT and the rate of heat conduction are proportional. Thus U-value does not depend on the temperature difference across the building material

3.5 D

Electric Vehicles are usually quieter than petrol vehicles

3.6 C

$P_{cm} = \frac{1}{2}\rho A v^3 \times \eta \times N = \frac{1}{2}(1.2)(\pi \times 18^2)(12.5)^3 \times 32\% \times 30 = 11.5$ MW

3.7 B

Intensity of solar radiation reaching the ground $= 1370 \times (1 - 60\%) = 548$ W m^{-2}

Electrical power $= 548 \times 2.5 \times 16\% = 219.2$ W $= 0.2192$ kW

By $E = P t$ $\therefore$ (1 kWh) = (0.2192 kW) t $\therefore t = 4.56$ hours

3.8 A

✓ (1) Compact fluorescent bulbs give out less heat which are useless, thus more energy efficient.

✗ (2) Compact fluorescent bulbs are more expensive indeed.

✗ (3) Compact fluorescent bulbs cause more pollution problem due to the mercury inside the bulbs.

Q3. (a) Nuclear binding energy is the energy required to separate completely all the nucleons inside the nucleus. [1]

(b) (i) $\Delta E = \dfrac{3.46 \times 10^{-28}}{1.661 \times 10^{-27}} \times 931 = 194$ MeV [1]

OR

$\Delta E = 3.46 \times 10^{-28} \times (3 \times 10^8)^2 = 3.114 \times 10^{-11}$ J $= \dfrac{3.114 \times 10^{-11}}{1.6 \times 10^{-19}} = 195 \times 10^6$ eV $= 195$ MeV [1]

(ii) The greater the binding energy per nucleon, the greater the energy needed to break the nucleus and hence the more stable is the nucleus. [1]

Since energy is released in the reaction, the daughter nuclides are more stable, therefore, they have greater binding energy per nucleon than the mother nuclide. [1]

(iii) In 1 second, energy generated is 500 MJ

Number of U-235 needed : $N = \dfrac{500 \times 10^6}{194 \times 10^6 \times 1.6 \times 10^{-19}} = 1.611 \times 10^{19}$ < accept 1.60 to 1.62 > [1]

Mass of U-235 needed : $m = \dfrac{1.611 \times 10^{19}}{6.02 \times 10^{23}} \times 0.235 = 6.29 \times 10^{-6}$ kg < accept 6.25 to 6.30 > [1]

(c) (i) Control rods are used to absorb the excess fission neutrons so as to control the rate of fission reaction. [1]

(ii) The moderator is to slow down the fission neutrons so as to increase the probability of fission. [1]

(d) (i) $\dfrac{m}{t} \times (9.81) \times (15) \times 45\% = 500 \times 10^6$ $\dfrac{m}{t} = 7.55 \times 10^6$ kg s^{-1} [1]

(ii) The building of hydroelectric power station requires drastic changes to environment and disturbs the ecology. [1]

Section D : Medical Physics

4.1 A

✓ (1) In viewing object at infinity, the eye lens should be the thinnest and the power is the smallest.

$P = \frac{1}{u} + \frac{1}{v}$ $(40) = \frac{1}{\infty} + \frac{1}{v}$ $v = 0.025$ m $= 2.5$ cm

The lens-to-distance of Mary's eye is 2.5 cm.

(2) In viewing object at near point, the eye lens should be the thickest and the power is the greatest.

$P = \frac{1}{u} + \frac{1}{v}$ ∴ $(42) = \frac{1}{u} + \frac{1}{(0.025)}$ ∴ $u = 0.5$ m $= 50$ cm

The near point, that is, the closet distance to give distinct vision, is 50 cm.

✓ (3) As the near point of Mary is longer than the normal of about 25 cm,
Mary cannot see close objects and Mary is suffering from long sight.
She should wear spectacles made of convex lens (converging lens) to correct her eye defect.

4.2 C

× (1) Cones give more detail information about the object.

✓ (2) Cones cannot work at very dim environment. Only rods can transmit signals to the brain.

✓ (3) Rods do not transmit colours, they can only transmit black and white signals to the brain.

4.3 B

$L = 10 \log \frac{I}{I_o}$ ∴ $I = 10^{L/10} I_o$

The intensity of the noise from the machine : $I_1 = 10^9 I_o$

The intensity of the noise from the background : $I_1 = 10^{8.5} I_o$

Total intensity of the two noises : $I = 10^9 I_o + 10^{8.5} I_o$

Sound level of the total noise : $L = 10 \log \frac{10^9 I_o + 10^{8.5} I_o}{I_o} = 91.2$ dB

4.4 D

✓ A. The intensity reflection coefficient α between bone and soft tissue is nearly equal to 1,
almost all ultrasound is reflected when it reaches the bone-tissue boundary.

✓ B. A-scan is the A-mode ultrasound imaging where A stands for amplitude.
A-scan provide one dimensional images of the amplitude against the depth.

✓ C. B-scan is the B-mode ultrasound imaging where B stands for brightness.
B-scan provides two dimensional images to give the cross-sectional view of the tissue

× D. Higher frequency of ultrasound has greater image resolution, but lower penetration power

4.5 C

Acoustic impedance of muscle : $Z_1 = \rho_1 c_1 = (1076)(1580) = 1.70$ MRayl

Acoustic impedance of muscle : $Z_2 = \rho_2 c_2 = (2560)(3050) = 7.81$ MRayl

Intensity reflection coefficient : $\alpha = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2} = \frac{(7.81 - 1.70)^2}{(7.81 + 1.70)^2} = 0.413$

4.6 B

× (1) Only part of the light entering an optical fibre can fall into the range of guided mode
and be transmitted to the other end of the fibre
To achieve this, the incident angle of the light must be smaller than a certain maximum angle θ_{max}
that depends on the refractive index of air, cladding and the core

(2) Coherent bundles transmit light from the human body inside to the outside.
Incoherent bundles transmit light from the human body outside to the inside

× (3) Coherent bundles transmit images to outside for observation.
Incoherent bundles transmit light to inside for illumination only.

4.7 D

By $I = I_o e^{-\mu x}$ ∴ $(50) = (80) e^{-\mu(6)}$ $\mu = 0.07833$ cm

$HVT = \frac{\ln 2}{\mu} = \frac{\ln 2}{0.07833} = 8.85$ cm

4.8 A

✓ (1) An artificial contrast medium must be non-toxic and gives no harmful effect to human bodies.

× (2) An artificial contrast medium should not be digestible and should be egested out of the body

× (3) An artificial contrast medium should have a linear attenuation coefficient much higher
than that of the soft tissue, so that the organ can appear white in the plain film to be observed easily

Q4. (a) (i) Ultrasound does not involve ionizing radiation. [1]
Ultrasound has a good contrast resolution of soft tissue. [1]

(ii) The coupling gel is used to eliminate the air between the skin and transducer [1]
It is necessary since the intensity reflection coefficient between air and soft tissue is nearly equal to 1,
almost all ultrasound is reflected when it reaches the air-tissue boundary. [1]

(iii) X-ray has a poor soft tissue contrast resolution that cannot differentiate different soft tissues on the image [1]

(iv) CT involves a higher radiation dose that may give harmful effect to the body. [1]

(b) (i) RNI images can provide the functional information about the liver of Billy [1]

(ii) Decay constant : $k = \frac{\ln 2}{6} = 0.1155$ h^{-1} [1]

$A = A_o e^{-kt}$

∴ $(0.1\%) = e^{-(0.1155)t}$

∴ $t = 60$ hours [1]

(iii) Technetium-99m has a biological half-life so that the effective half-life inside the human body is much shorter [1]