HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION

2022 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 50 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.

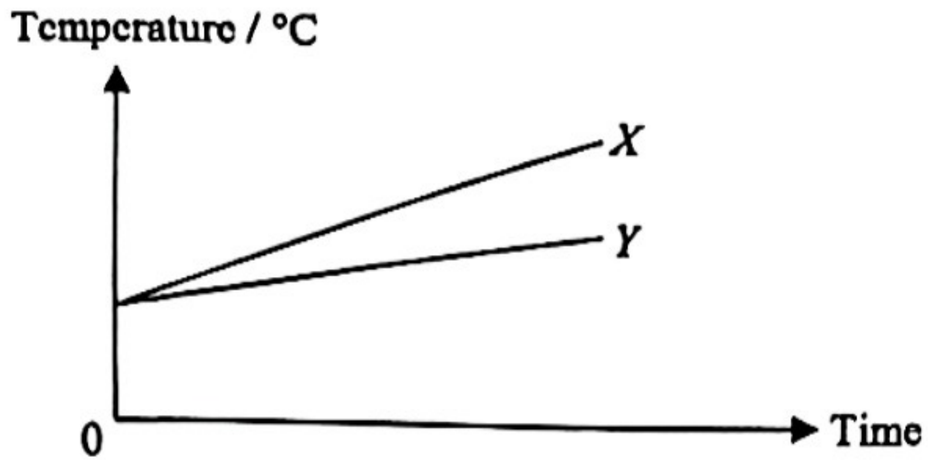
5. You should mark only **ONE** answer for each question. If you mark more than one answer, you will receive **NO MARKS** for that question.

6. No marks will be deducted for wrong answers.

Section A

There are 33 questions.

1.

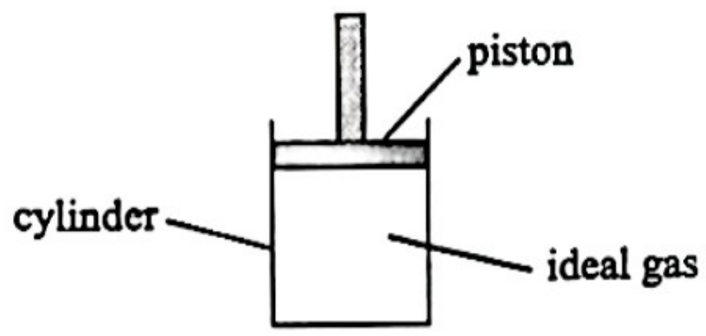


The above figure shows the temperature - time graph of two liquids *X* and *Y* at the same initial temperature being heated by heater with the same power. Neglect the heat lost to the surroundings, which of the following deductions are correct ?

(1) The heat capacity of *X* is smaller.
(2) The specific heat capacity of *X* is smaller.
(3) If both of the two liquids are water, then the mass of *X* is less than that of *Y*.

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

2.



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 cooled under constant pressure, which of the following statements are correct ?

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

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

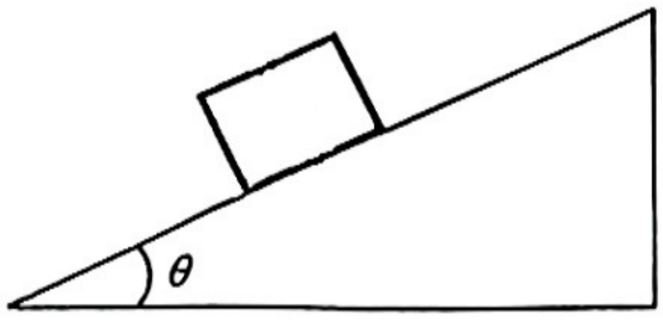
3. A gas vessel of volume 500 cm^3 contains an ideal gas at room temperature of 25 °C. If the number of gas molecules inside the vessel is 3×10^{22}, what is the pressure of the gas inside the vessel ?

A 247 kPa
B. 285 kPa
C. 365 kPa
D. 406 kPa

4. David is driving his car with a constant speed of 24 m s^{-1}. He suddenly observes a pedestrian rushing out. After a reaction time of 0.5 s, he then applies the brake of his car to give a uniform deceleration. If the total stopping distance of his car is 52 m, what is the deceleration of the car during the braking ?

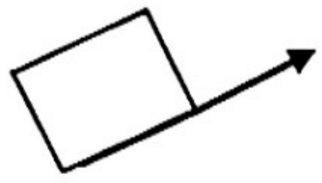
A. 3.6 m s^{-2}
B. 4.8 m s^{-2}
C 7.2 m s^{-2}
D. 9.6 m s^{-2}

5.

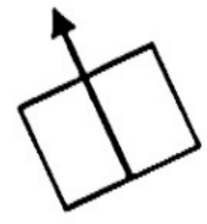


A block is resting on a rough inclined plane. Which of the following figures shows correctly the resultant force acting on the block by the inclined plane ?

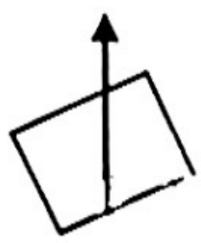
A.

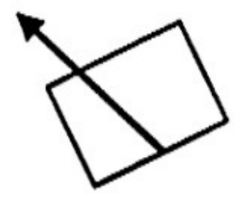


B.

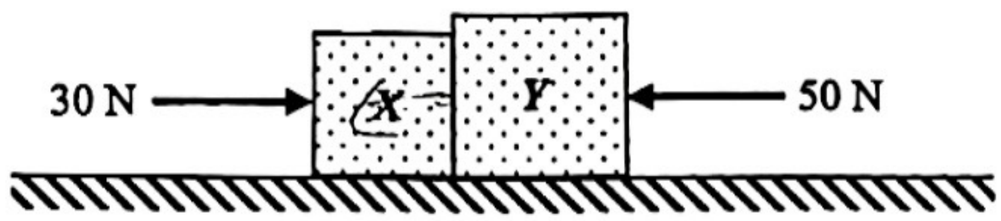


C.





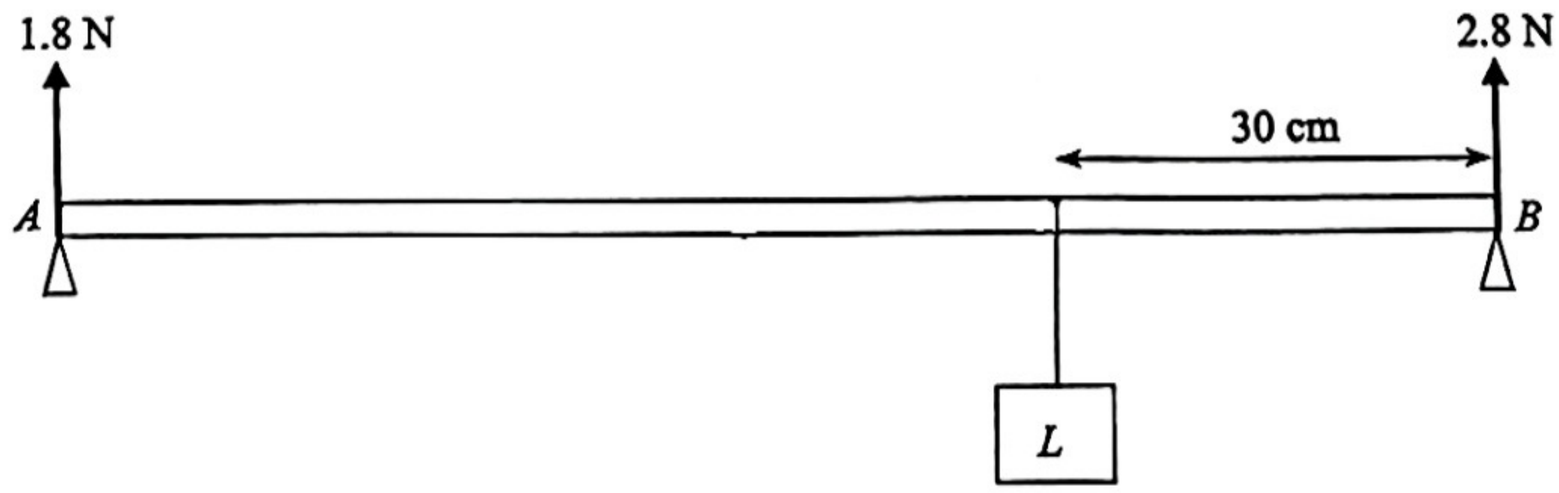
6.



Blocks X and Y of mass $2m$ and $3m$ respectively are in contact on a smooth horizontal floor. Two horizontal forces of 30 N and 50 N act on X and Y respectively as shown in the above figure. Calculate the normal reaction force acting on X by Y, with both magnitude and direction.

	magnitude	direction
A.	38 N	leftwards
B.	38 N	rightwards
C.	42 N	leftwards
D.	42 N	rightwards

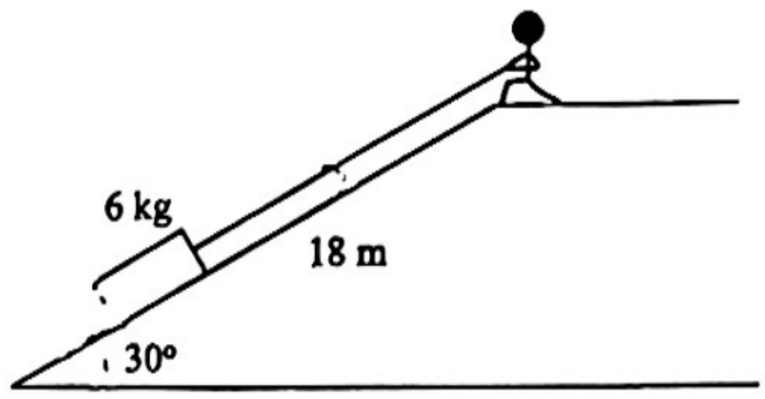
7.



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 1.8 N and 2.8 N respectively. A load L is hanged at 30 cm from B as shown. Calculate the weight of the metre rule.

A. 1.5 N
B. 2.1 N
C. 2.5 N
D. 3.6 N

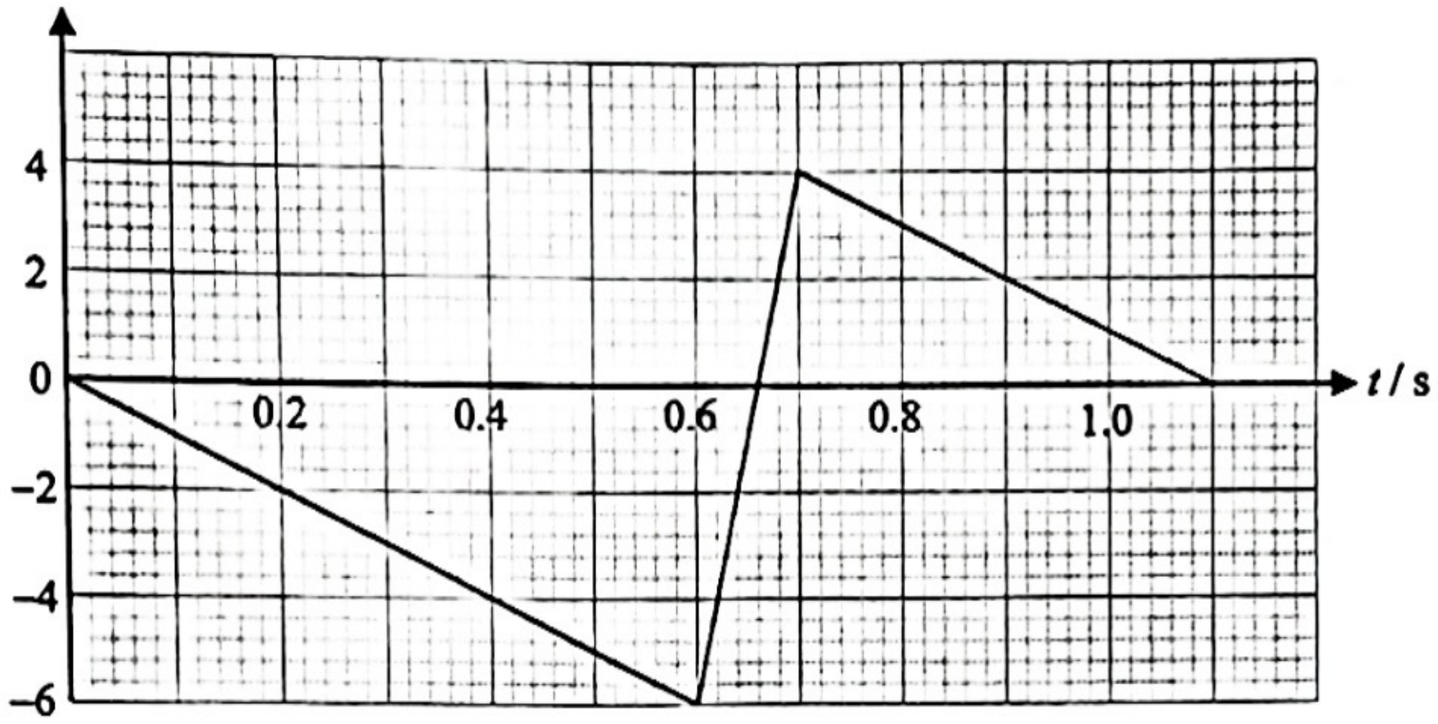
8. A man pulls a 6 kg block up a rough inclined plane with a constant velocity of 1.2 m s^{-1}. The inclined plane is 18 m long and makes an angle of 30° with the horizontal as shown above. If the power output by the man to pull the block is 54 W, what is the frictional force acting on the block by the inclined plane ?



Take the acceleration due to gravity to be 10 m s^{-2}.

A. 10 N
B. 12 N
C. 15 N
D. 18 N

9.

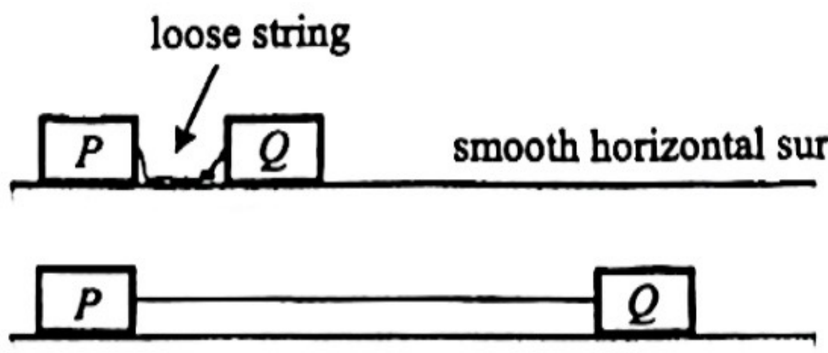


A ball of mass 0.25 kg is released from rest at a certain height. It hits the ground and rebounds. The velocity-time graph of the ball is shown above. Upward direction is taken as positive. The acceleration due to gravity is taken as 10 m s^{-2}. Which of the following statements is/are correct ?

(1) The ball is released at a height of 1.8 m.
(2) The loss of kinetic energy of the ball during the collision with the ground is 2.5 J.
(3) The magnitude of the average force acting on the ball by the ground during the collision is 25 N.

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

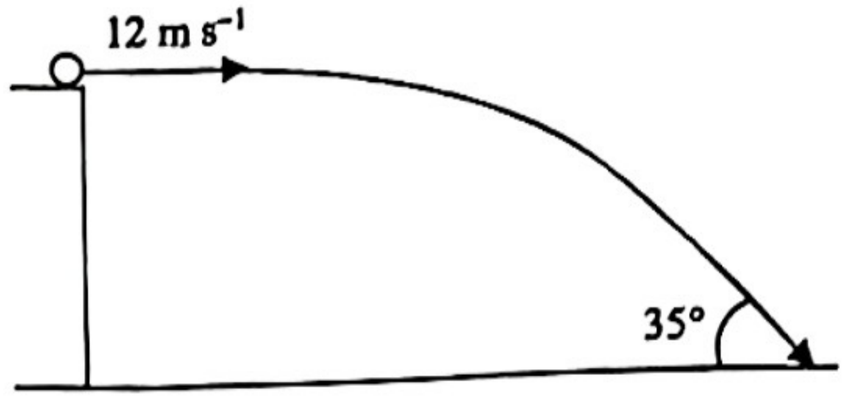
10. Two identical blocks *P* and *Q*, each of mass 0.25 kg, are connected by a light inextensible string. The blocks are at rest and the string is loose initially.



Now block *Q* is given a speed of 8 m s^{-1} and moves to the right. Find the loss of kinetic energy of the two blocks when the string just becomes taut and *P* starts to move.

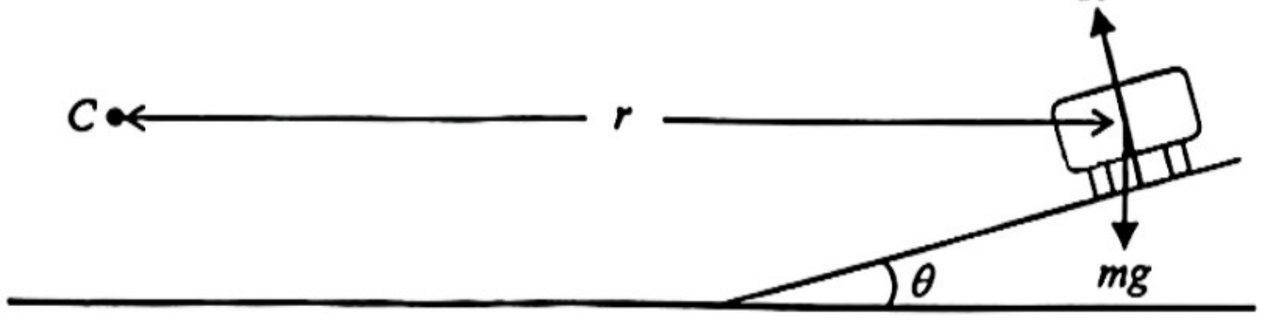
A. 1 J
B 2 J
C. 4 J
D. 8 J

11. A small particle is projected horizontally at the top of a table with an initial horizontal velocity of 12 m s^{-1}. The particle performs projectile motion and reaches the ground. If the landing velocity of the particle makes an angle of 35° with the horizontal, what is the height of the table ?



A. 2.8 m
B. 3.6 m
C. 6.2 m
D. 8.6 m

12.



A vehicle of mass m is moving with a constant speed of 16 m s^{-1} on an ideal banking road along a horizontal path of radius 60 m. 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 ?

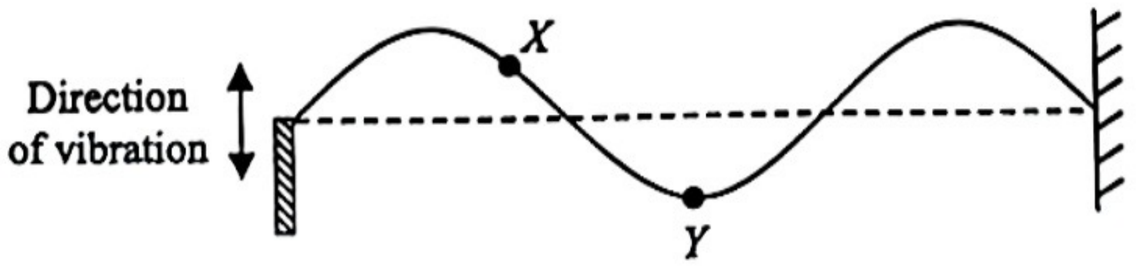
(1) The centripetal force is provided by a component of the weight mg towards the centre of the path.
(2) The normal reaction force R is equal to $mg \cos \theta$.
(3) To travel safely along the circular path, the angle of the banking road should be 23.5°.

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

13. A satellite orbits the Earth in a circular path of radius 7500 km. What is the linear speed of the satellite ? Given that the mass of the Earth is 6.0×10^{24} kg.

A. 6800 m s^{-1}
B. 7300 m s^{-1}
C. 7600 m s^{-1}
D. 7800 m s^{-1}

14.



A vibrator generates a stationary transverse wave on a string. The above figure shows the string at a certain instant but not at the extreme position. Particles X and Y are shown in the figure. Which of the following statements is correct ?

A. Particle X is moving downwards and particle Y is moving upwards at this instant.
B. Particles X and Y vibrate with the same amplitude.
C. Particles X and Y vibrate with the same speed.
D. When particle X is at rest, particle Y must also be at rest.

15.

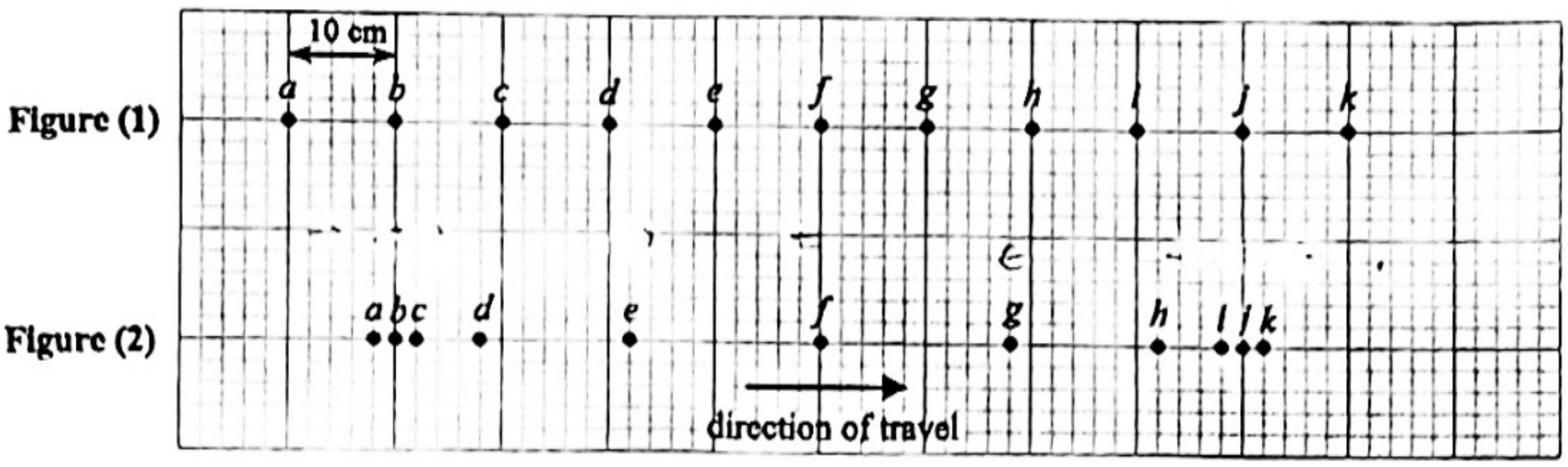


Figure (1) shows the equilibrium positions of particles a to k separated by 10 cm from each other in a medium. A longitudinal wave is travelling from left to right with a speed of 40 cm s^{-1}. At a certain instant t_o, the positions of the particles are shown in Figure (2). Which of the following statements is **NOT** correct ?

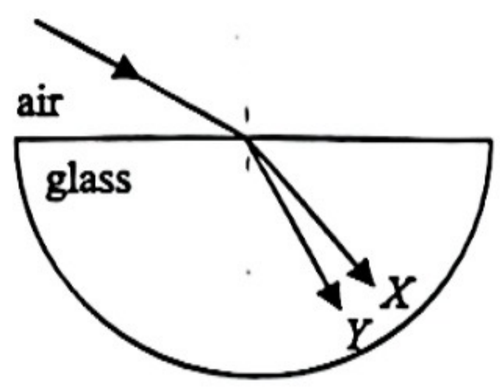
A. The frequency of the longitudinal wave is 0.5 Hz.
B. Particles g and i are moving towards the left at the instant t_o.
C. The amplitude of the wave is 12 cm.
D. The speed of particle b is greater than that of c at the instant t_o.

16. An object is placed at 20 cm in front of a lens L. An inverted, diminished image is formed at the other side of the lens. Which of the following statements are correct ?

(1) L is a converging lens.
(2) The focal length of the lens L is shorter than 10 cm.
(3) If the lens is moved slightly away from the object, the size of the image will decrease.

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

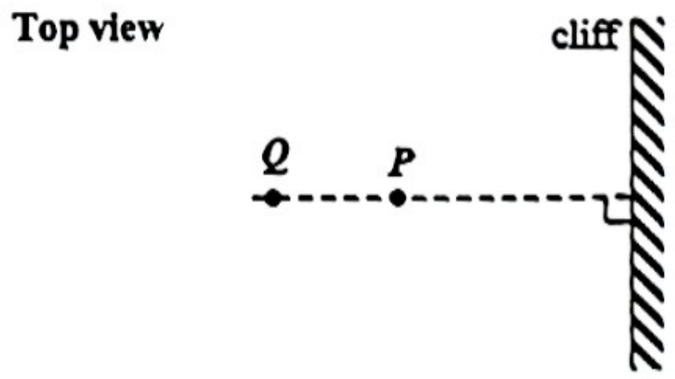
17. A beam of white light is directed towards a semi-circular glass block. It splits into a spectrum with two ends X and Y as shown in the figure. Which of the following descriptions is/are correct ?



(1) X is the red light and Y is the violet light.
(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. (3) only
C. (1) and (2) only
D. (2) and (3) only

18. Peter stands at position P which is 200 m in front of a vertical cliff. Mary stands at position Q which is 100 m from P as shown in the figure. The speed of sound in air is 325 m s^{-1}. When Peter claps his hands once, Mary hears two clapping sounds separated by a time interval of t second. Find the value of t.

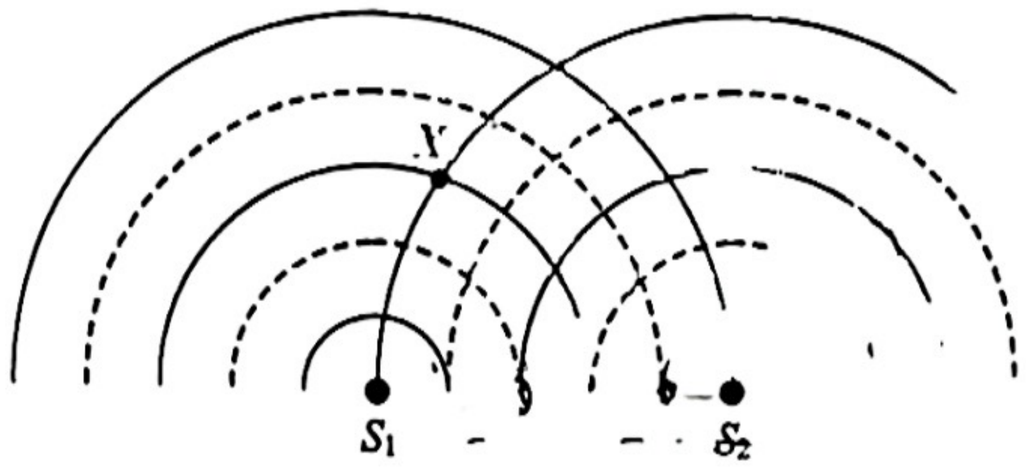


A. 0.62 s
B 0.92 s
C 1.23 s
D. 1.85 s

19. A Young's double-slit experiment is performed using a monochromatic light source of wavelength 650 nm. The slit separation of the double slit is 0.25 mm. Alternate bright and dark fringes are formed on a screen placed at 1.6 m away from the double slit. What is the separation of the 5th order dark fringe from the central line on the screen ?

A 18.7 mm
B 20.8 mm
C. 22.5 mm
D. 22.9 mm

20.

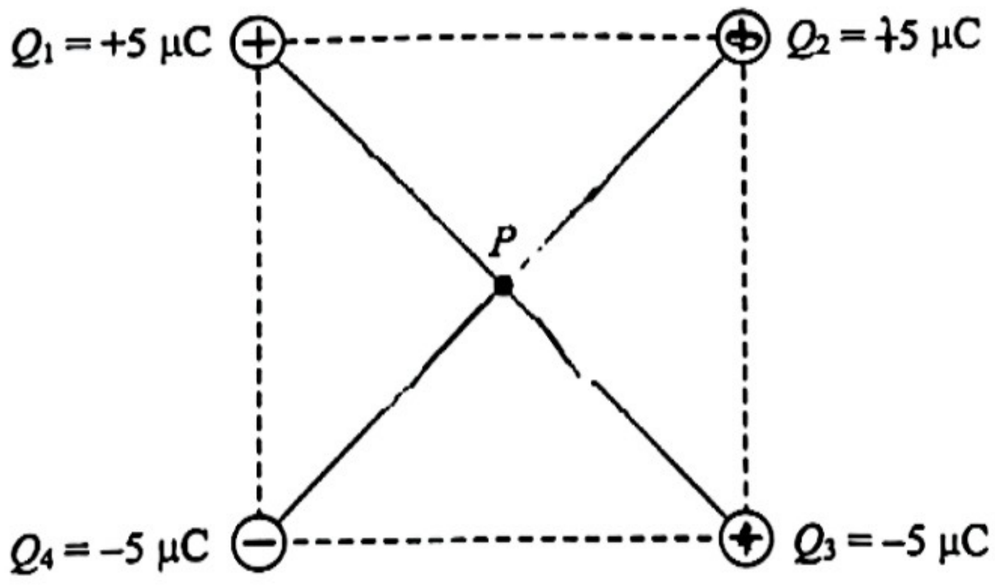


Two point sources S_1 and S_2 are producing circular water waves in a ripple tank. The figure shows part of the wave pattern at a certain instant. Solid lines represent crests and dotted lines represent troughs. Which of the following statements is/are correct ?

(1) The water particle at X is always at the crest.
(2) The water particle at Y is always at rest.
(3) There are 5 antinodal lines formed in the interference pattern.

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

21.



As shown in the above figure, there are four point charges Q_1, Q_2, Q_3 and Q_4 situated at the four corners of a square. Each side of the square has a length of 10 cm. Point P is at the centre of the square. Find the resultant electric field at the point P, with magnitude and direction.

	magnitude	direction
A.	$9.0 \times 10^6\ N\ C^{-1}$	towards Q_1
B.	$9.0 \times 10^6\ N\ C^{-1}$	towards Q_3
C.	$1.8 \times 10^7\ N\ C^{-1}$	towards Q_1
D.	$1.8 \times 10^7\ N\ C^{-1}$	towards Q_3

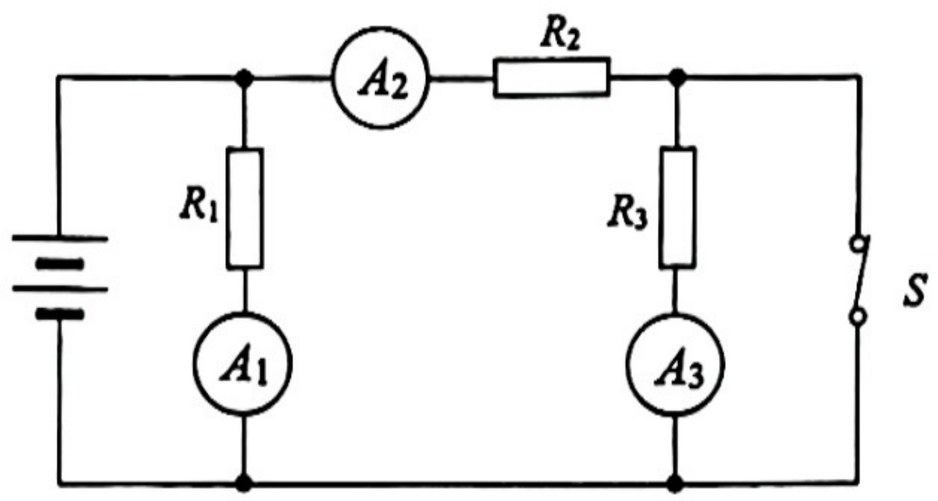
22. Two horizontal parallel plates with separation 2.5 cm are connected to a power supply of 500 V, with the upper plate connected to the positive terminal of the supply. If a charged oil droplet of mass 4×10^{-12} kg is floating between the two parallel plates, what is the sign and magnitude of the charge carried by the oil droplet ? (Take g to be 10 m s^{-2}.)

A. -2×10^{-15} C
B. $+2 \times 10^{-15}$ C
C. -4×10^{-15} C
D. $+4 \times 10^{-15}$ C

23. A battery used in mobile phone has a capacity of 3300 mA h. The operating voltage of the phone remains at 3.7 V. If the battery can supply current steadily within 30 hours in stand-by mode, what is the average power delivered by the battery ?

A. 0.204 W
B. 0.407 W
C. 0.611 W
D. 0.814 W

24.

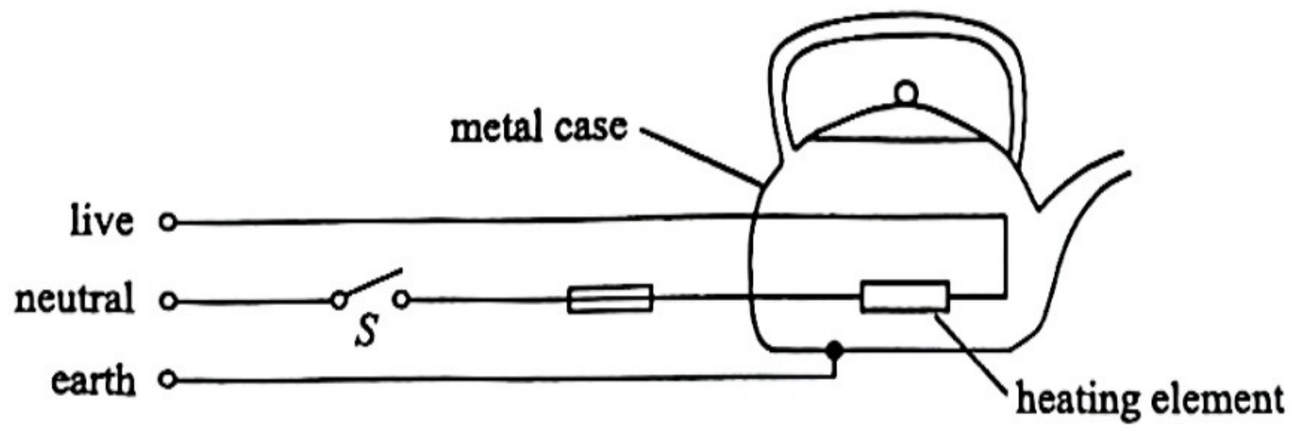


In the above circuit, the three resistors are identical. The internal resistance of the battery is negligible. The ammeters are all ideal. Which of the following statements are correct if the switch S is now opened ?

(1) The reading of A_1 decreases.
(2) The reading of A_2 decreases.
(3) The reading of A_3 increases.

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

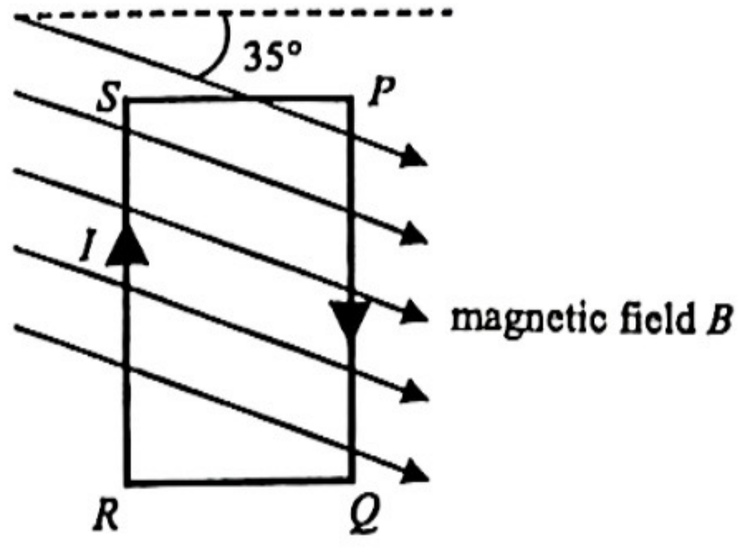
25.



In the figure above, the kettle is wired incorrectly. Which of the following statements concerning the operation of the kettle is correct ?

A. A current will flow through the live wire even when S is open.
B. The kettle will not operate at its rated value when S is closed.
C. The fuse will blow when S is closed.
D. The heating element is at high potential when S is open.

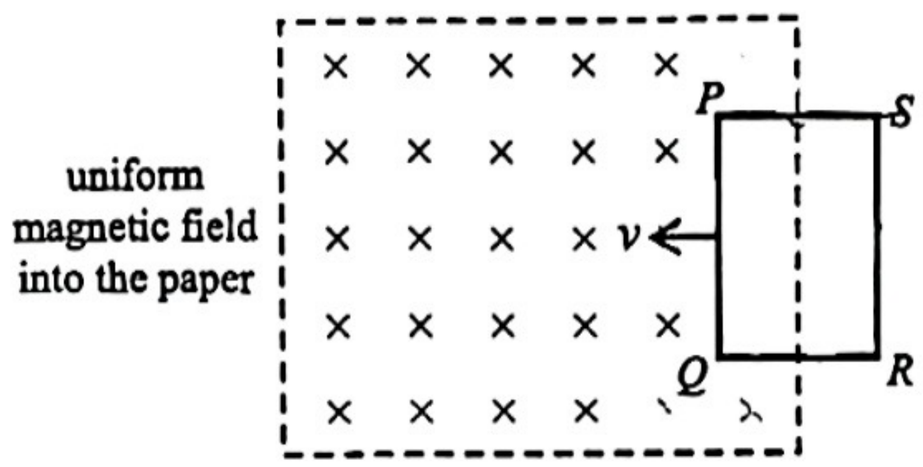
26.



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 is **NOT** correct ?

A. The direction of the magnetic force acting on the segment *PQ* is perpendicularly out of paper.
B. The magnitude of the magnetic force acting on the segment *PQ* is 0.393 N.
C. There is no magnetic force acting on the segment *SP*.
D. The resultant force acting on the whole loop is zero.

27.

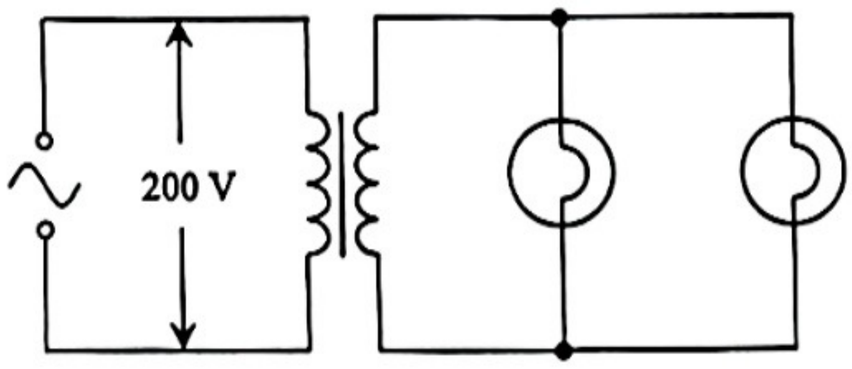


A rectangular metal frame *PQRS* is moving with constant velocity into a region of uniform magnetic field perpendicularly into the paper. Which of the following statements are correct when the frame is at the position shown in the above figure ?

(1) The point *P* is at a higher potential than *Q*.
(2) An induced current flows in the frame in anticlockwise direction.
(3) A magnetic force acts on the side *PQ* towards the right.

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

28.



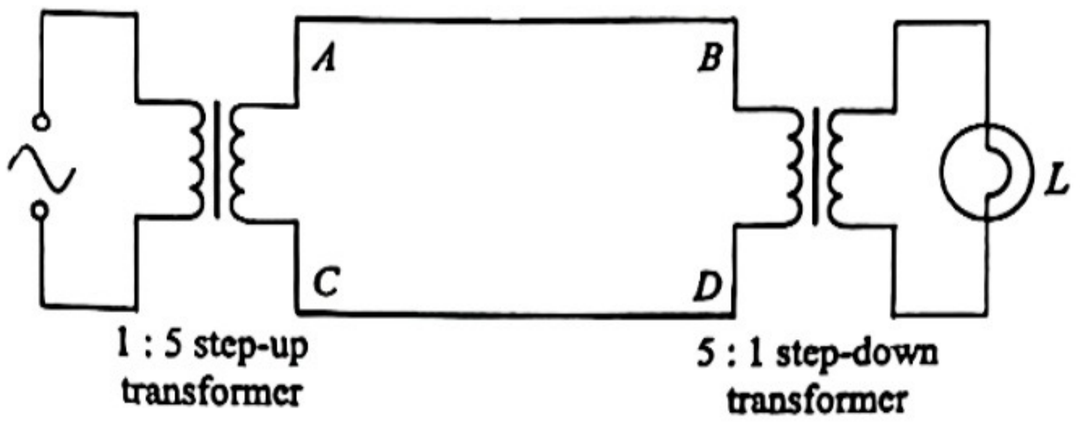
In the above circuit, each light bulb has a resistance of 50 Ω. If the turns ratio of the step-down transformer is 5 : 1, and the efficiency of the transformer is 80%, find the current in the primary coil ?

A. 0.4 A
B. 0.5 A
C. 0.6 A
D. 0.8 A

29. A long solenoid has a diameter of 5 cm and a turn density of 3000 m^{-1}. When a steady current I is flowing, the magnetic flux through the solenoid is 4.5×10^{-6} Wb. The current I is

A. 0.152 A.
B 0.304 A.
C 0.608 A.
D 0.912 A.

30.



The above figure shows a model power transmission system. An a.c. supply and two ideal transformers are used to transmit power to a lamp L of rating values of '6 V, 12 W'. The total resistance of the cables AB and CD is 10 Ω. Find the input power of the a.c. supply so that the lamp L works at its rated value.

A. 13.6 W
B. 15.2 W
C. 90 W
D. 102 W

31. The activity of a radioisotope is measured to be 28 MBq. If the activity of the radioisotope is 40 MBq at 10 hours before, what is the activity of the radioisotope at 15 hours before ?

A. 16.4 MBq
B 35.6 MBq
C. 47.8 MBq
D. 52.6 MBq

32. The activity of a radioactive sample is 2.4 GBq. The number of undecayed nuclei in the sample is 6.4×10^{18}. What is the half-life of the radioactive sample ?

A. 29.3 year
B. 44.0 year
C. 58.6 year
D. 87.9 year

33. A typical fission reaction of uranium-235 is given as follows :

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3{}^{1}_{0}n + 200\,MeV$$

A uranium fuel rod contains 5 kg of uranium-235. What is the total energy that can be released by the fuel rod if all the uranium-235 nuclei have undergone fission reaction ? (Molar mass of uranium-235 is 235 g.)

A. 4.1×10^{11} J
B 4.1×10^{14} J
C. 4.5×10^{14} J
D. 4.9×10^{17} J

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	$\text{AU} = 1.50 \times 10^{11}\ \text{m}$
light year	$\text{ly} = 9.46 \times 10^{15}\ \text{m}$
parsec	$\text{pc} = 3.09 \times 10^{16}\ \text{m} = 3.26\ \text{ly} = 206265\ \text{AU}$
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 :

$$v = u + at$$

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

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

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

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

Atomic World

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

Energy and Use of Energy

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

Medical Physics

$\theta \approx \dfrac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)
$\text{power} = \dfrac{1}{f}$	power of a lens
$L = 10\log\dfrac{I}{I_0}$	intensity level (dB)
$Z = \rho c$	acoustic impedance
$\alpha = \dfrac{I_r}{I_0} = \dfrac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$	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.	$pV = \frac{1}{3}Nmc^2$	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.	$N = N_0e^{-\lambda t}$	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

2022

Mock Examination

PHYSICS PAPER 1

SECTION B : Question-Answer Book B

This paper must be answered in English

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.

Please stick the barcode label here.

Candidate Number

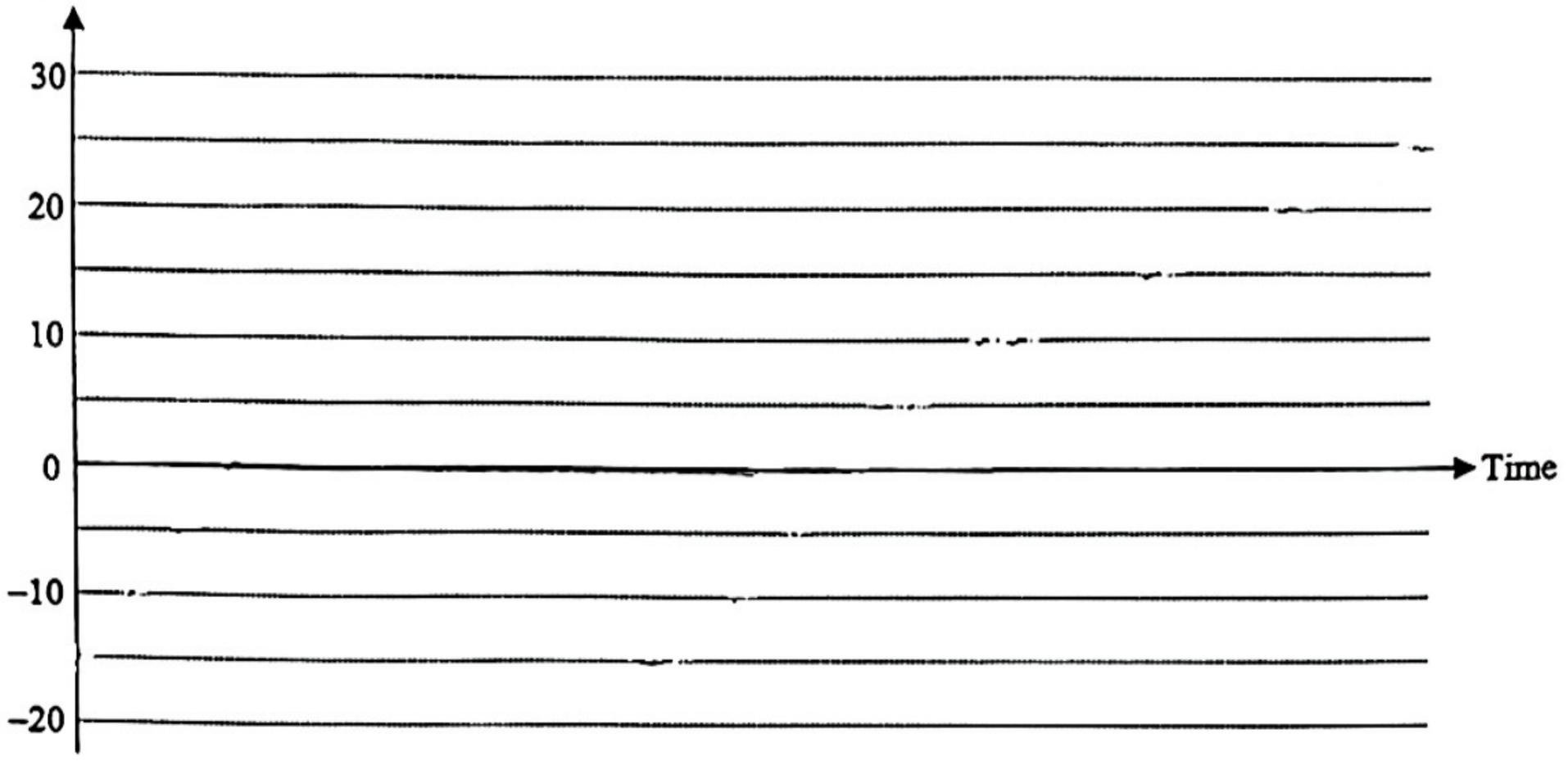
Question No.	Marks
1	7
2	8
3	12
4	7
5	7
6	5
7	8
8	12
9	9
10	9

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)

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   (ii) If the piece of ice at −15 °C is put into a beaker 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)

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   (iii) If the heat capacity of the beaker is taken into consideration, explain the effect on the final temperature of the mixture. (1 mark)

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Answers written in the margins will not be marked.

2.

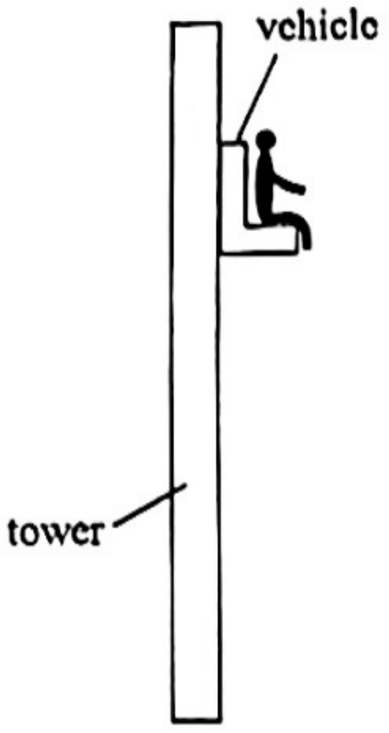

Figure (a)

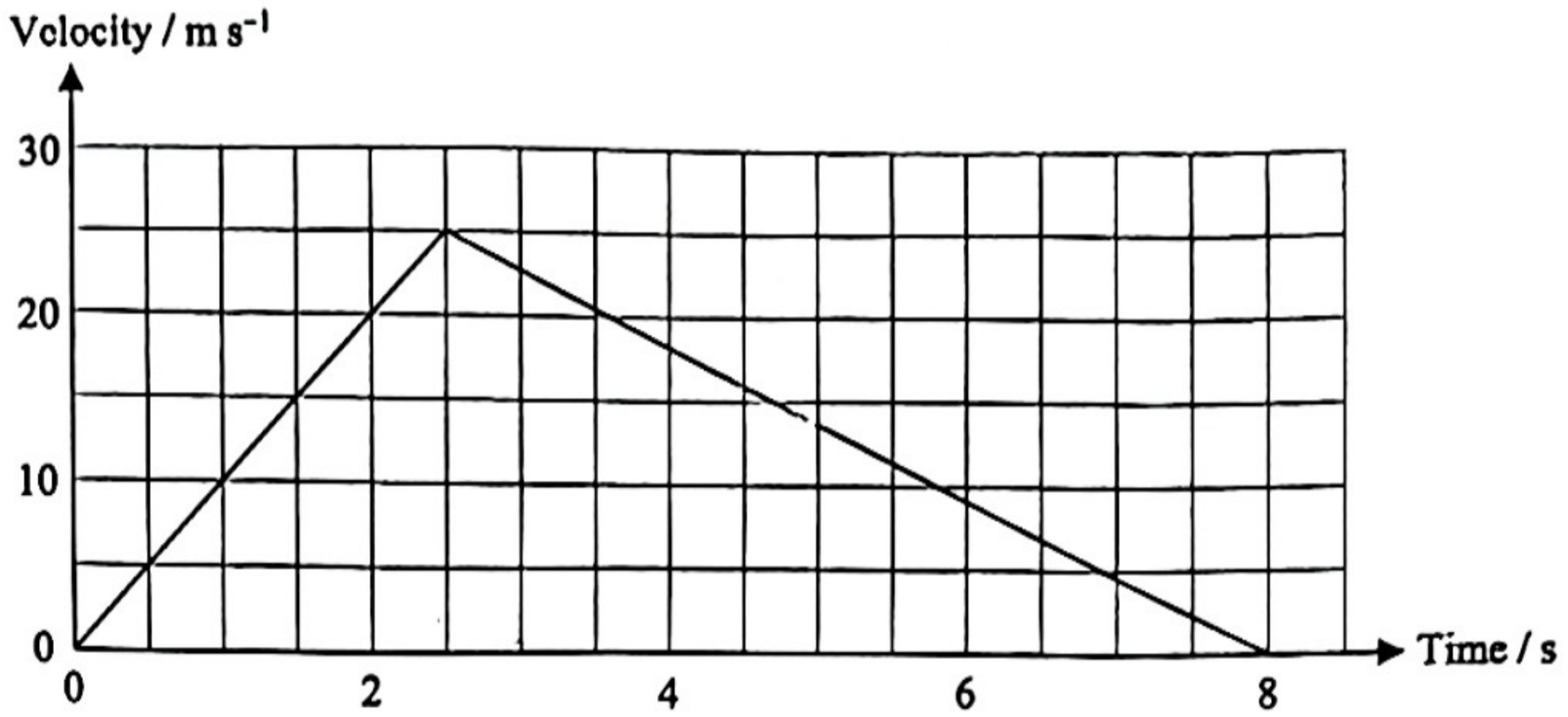

Figure (b)

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)

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(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)

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

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(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 deceleration time interval. Explain whether the feeling of the passenger is normal, heavier or lighter during this time interval. (3 marks)

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Answers written in the margins will not be marked.

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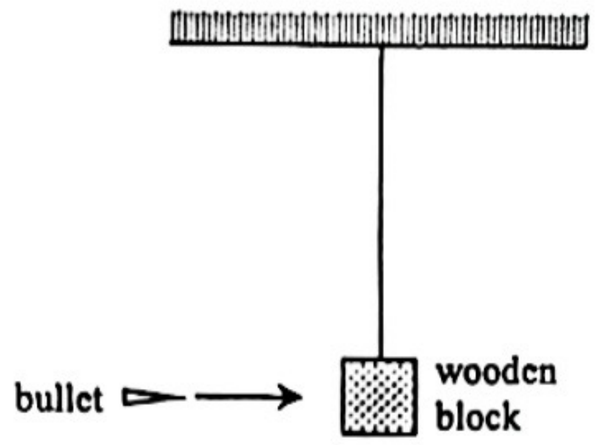
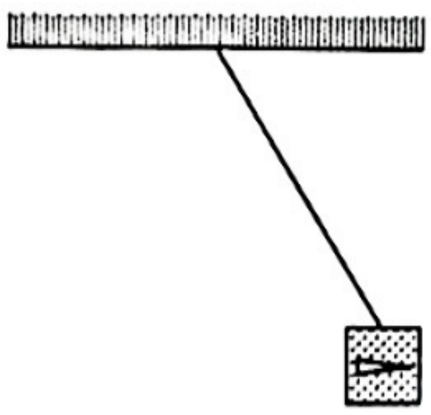


A wooden block of mass 1.24 kg is hanging freely in the air from a light string of length 20 cm. A bullet of mass 10 g travelling at a speed of 200 m s^{-1} hits the block and becomes embedded in it. The block then swings upwards as shown in the figure below.



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

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

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

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(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."

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

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

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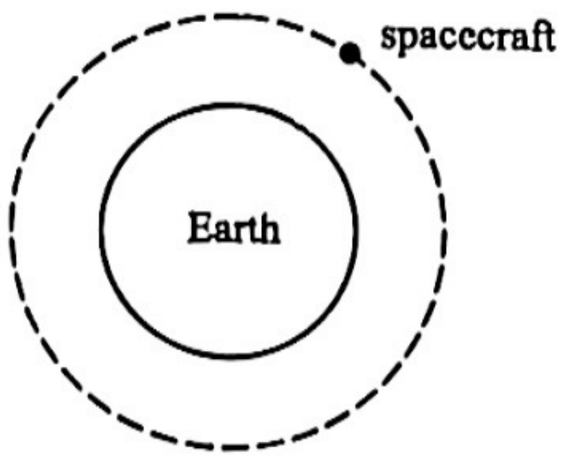
Answers written in the margins will not be marked.

4. 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)

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(b) Explain why the spacecraft can travel in constant speed even though there is gravitational force acting on it. (1 mark)

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

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(d) How many number of revolutions does the spacecraft take in 24 hours ? Give the answer corrected to 1 decimal place. (2 marks)

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Answers written in the margins will not be marked.

5.

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

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

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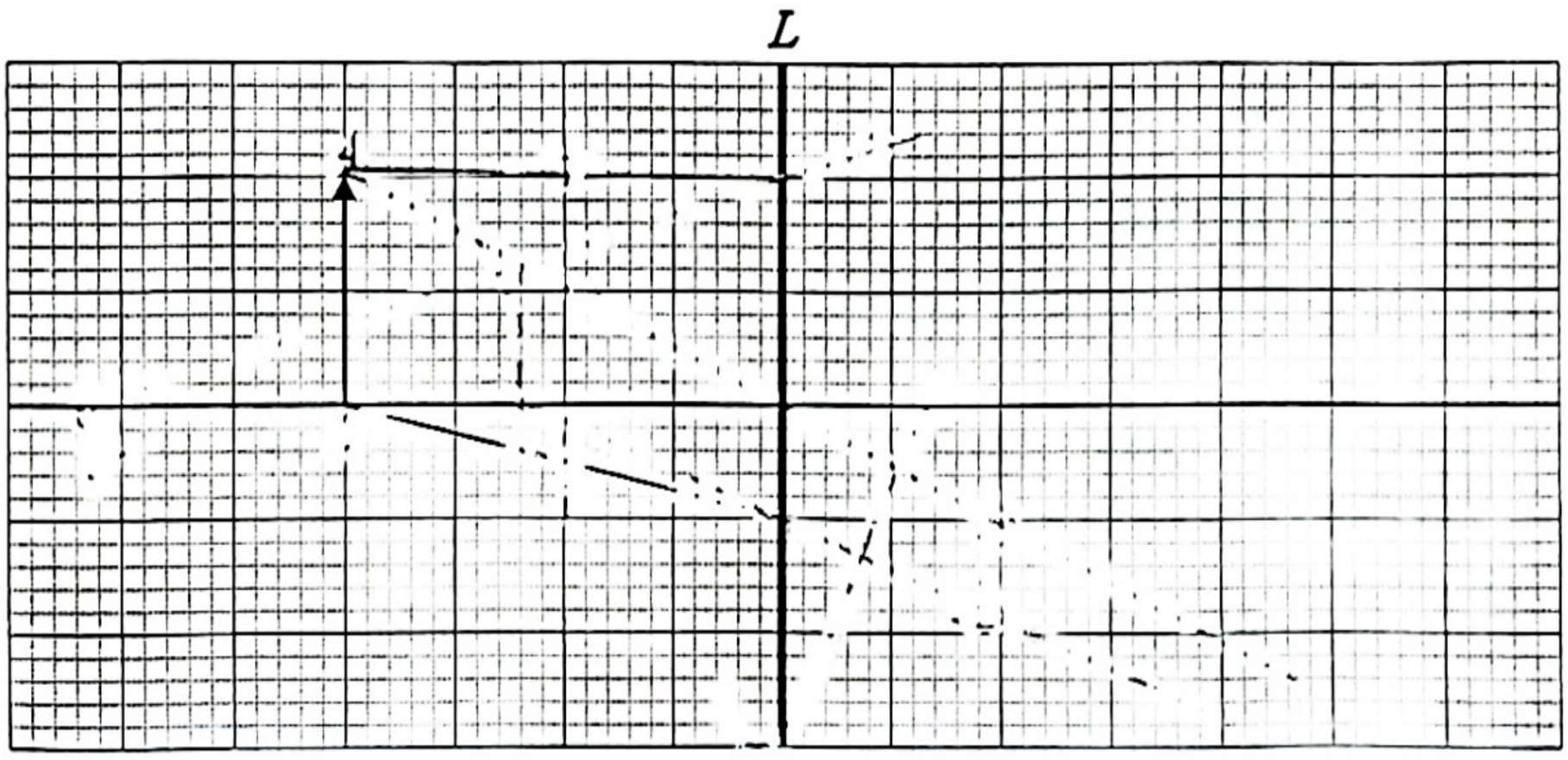
(b) The figure below shows the object AB representing the baby and the lens L.



(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)

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

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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

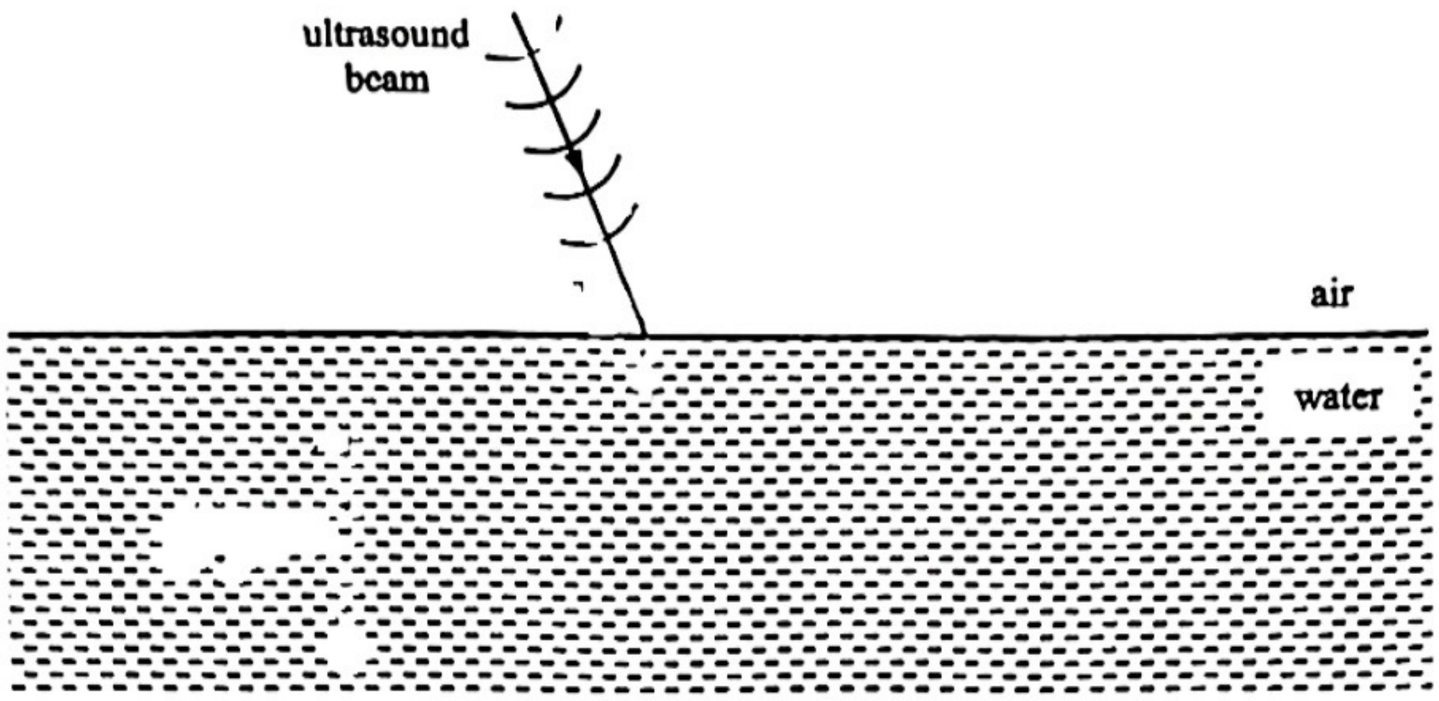
a cathode-ray oscilloscope (CRO)

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 on the CRO.
(5 marks)

Answers written in the margins will not be marked.

7.



A beam of ultrasound with frequency 3 MHz 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)

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(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)

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(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)

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

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(iii) Explain why an audible sound of frequency 1000 Hz is not suitable to be used in sonar system. (1 mark)

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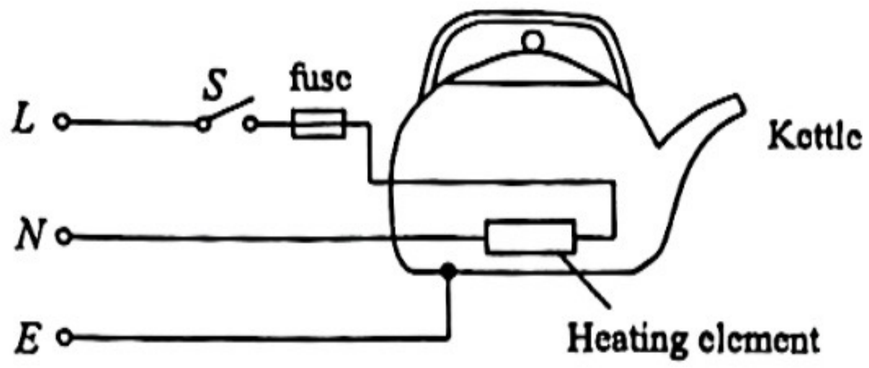
Answers written in the margins will not be marked.

8.



An electric kettle of rating "220 V 2800 W" contains water of mass 1.8 kg at an initial temperature of 25°C. The kettle is connected to the mains circuit via live wire (L), neutral wire (N) and earth wire (E) as shown in the figure.

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

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(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)

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

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

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

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(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 inside the kettle after 10 minutes ? Given : specific heat capacity of water = 4200 J kg^{-1} $°C^{-1}$ and specific latent heat of vaporization of water = 2.26×10^6 J kg^{-1} (2 marks)

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(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)

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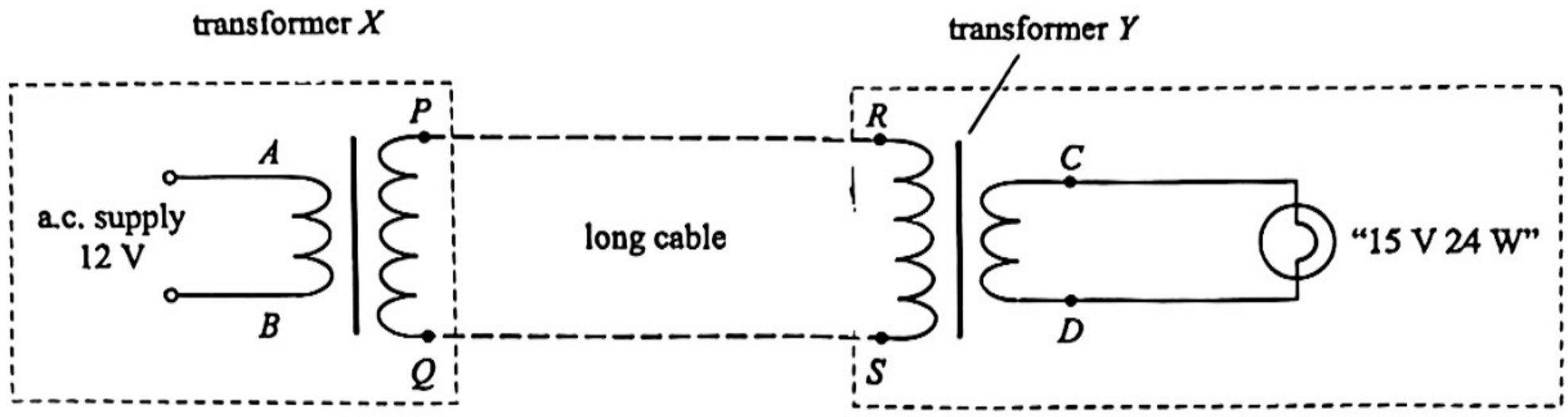
Answers written in the margins will not be marked.

9.



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)

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

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

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

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(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)

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

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Answers written in the margins will not be marked.

10. Polonium-218 (Po-218) has a half-life of 3.08 minutes. A polonium-218 nucleus 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

Please stick the barcode label here.

Candidate Number

2022

Mock Examination

PHYSICS PAPER 2

Question-Answer Book

(1 hour)

This paper must be answered in English

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 to the structured questions in the **ANSWER Book** provided. 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 Question-Answer Book and Answer Book will be collected **SEPARATELY** at the end of the examination.

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

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

(8) 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 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 7.4×10^{-7} rad 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. 43 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
○	○	○	○

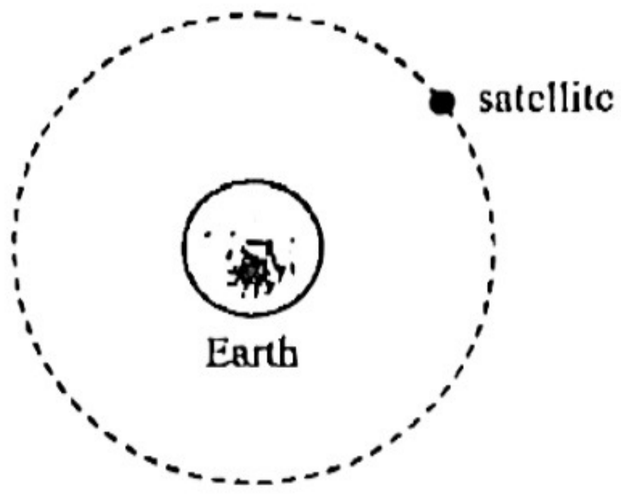
1.8

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



(a) For a satellite of mass m moving in a circular orbit of radius r around the Earth of mass M, the only force acting on the satellite is the gravitational force, if air resistance is negligible.

(i) Derive an expression for the kinetic energy K of the satellite, in terms of G, M, m and r. (1 mark)

(ii) Take the gravitational potential energy U of the satellite at infinity to be zero, derive an expression for the total mechanical energy E of the satellite, in terms of G, M, m and r. (1 mark)

(b) A geostationary satellite orbiting around the Earth above the equator always seems to stay at a certain position.

(i) State the period of a geostationary satellite. (1 mark)

(ii) Calculate the radius of the orbit of the geostationary satellite. (3 marks)

(iii) Explain why a geostationary satellite is used as a communication satellite. (1 mark)

(c) After a few years, the geostationary satellite loses a mechanical energy of 2.0×10^9 J due to the effect of the Earth's atmosphere.

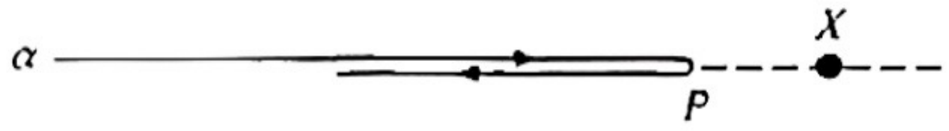
(i) Calculate the new orbital radius of the satellite. (2 marks)

(ii) State the change of the linear speed of the satellite after it moves into the new orbit. (1 mark)

Section B : Atomic World

Q.2: Multiple-choice questions

2.1



The above figure shows the path of an α-particle moving head-on towards a gold nucleus X. At point P, the α-particle is closest to the nucleus. Which statement below is **NOT** correct ?

A. The potential energy of the α-particle at P is at a maximum.
B. The distance PX gives an upper limit of the size of the nucleus X.
C. If the α-particle has a larger initial speed, the distance between P and X would be greater.
D. If the gold nucleus is replaced by another nucleus of greater atomic number, the distance P and X would be greater.

A	B	C	D
○	○	○	○

2.2 Some hydrogen atoms in the third excited state (i.e. $n = 4$) subsequently produce a spectrum consisting of a series of discrete lines. How many spectral lines of different wavelengths are there in the spectrum ?

A. 3
B. 4
C. 6
D. 8

A	B	C	D
○	○	○	○

2.3 The orbital radius of the electron of a hydrogen atom at the ground state is 5.3×10^{-11} m. What is the linear momentum of the electron when it is at the second excited state ($n = 3$) ?

A. 3.3×10^{-25} N s
B. 4.4×10^{-25} N s
C. 5.5×10^{-25} N s
D. 6.6×10^{-25} N s

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 photon makes a collision with an atom at ground state. The photon is absorbed by the atom. Which of the following consequences may occur ?

(1) The atom becomes ionized.
(2) The atom emits a photon of the same wavelength as the incident photon.
(3) The atom emits a few photons of different wavelengths.

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

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
○	○	○	○

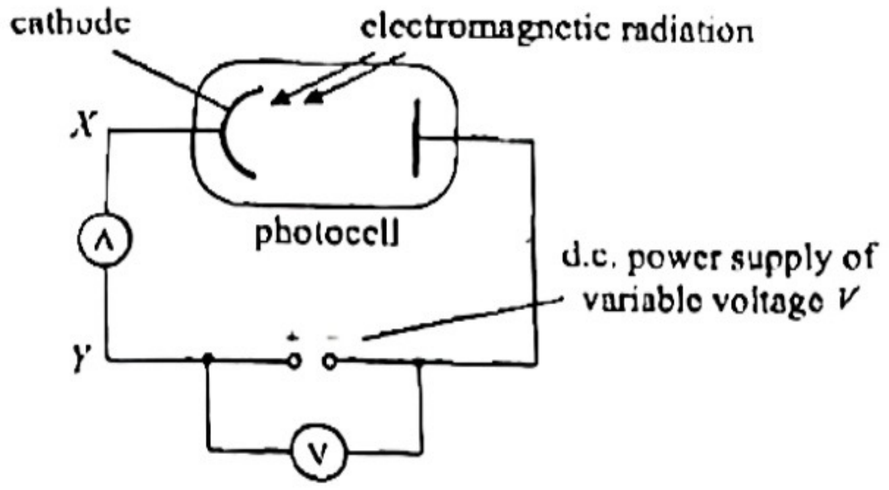
2.8 Which of the following may be the possible applications of nanotechnology ?

(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



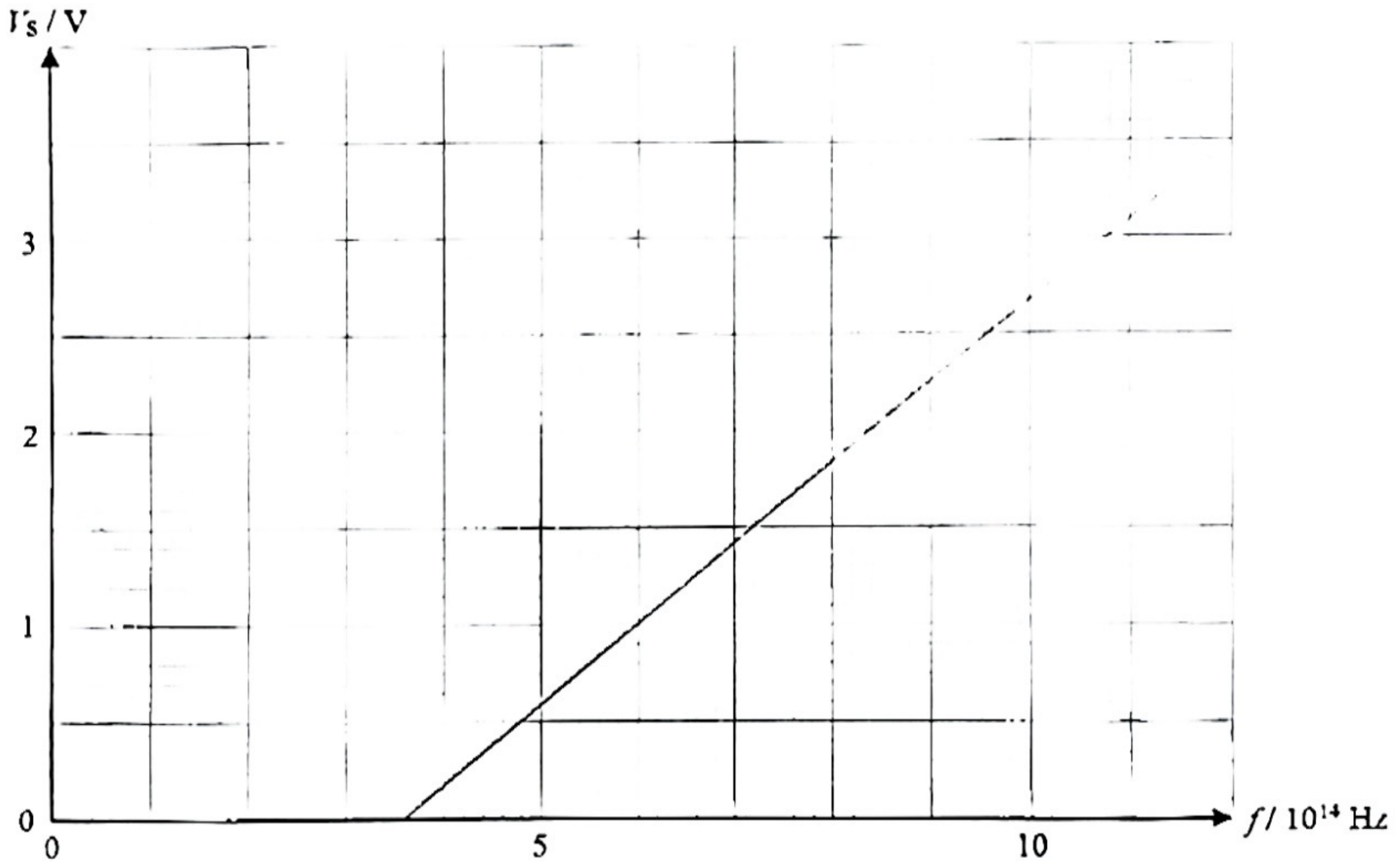
The above set-up is used to investigate the stopping potential of the photoelectrons emitted from the cathode of a photocell when electromagnetic radiation of different frequencies are incident onto the cathode. The d.c. power supply gives a variable voltage V across the photocell.

(a) Briefly describe how the stopping potential V_S of the photoelectrons emitted can be measured using this set-up for a certain frequency of radiation. (1 mark)

(b) When photoelectrons are emitted from the cathode, state the direction of current through the ammeter (from X to Y or from Y to X), if the ammeter has deflection. (1 mark)

(c) Sketch a graph of the current I through the ammeter against the voltage V. (1 mark)

The graph below shows how the stopping potential V_S of the photoelectrons emitted from the surface of a metal A varies with the frequency f of the incident radiation.



(d) Derive an expression represented by the slope of the graph. (1 mark)

(e) From the graph, state and explain an observation that cannot be explained by the wave theory of light. (2 marks)

(f) Suppose now a beam of monochromatic light of wavelength 400 nm is incident onto the cathode.

(i) From the graph, find the maximum kinetic energy of the photoelectrons emitted from the cathode. (2 marks)

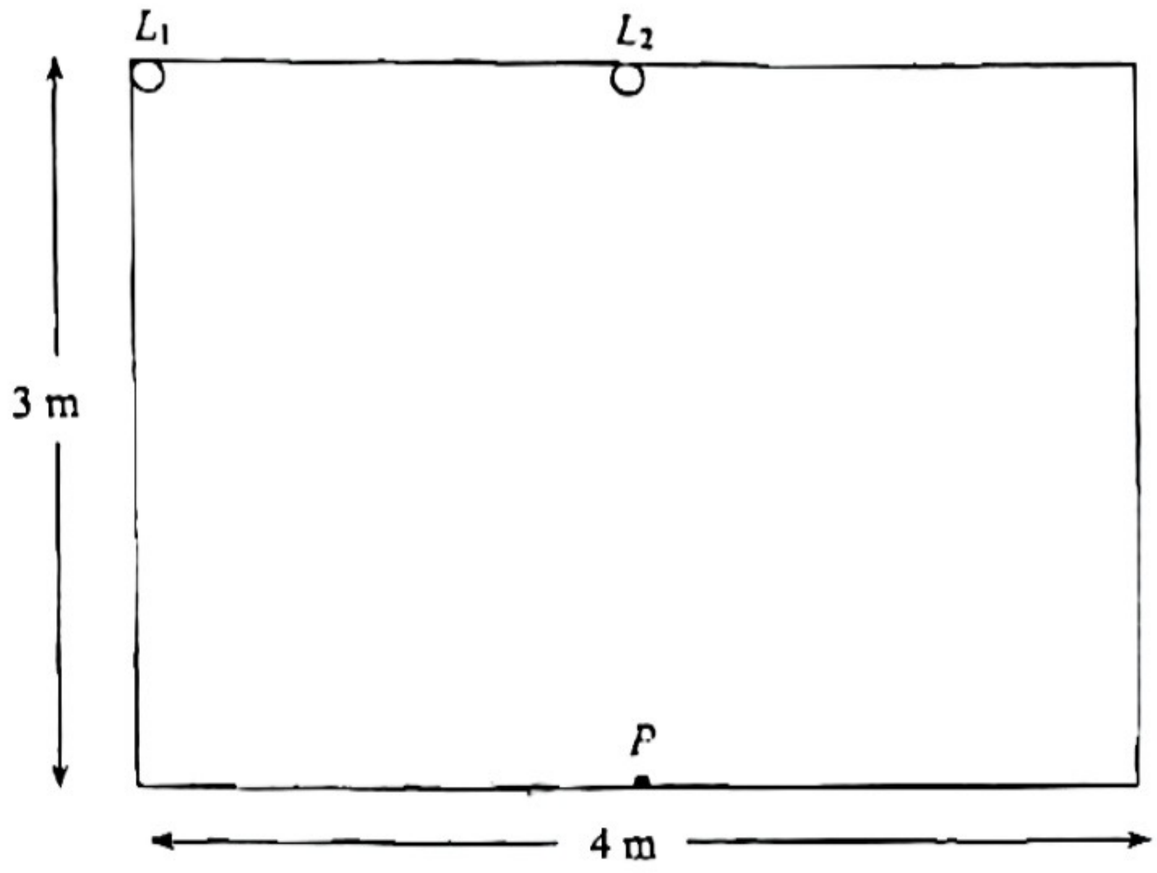
(ii) Find the maximum kinetic energy of the photoelectrons reaching the anode if the voltage of the d.c. power supply is adjusted to 0.8 V. (1 mark)

(g) State the change of the x-intercept of the graph if the experiment is repeated by using higher intensity of electromagnetic radiation. (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. Two identical small lamps L_1 and L_2, each gives out a steady luminous flux of 2500 lm, are used to illuminate the room. L_1 is fixed at the corner and L_2 is fixed at the middle of the ceiling, as shown in the figure. Neglect the reflection of light by the surrounding walls and ceiling. Calculate the illuminance at the point P, which is exactly at the middle of the floor.

A. 13 lx
B. 22 lx
C. 28 lx
D. 35 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 36 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. 2.0
B. 2.2
C. 2.4
D. 2.8

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 following descriptions about a hybrid car is/are correct ?

(1) A hybrid car has no pipe emission.
(2) A hybrid car does not require charging via an external power source.
(3) The battery of a hybrid car can only be charged by regenerative braking system.

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

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 ?

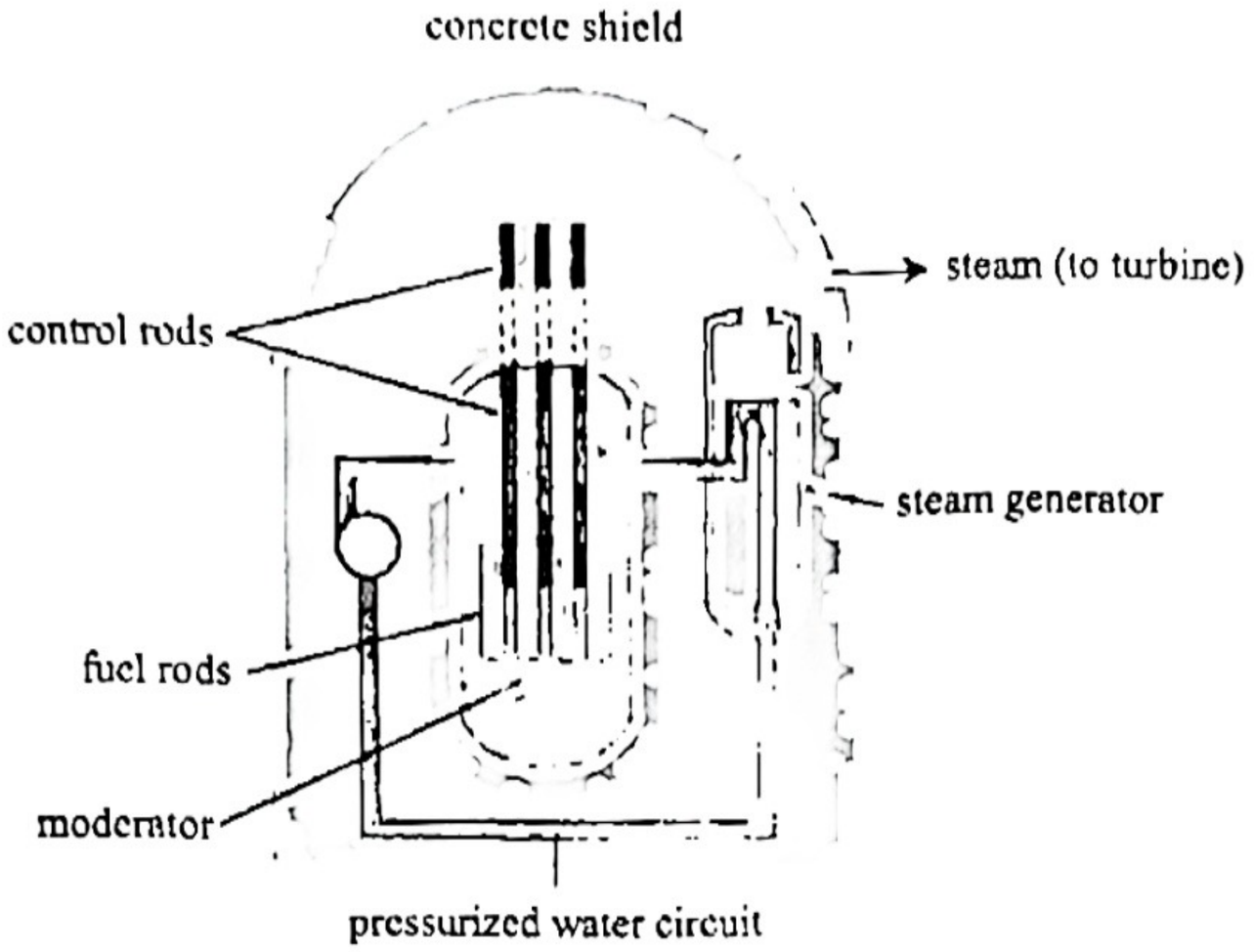
(1) Compact fluorescent bulbs are more energy efficient than incandoscent light bulbs.
(2) The capital cost of compact fluorescent bulbs is less expensive than incandescent light bulbs.
(3) The disposal of compact fluorescent bulbs causes less pollution problem to the environment.

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 0.208 u for each fission.

(i) Calculate the energy released in each fission of U-235. Give your answer in J. (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 generating an average electrical power of 500 MW, calculate the mass of U-235 needed in one day, if the energy conversion efficiency is 38%. Given that the molar mass of U-235 is 235 g. (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 hydroclectric 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.	B	6.	A	11.	B	16.	D	21.	D	26.	C	31.	C
2.	D	7.	B	12.	B	17.	C	22.	A	27.	C	32.	C
3.	A	8.	C	13.	B	18.	C	23.	B	28.	A	33.	B
4.	C	9.	C	14.	D	19.	A	24.	C	29.	C		
5.	C	10.	C	15.	B	20.	D	25.	D	30.	A		

Solution

1. B

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

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

∴ (2) Although the value of mc for X is smaller, 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 smaller.

2. D

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

(2) As the temperature decreases, kinetic energy and average speed of gas molecules decrease. Thus, the momentum of each gas molecule decreases. Each gas molecule then hits the wall with a smaller force due to its smaller momentum.

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

3. A

By $PV = nRT = \frac{N}{N_A}RT$

$\therefore P(500 \times 10^{-6}) = \frac{(3\times10^{22})}{(6.02\times10^{23})}(8.31)(25+273)$ $\therefore P = 247000\ \text{Pa} = 247\ \text{kPa}$

4. C

Thinking distance : $l = 24 \times 0.5 = 12\ \text{m}$

Braking distance : $s = 52 - 12 = 40\ \text{m}$

By $v^2 = u^2 + 2as$ $\therefore (0) = (24)^2 + 2a(40)$ $\therefore a = -7.2\ \text{m s}^{-2}$

Deceleration of the car $= 7.2\ \text{m s}^{-2}$

5. C

There are 3 forces acting on the block :

1. weight W of the block, acting on the block by the Earth
2. normal reaction R, acting on the block by the inclined plane
3. friction f, acting on the block by the inclined plane

Both R and f are the forces acting on the block by the inclined plane.

The resultant force of R and f must balance the weight W.

Thus, the resultant force of R and f must be equal in magnitude and opposite in direction to W.

As the direction of W is vertically downwards, the direction of the resultant force of R and f must be vertically upwards.

6. A

Assume the normal reaction force between X and Y is R.

As the force 50 N is greater than 30 N, the system would move to the left with constant acceleration a.

Consider block X : $R - 30 = 2ma$

Consider block Y : $50 - R = 3ma$

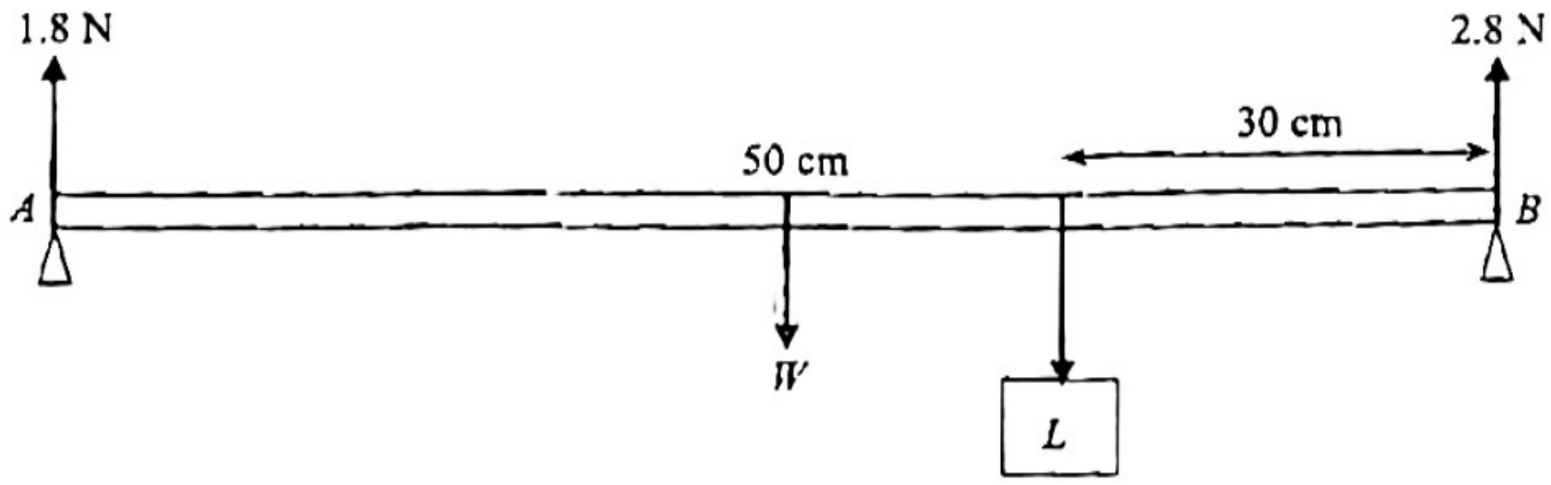
Adding the two equations together : $50 - 30 = 5ma$ $\therefore ma = 4$

For X : $R - 30 = 2 \times 4$ $\therefore R = 38$ N towards the left

7. 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. (The weight W of the metre rule has no moment about this point)

Moments of 1.8 N and L are clockwise and moment of 2.8 N is anticlockwise about the middle.

$1.8 \times 50 + L \times 20 = 2.8 \times 50$ $\therefore L = 2.5$ N

Balance of forces : $1.8 + 2.8 = W + 2.5$ $\therefore W = 2.1$ N

8. C

By $P = Fv$ $(54) = F(1.2)$ $\therefore F = 45$ N

Since the block is moved with constant velocity, the acceleration is zero, net force is zero.

Thus, the applied force F is equal to the component of weight and friction.

By $F = mg \sin\theta + f$

$(45) = (6)(10) \sin 30° + f$ $\therefore f = 15$ N

9. C

(1) Height = area of the graph from 0 to 0.6 s $= \frac{1}{2} \times 6 \times 0.6 = 1.8$ m

(2) Loss of K.E. $= \frac{1}{2}(0.25)(6)^2 - \frac{1}{2}(0.25)(4)^2 = 2.5$ J

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

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

$\therefore R - (0.25)(10) = \frac{(0.25)(4) - (0.25)(-6)}{(0.1)} \quad \therefore R = 27.5$ N

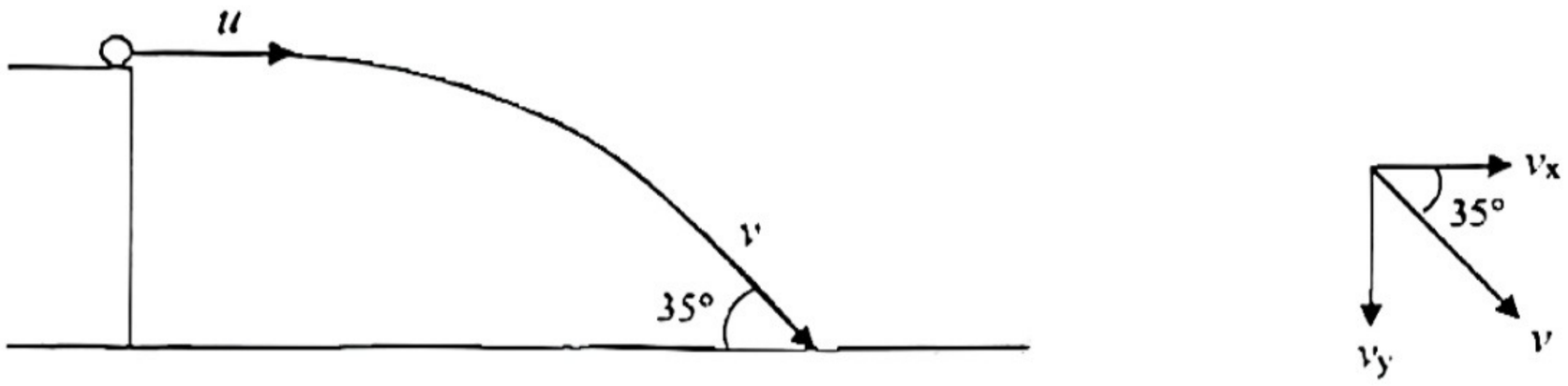
10. C

By Conservation of momentum : $m_1 u_1 + m_2 u_2 = (m_1 + m_2) v$

$\therefore (0.25)(8) = (0.25 + 0.25) v \quad \therefore v = 4 \text{ m s}^{-1}$

$\Delta KE = \frac{1}{2}(0.25)(8)^2 - \frac{1}{2}(0.25 + 0.25)(4)^2 = 4$ J

11. B



Resolve the landing velocity v into 2 components.

Horizontal component : $v_x = u = 12 \text{ m s}^{-1}$

By $\tan\theta = \frac{v_y}{v_x} \quad \therefore \tan 35° = \frac{v_y}{(12)} \quad \therefore v_y = 8.40 \text{ m s}^{-1}$

By $v_y^2 = u_y^2 + 2 a s_y \quad \therefore (8.40)^2 = 2(9.81) s_y \quad \therefore s_y = 3.6$ m

12. 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 $R\cos\theta = mg \quad \therefore \tan\theta = \frac{v^2}{gr} = \frac{(16)^2}{(9.81)(60)} \quad \therefore \theta = 23.5°$

13. B

As $\frac{GMm}{r^2} = \frac{mv^2}{r} \quad \therefore v = \sqrt{\frac{GM}{r}} = \sqrt{\frac{(6.67\times10^{-11})(6.0\times10^{24})}{(7500\times10^{3})}} = 7300 \text{ m s}^{-1}$

14. D

× A. At the instant shown, particle X may be moving upwards or downwards, and particle Y may be moving downwards or upwards.

× B. Particle Y is the antinode, it has greater amplitude than X.

× C. Since particle Y is the antinode, it has greater speed than X.

✓ D. Since X and Y are in opposite phase, both of them come to rest at the extreme positions at the same time.

15. B

✓ A. By $v = f\lambda$ $\therefore$ $(40) = f(80)$ $\therefore$ $f = 0.5$ Hz

× B. Particle g is moving towards the left but particle i is moving towards the right.

· C. Particle d is at the extreme position. Displacement of particle d is the amplitude, which is 12 cm.

✓ D. Particle b is at the equilibrium position, which has the greatest speed at this position.

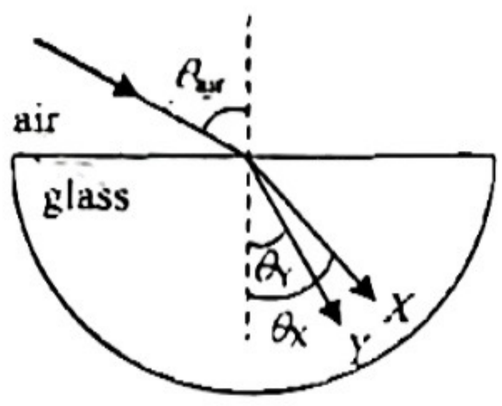
16. D

(1) Since the image is inverted, it is a real image. Only converging lens (convex lens) can give real image.

(2) Since the real image is diminished, the object must be beyond $2f$, that is, $u > 2f$ and $f < v < 2f$.
As $20 > 2f$, therefore, $f < 10$ cm.

(3) If the lens is moved slightly away from the object, object distance increases.
The real image will shift towards the lens and becomes smaller.

17. C



(1) Red light has the least deviation, thus X is the red light and Y is the violet light.

(2) During refraction, $\sin\theta \propto v$. Thus, $\sin\theta_{air} / \sin\theta_{glass} = v_{air} / v_{glass}$.
Since $\sin\theta_{air}$ and v_{air} are the same for all colours, the refracted angle in glass $\theta_X > \theta_Y$ $\therefore$ $v_X > v_Y$.
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.

18 C

The sound produced at P travels a distance of PQ towards Q and Q hears the first sound.

The sound produced at P travels towards the cliff and reflected to Q and Q hears the second sound.

The extra distance travelled by the second sound is two times the distance between P and the cliff.

By $2d = vt$ $2(200) = (325)t$ $t = 1.23$ s

19. A

$$\Delta y = \frac{\lambda D}{a} = \frac{(650\times10^{-9})(1.6)}{(0.25\times10^{-3})} = 4.16\times10^{-3}\text{ m} = 4.16\text{ mm}$$

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

Separation of the 5th order dark fringe from the central line $= 4.5\ \Delta y = 4.5\times4.16 = 18.72$ mm

20. D

× (1) The path difference at X is 1 λ, thus X is at constructive interference that has maximum amplitude. However, particle at X is oscillating up and down, thus it may be at crest or at trough.

(2) The path difference at Y is 2.5 λ, thus Y is at destructive interference and is always at rest.

(3) Since the separation a between the two sources is 2.5 λ, there are 5 antinodal lines between them, which have path difference of 0 λ, ± 1 λ, ± 2 λ.

21. D

The electric fields due to Q_2 and Q_4 are in opposite directions and they balance each other.

The electric fields due to Q_1 and Q_3 at P are both pointing to Q_3 and they add up to give the resultant E field.

Distance of P from $Q_1 = \sqrt{10^2+10^2}/2 = 7.07$ cm

Resultant electric field : $E = \frac{Q}{4\pi\varepsilon_0 r^2}\times2 = \frac{(5\times10^{-6})}{4\pi(8.85\times10^{-12})(7.07\times10^{-2})^2}\times2 = 1.8\times10^7\text{ N C}^{-1}$

Direction of the resultant electric field E is towards Q_3.

22. A

Electric field between the two parallel plates : $E = \frac{V}{d} = \frac{(500)}{(0.025)} = 2\times10^4\text{ V m}^{-1}$

Since the upper plate is positive, the direction of the E field is downwards.

Since the oil droplet is floating, electric force on the oil droplet = weight of oil droplet.

By $qE = mg$ $\therefore\ q(2\times10^4) = (4\times10^{-12})(10)$ $\therefore\ q = 2\times10^{-15}$ C

As the direction of weight is downwards, the direction of electric force is upwards.

Since the direction of electric force and electric field is in opposite directions, the sign of the charge is negative.

23. B

Capacity : $Q = 3300\text{ mA h} = 3300\times10^{-3}\text{ A}\times3600\text{ s} = 11880\text{ C}$

Energy stored in the battery : $E = QV = (11880)(3.7) = 43956$ J

Average power : $P = \frac{E}{t} = \frac{(43956)}{(30\times3600)} = 0.407$ W

OR

Average current : $I = \frac{Q}{t} = \frac{3300\text{ mA h}}{30\text{ h}} = 110\text{ mA} = 0.11\text{ A}$

Average power : $P = VI = (3.7)(0.11) = 0.407$ W

24. C

× (1) Since the voltage across the resistor R_1 remains unchanged, reading of A_1 should be unchanged.

(2) Initially when the switch is closed, R_3 is shorted.
When the switch S is opened, the resistor R_3 is in series with R_2.
The resistance in this branch increases from $1R$ to $2R$, thus the current decreases.

(3) As R_3 is initially shorted, A_3 is zero. After the switch is opened, A_3 is equal to A_2, thus A_3 increases.

25. D

× A. When S is open, the circuit is not complete, there is no current flow.

× B. When S is closed, the mains voltage is still applied to the kettle, it can work normally.

× C. When S is closed, rated current flows through the fuse, thus the fuse will not blow.

✓ D. When S is open, the heating element is still connected to live, which is at high potential.
There will be electric shock if someone touches the heating element when S is open.

26. C

✓ A. Consider the effective component of the magnetic field in horizontal direction.
By use of the Left hand rule, direction of the magnetic force on PQ is perpendicularly out of paper.

B. $F = BIl = (0.6 \cos 35°) \times (2) \times (0.40) = 0.393$ N

× C. Segment SP experiences the vertical downward component of the magnetic field.
The magnetic force on SP is perpendicularly into paper.

D. 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 always be balanced.
However, there are couples acting on the loop, and the loop will rotate.

27. C

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

(2) E.m.f. are induced on the side PQ from P to Q, thus induced current flows in direction $PQRS$.

(3) Since induced current flows from P to Q, by Left hand rule, magnetic force on PQ acts towards the right.

28. A

Secondary voltage of the transformer $= 200 \times \frac{1}{5} = 40$ V

Power output of the transformer $= \frac{(40)^2}{50} \times 2 = 64$ W

By $\eta = \frac{P_{out}}{P_{in}}$

$\therefore (80\%) = \frac{(64)}{(200) \times I_p}$ $\therefore I_p = 0.4$ A

29. C

By $\Phi = BA$

$\therefore\ (4.5 \times 10^{-6}) = B(\frac{\pi}{4} \times 0.05^2)$ $\therefore\ B = 2.29 \times 10^{-3}$ T

By $B = \mu_0 n I$

$\therefore\ (2.29 \times 10^{-3}) = (4\pi \times 10^{-7})(3000) I$ $\therefore\ I = 0.608$ A

30. A

For the lamp to operate at its rated value, the current through the lamp should be $\frac{12}{6} = 2$ A

As it is a step down transformer, the current through the wire $ABCD$ should be $\frac{2}{5} = 0.4$ A

Power loss in the cables $= I^2 R = (0.4)^2(10) = 1.6$ W

Power input of the a.c. supply = power loss + power output $= 1.6 + 12 = 13.6$ W

31. C

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

At 10 hours before :

$(28) = (40) e^{-k(10)}$ $\therefore\ k = 0.03567$ hour^{-1}

At 15 hours before :

$(28) = A_0 e^{-(0.03567)(15)}$ $\therefore\ A_0 = 47.8$ MBq

32. C

By $A = kN$

$\therefore\ (2.4 \times 10^9) = k(6.4 \times 10^{18})$ $\therefore\ k = 3.75 \times 10^{-10}$ s^{-1}

By $t_{1/2} = \frac{\ln 2}{k}$

$\therefore\ t_{1/2} = \frac{\ln 2}{(3.75 \times 10^{-10})} = 1.85 \times 10^9$ s $= 58.6$ year

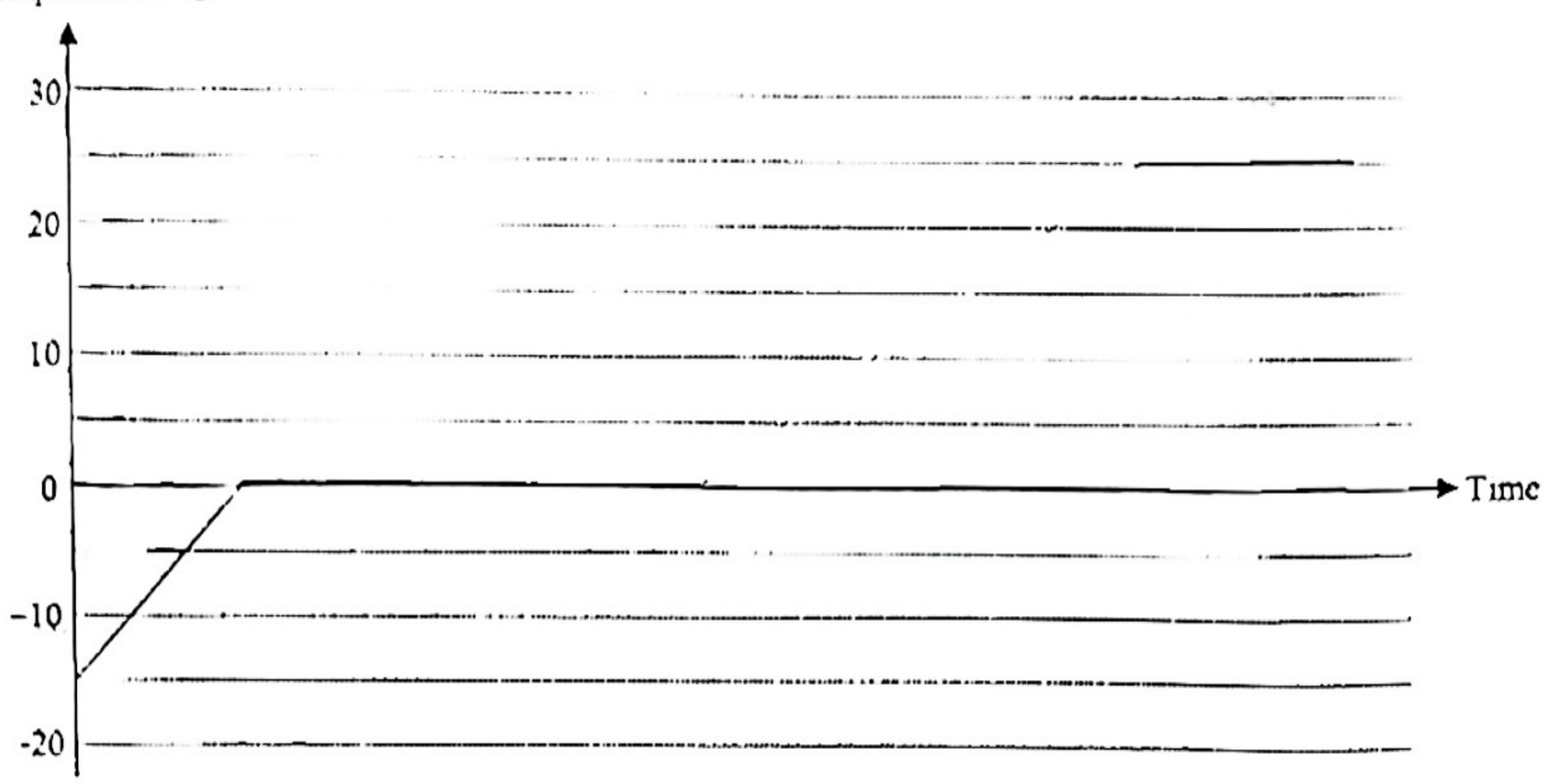
33. B

Number of uranium-235 nuclei in the fuel rod $= \frac{5}{0.235} \times (6.02 \times 10^{23}) = 1.28 \times 10^{25}$

Total energy release $= (1.28 \times 10^{25}) \times (200 \times 10^6 \times 1.6 \times 10^{-19}) = 4.1 \times 10^{14}$ J

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 $= m c \Delta T + m l_f$ [1]

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

$= 36700$ J [1]

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

$\therefore \theta = 35.4°C$ [1]

(iii) The final temperature would be higher since heat is also given out by the beaker. [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 $= - \dfrac{(25)}{(8 \quad 2.5)} = -4.545$ m s^{-2} [1]

$F - mg = ma$

$F - (80)(10) = (80)(4.545) \quad \therefore F = 1160$ N < accept 1160 N to 1170 N > [1]

The passenger would feel heavier since the supporting force is greater than his weight. [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) $\frac{1}{2} M v^2 = M g h$ $\therefore \frac{1}{2}(1.6)^2 = (9.81) h$ [1]

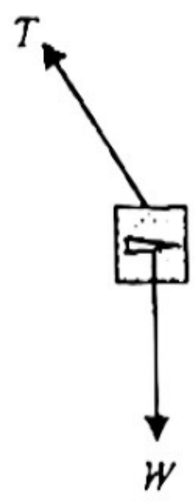
$\therefore h = 0.130 \text{ m}$ < accept 0.13 m > [1]

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

$= \frac{(0.01)(1.6) - (0.01)(200)}{(5 \times 10^{-3})}$ [1]

$= -397 \text{ N}$ < accept – 396.8 N > < accept 397 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) $g = \frac{G M_E}{r^2}$ $\therefore g \propto \frac{1}{r^2}$ $\frac{g}{(9.81)} = \frac{(6380)^2}{(6380 + 750)^2}$

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

OR

$G M_E = g R^2 = (9.81)(6380 \times 10^3)^2 = 3.993 \times 10^{14}$

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

(b) Since the direction of the gravitational force is always perpendicular to the motion of the spacecraft, it has no work done on the spacecraft.

(c) $m g = \frac{m v^2}{r}$ $\therefore (7.85) = \frac{v^2}{(6380 + 750) \times 10^3}$

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

4. (d) $T = \dfrac{2\pi r}{v}$

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

$= 5989$ s

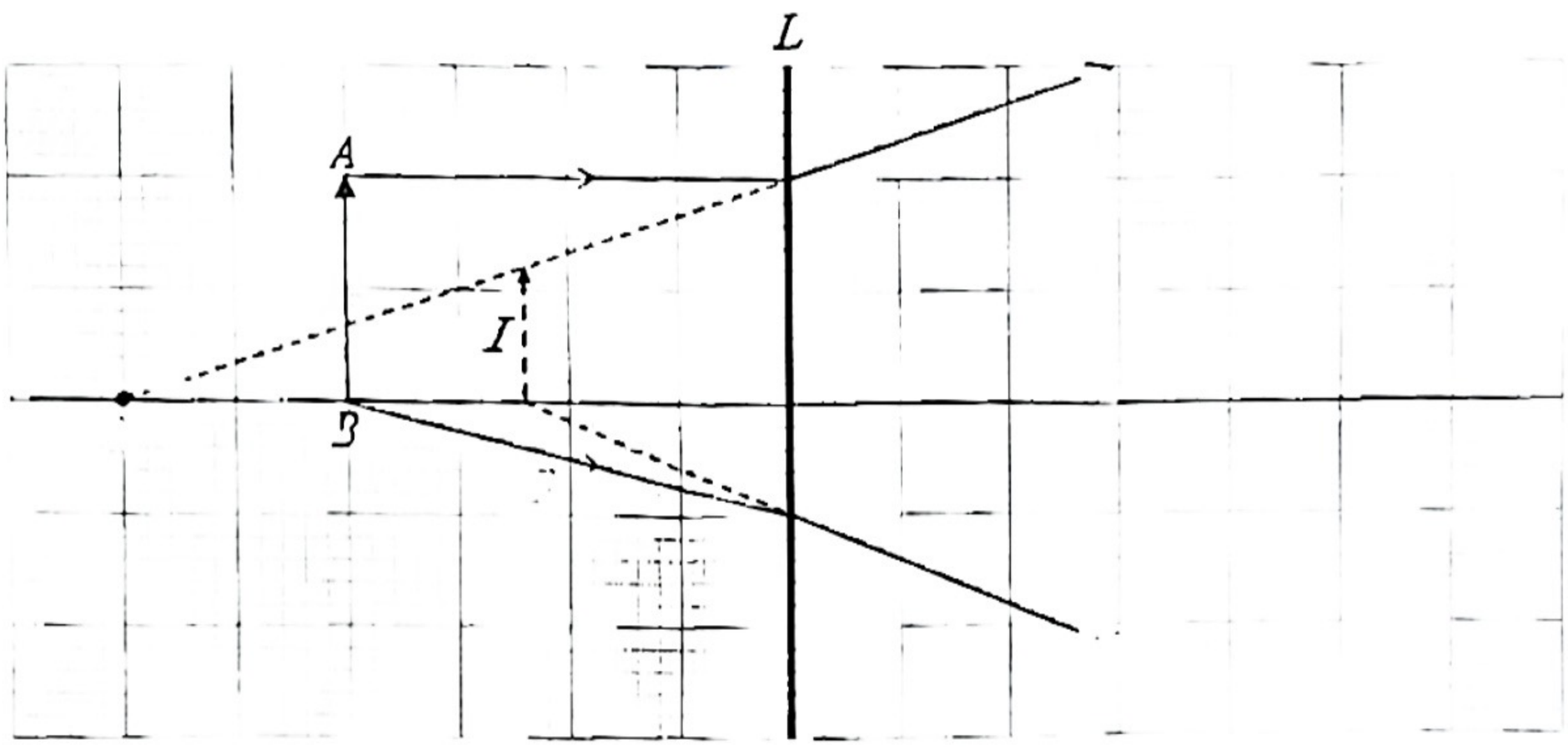
Number of revolutions in 24 h $= \dfrac{24\times 3600}{5989}$

$= 14.4$ < 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. < only erect **OR** only diminished **is NOT** accepted > [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) $\frac{\sin(90° - 78°)}{\sin r} = \frac{340}{1500}$ [1]

$\therefore \quad r = 66.5°$ [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) $t = \frac{2d}{v} = \frac{2 \times 240}{1500}$ [1]

$= 0.32$ s [1]

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

(iii) Audible sound has much longer wavelength

that 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 $= \frac{2800}{220} = 12.7$ 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 couvection currents. [1]

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

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

$\therefore \quad (2800)(10 \times 60) \times (1 - 20\%) = (1.8)(4200)(100 - 25) + m_s (2.26 \times 10^6)$

$\therefore \quad m_s = 0.344$ kg

Water left in the kettle $= 1.8 - 0.344 = 1.46$ kg <accept 1.456 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 $RS = 15 \times \frac{200}{50} = 60$ V [1]

9 (b) By $P = VI$ $(24) = (60)\,I$ [1]

$I = 0.4$ A [1]

OR

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

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

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

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

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

(e) $N_P = 340 \times \frac{12}{68} = 60$ [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) $\Delta m = \frac{5.2}{931}$ u [1]

$= \frac{5.2}{931} \times 1.661 \times 10^{-27}$ 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) $k = \frac{\ln 2}{3.08 \times 60} = 3.75 \times 10^{-3}\ s^{-1}$ [1]

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

(c) By $A = kN$

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

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

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

(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 $>$

$\therefore\ (75)^2 = a^3 \qquad \therefore\ a = 17.8$ 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 $= 5.3 \times 10^{12}$ 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

$$b = \frac{L}{4\pi d^2} = \frac{(3.9\times10^{26})}{4\pi(1.5\times10^{11})^2} = 1380 \text{ W m}^{-2}$$

1.5 B

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

$KE + PE = 0$

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

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

1.6 C

Parallax : $p = \frac{1}{2} \times (7.4 \times 10^{-7}) \times \frac{180^\circ}{\pi} = (2.12 \times 10^{-5})^\circ = (2.12 \times 10^{-5}) \times 60 \times 60'' = 0.0763''$

Distance : $d = \frac{1}{p} = \frac{1}{0.0763} = 13.1$ pc $= 13.1 \times 3.26$ ly ≈ 43 ly

1.7 B

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

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

1.8 A

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

By Doppler effect : $\frac{v_r}{c} = \frac{\Delta\lambda}{\lambda_0}$ $\therefore \frac{498\times10^3}{3\times10^8} = \frac{\Delta\lambda}{524.65}$ $\therefore \Delta\lambda = 0.87$ nm

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

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

Q1. (a) (i) $\frac{GMm}{r^2} = \frac{mv^2}{r}$

$\therefore K = \frac{1}{2}mv^2 = \frac{GMm}{2r}$ [1]

(ii) $E = U + K$

$= -(\frac{GMm}{r}) + (\frac{GMm}{2r})$

$= -\frac{GMm}{2r}$ [1]

(b) (i) $T = 24$ hours [1]

(ii) $g = \frac{GM}{R^2}$ $\therefore GM = gR^2 = (9.81)(6.4\times10^6)^2 = 4.018\times10^{14}$ [1]

By $\frac{GMm}{r^2} = mr\omega^2$ $\therefore \frac{GM}{r^3} = \omega^2 = (\frac{2\pi}{T})^2$ [1]

$\therefore \frac{(4.018\times10^{14})}{r^3} = (\frac{2\pi}{24\times3600})^2$

$r = 4.24\times10^7$ m <accept $4.2 - 4.3\times10^7$ m> [1]

(iii) The ground station can transmit radio signals to the satellite in a fixed direction without the need of tracking [1]

(c) (i) $\Delta E = (-\frac{GMm}{2r_2}) - (-\frac{GMm}{2r_1}) = \frac{GMm}{2}(\frac{1}{r_1} - \frac{1}{r_2})$

$(-2.0\times10^9) = \frac{(4.018\times10^{14})(2000)}{2}(\frac{1}{(4.24\times10^7)} - \frac{1}{r_2})$ [1]

$r_2 = 3.50\times10^7$ m [1]

(ii) The linear speed of the satellite increases when it moves to the new orbit. [1]

Section B : Atomic World

2.1 C

✓ A. Since both of the α-particle and the nucleus are positive, the electrical potential energy is positive.
As $PE = \frac{Qq}{4\pi\varepsilon_0 r}$, when r is minimum at P, PE is maximum.

B. As the α-particle will not enter the nucleus, the size of the nucleus cannot be greater than PX.
Thus, PX is the upper limit of the size of the nucleus.

× C. If the α-particle has a larger initial speed, it has greater kinetic energy.
When it comes to rest at P, the potential energy is greater.
As $PE = \frac{Qq}{4\pi\varepsilon_0 r}$, for greater PE, r should be smaller.

D. For another nucleus of greater atomic number, the number of protons is greater,
thus the nucleus has greater positive charge Q.
As $PE = \frac{Qq}{4\pi\varepsilon_0 r}$, for same potential energy at P, r is greater for greater Q.

2.2 C

When the atom is at the level E_4, there are 6 possible transitions :

$E_4 \rightarrow E_3$; $E_4 \rightarrow E_2$; $E_4 \rightarrow E_1$; $E_3 \rightarrow E_2$; $E_3 \rightarrow E_1$; $E_2 \rightarrow E_1$

2.3 D

By $r_n = n^2 r_1$ $\therefore r_3 = 3^2 \times (5.3 \times 10^{-11}) = 4.77 \times 10^{-10}$ m

By $mvr = n\frac{h}{2\pi}$

$\therefore mv \times (4.77 \times 10^{-10}) = (3)\frac{(6.63\times10^{-34})}{2\pi}$ $\therefore mv = 6.6 \times 10^{-25}$ N s

OR

By $2\pi r = n\lambda$

$\therefore 2\pi(4.77 \times 10^{-10}) = (3)\lambda$ $\therefore \lambda = 9.99 \times 10^{-10}$ m

By $\lambda = \frac{h}{mv}$

$\therefore (9.99 \times 10^{-10}) = \frac{(6.63\times10^{-34})}{mv}$ $\therefore mv = 6.6 \times 10^{-25}$ N s

2.4 A

By $\lambda = \frac{h}{p}$ $\therefore (2.5 \times 10^{-12}) = \frac{(6.63\times10^{-34})}{p}$

$\therefore p = 2.652 \times 10^{-22}$ kg m s^{-1}

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

$\therefore (1.6 \times 10^{-19})V = \frac{(2.652\times10^{-23})^2}{2(1.67\times10^{-27})}$ $\therefore V = 132$ V

2.5 D

(1) If the energy of the photon is greater than the ionization energy of the atom,
the photon can be absorbed by the atom and becomes ionized.
and the free electron will carry the rest of energy.

(2) If the energy of the photon is exactly equal to the difference of two energy levels of the atom,
the photon can be absorbed and the atom is excited.
The excited atom may then emit a photon of the same energy, that is, same wavelength.

(3) If the photon is absorbed and the atom is excited to an energy level higher than E_2,
then the excited atom may emit more than one photon through a number of transitions.

2.6 C

By Rayleigh criterion :

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

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

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

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

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.

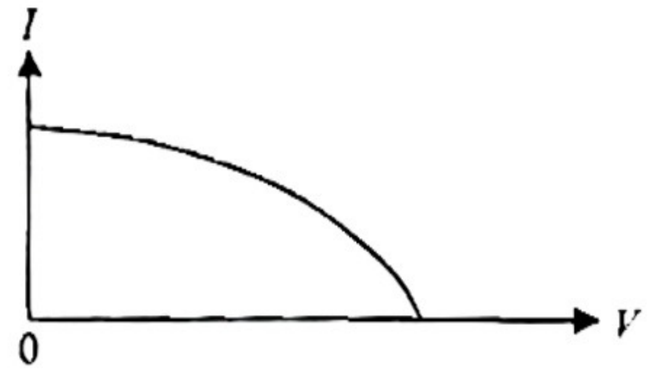
(2) Drugs may contain nanoparticles that can be delivered into the human body faster and easier.

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

Q2. (a) Increase the voltage V until the ammeter reading drops to zero, at which the voltage V is the stopping potential. [1]

(b) Current flows through the ammeter from X to Y. [1]

(c)



< Current I gradually drops to zero. > [1]

(d) By $hf = \phi + eV_S$ $\therefore$ $V_S = \frac{h}{e}f - \frac{\phi}{e}$

slope $= \frac{h}{e}$ [1]

(e) From the graph, when the frequency f of the radiation is below a certain value, there is no photoelectrons emitted. [1]
But wave theory expects that electrons can be emitted by any frequency of light if the intensity is strong enough. [1]

(f) (i) Frequency of light : $f = \frac{c}{\lambda} = \frac{3\times10^8}{400\times10^{-9}} = 7.5\times10^{14}$ Hz [1]

From the graph, $V_S = 1.65$ V

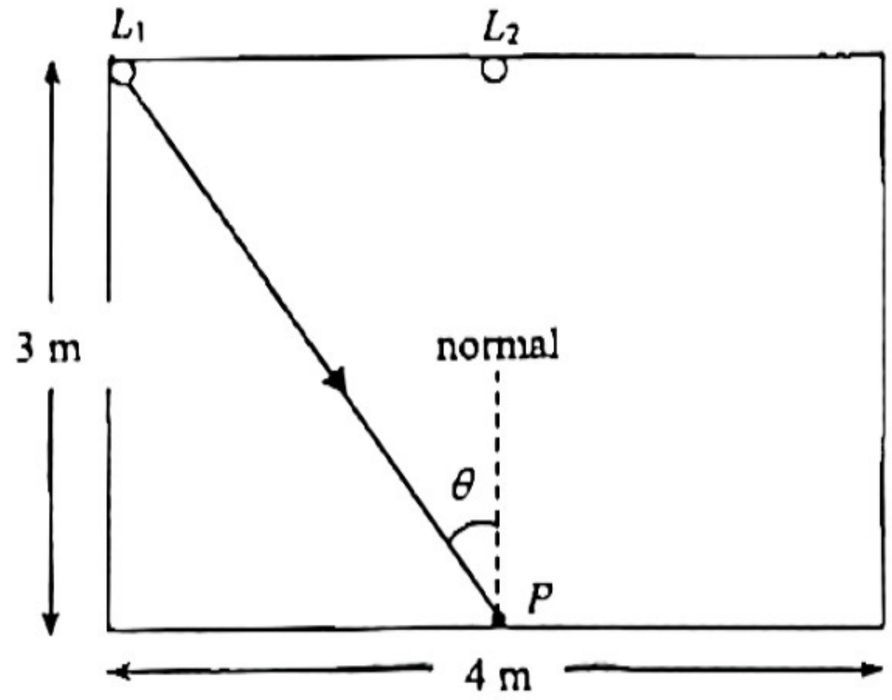
$\therefore$ $K_{max} = 1.65$ eV < accept 1.6 to 1.7 eV > [1]

(ii) Maximum K.E. of electrons reaching the anode $= 1.65 - 0.8 = 0.85$ eV < accept 0.82 to 0.88 eV > [1]

(g) The x-intercept is unchanged. [1]

Section C : Energy and Use of Energy

3.1 D



Distance from L_1 to P : $r = \sqrt{(3)^2 + (2)^2} = 3.606$ m

Angle that the incident light from L_1 made with the normal : $\tan\theta = \frac{2}{3} \quad \therefore \ \theta = 33.7°$

Illuminance at P due to L_1 : $E_1 = \frac{\Phi}{4\pi r^2}\cos\theta = \frac{(2500)}{4\pi(3.606)^2}\cos 33.7° = 12.7$ lx (lux)

Illuminance at P due to L_2 : $E_2 = \frac{\Phi}{4\pi r^2}\cos\theta = \frac{(2500)}{4\pi(3)^2}\cos 0° = 22.1$ lx (lux)

Total illuminance at $P = 12.7 + 22.1 = 34.8 \approx 35$ lx

3.2 C

Mass of air $= 36 \times 1.2 = 43.2$ kg

Heat extracted from the air : $Q_c = m c \Delta T = (43.2)(1000)(40 - 25) = 648\,000$ J

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

$\text{COP} = \frac{Q_c}{W} = \frac{648000}{270000} = 2.4$

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

$\text{OTTV} = \frac{Q/t}{A} = \frac{60750 + 750}{300 + 20} = 192$ 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 B

× (1) A hybrid car has combustion engine. When the engine operates, there is pipe emission.

✓ (2) A hybrid car does not have plug-in socket. The battery does not required charging by external source..

× (3) A hybrid car can be charged during engine operation or during braking by regenerative braking system.

3.6 C

$P_{out} = \frac{1}{2}\rho A v^3 \times \eta \times N = \frac{1}{2}(1.2)(\pi \times 18^2)(12.5)^3 \times 32\% \times 30 = 11.5 \times 10^6\ W = 11.5\ MW$

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 $E = Pt$ $\therefore$ $(1\ kWh) = (0.2192\ kW)\,t$ $\therefore$ $t = 4.56$ 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) $\Delta E = 0.208 \times 931 \times 10^6 \times 1.6 \times 10^{-19} = 3.10 \times 10^{-11}\ J$ [1]

OR

$\Delta E = 0.208 \times (1.661 \times 10^{-27}) \times (3 \times 10^8)^2 = 3.11 \times 10^{-11}\ J$ [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) $\frac{m}{0.235} \times (6.02 \times 10^{23}) \times (3.10 \times 10^{-11}) \times 38\% = (500 \times 10^6) \times (24 \times 3600)$ [1]

$\therefore$ $m = 1.43\ kg$ [1]

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

(ii) Moderator is used to slow down the fission neutrons so as to increase the chance of neutron capture by U-235. [1]

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

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

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.

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

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

$L = 10 \log \frac{I}{I_0}$ $\therefore$ $I = 10^{L/10} I_0$

The intensity of the noise from the machine : $I_1 = 10^9 I_0$

The intensity of the noise from the background : $I_1 = 10^{8.5} I_0$

Total intensity of the two noises : $I = 10^9 I_0 + 10^{8.5} I_0$

Sound level of the total noise : $L = 10 \log \frac{10^9 I_0 + 10^{8.5} I_0}{I_0} = 91.2\text{ dB}$

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 : $Z_1 = \rho_1 c_1 = (1076)(1580) = 1.70\text{ MRayl}$

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

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 $I = I_0 e^{-\mu x}$ $\therefore$ $(50) = (80) e^{-\mu (6)}$ $\therefore$ $\mu = 0.07833\ cm^{-1}$

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

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]

$A = A_0 e^{-kt}$

$\therefore$ $(0.1\%) = e^{-(0.1155)t}$

$\therefore$ $t = 60$ hours [1]

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