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# General Certificate of Education (Adv.Level) Examination, August 2015

## Physics - I Two hours

**Instructions:**

* This question paper consists of 50 questions in 10 pages.
* Answer **all** the questions.
* Write your **Index Number** in the space provided in the answer sheet.
* In each of the questions 1 to 50, pick one of the alternatives from (1), (2), (3), (4), (5) which is **correct** or **most appropriate and mark your response on the answer sheet with a Cross (x) in accordance with the instructions given on the back of the answer sheet.**

**Use of calculators is not allowed.**

($g = 10\ N\ kg^{-1}$)

01. Electron volt (eV) is a unit of

(1) charge (2) potential (3) capacitance
(4) energy (5) electric field intensity

02. The following measurements $A$, $B$ and $C$ have been taken using correctly selected measuring instruments.

$A = 3.1$ cm $B = 4.23$ cm $C = 0.354$ cm

Instruments used for the measurements $A$, $B$ and $C$ are

| | A | B | C |
|---|---|---|---|
| (1) | Vernier calliper | Vernier calliper | Micrometer screw gauge |
| (2) | Metre ruler | Metre ruler | Vernier calliper |
| (3) | Metre ruler | Micrometer screw gauge | Travelling microscope |
| (4) | Metre ruler | Vernier calliper | Micrometer screw gauge |
| (5) | Vernier calliper | Metre ruler | Travelling microscope |

03. Radii of capillary tubes of two mercury-in-glass thermometers $A$ and $B$ having equal volumes of mercury inside their bulbs are $r$ and r/3 respectively. When the temperatures of the bulbs are increased by 1 °C, the ratio

$$\frac{\text{Change in length of mercury column in } A}{\text{Change in length of mercury column in } B}$$

is approximately (Neglect the expansion of glass)

(1) 1/9 (2) 1/3 (3) 1
(4) 3 (5) 9

04. By what factor does the sound intensity increase if the sound intensity increase if the sound intensity level increases by 1 dB?

(1) 1 (2) $10^{0.1}$ (3) $10^{1}$
(4) $10^{10}$ (5) $10^{12}$

05. Consider the following statements made ragarding three optical instruments.

(A) Simple microscope has a single convex lens, and when in normal adjustment, the microscope produces a virtual image at the least distance of distinct vision.

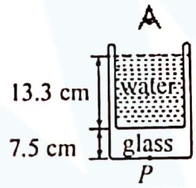
(B) Compound microscope has two convex lenses, and when in normal adjustment, the microscope produces a virtual magnified image at infinity.

(C) Astronomical telescope has two convex lenses, and when in normal adjustment, the telescope produces a real magnified image at infinity.

Of the above statements,

(1) only A is true. (2) only A and B are true.
(3) only A and C are true. (4) only B and C are true.
(5) all A, B and C are true.

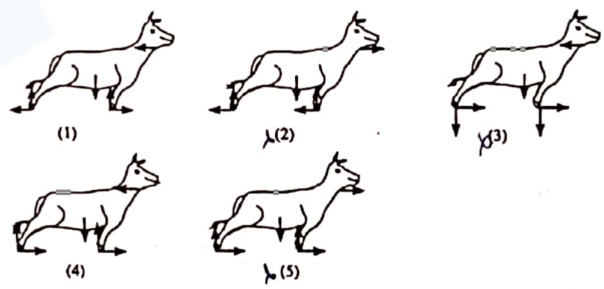
06. A cylindrical glass vessel with a 7.5cm thick bottom, is filled with water up to a height of 13.3 cm as shown in the figure. Refractive indices of glass and water are 1.5 and 1.33 respectively. The apparent depth of a mark located at point $P$ of the bottom of the vessel when observed from above the water surface is



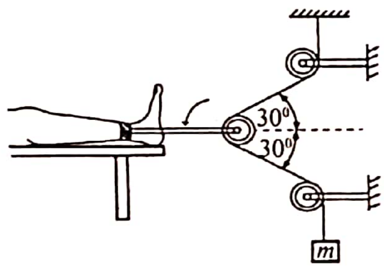

(1) 5.8 cm (2) 10.9 cm
(3) 11.6 cm (4) 11.9 cm
(5) 15.0

07. A bull fastened to a strong tree with a rope attempting to eat a nearby coconut plant is shown in figure (a). The free-body diagram for the bull is correctly represented by

Figure (a)




08. The pulley arrangement shown in the figure exerts a force on a leg of a patient connected to a traction device $D$. The pulleys are frictionless and the system is at equilibrium. If the horizontal force acting on the leg by $D$ is 80 N, then the value of the hanging mass $m$ will be $\left(\cos 30^\circ = \frac{\sqrt{3}}{2}\right)$



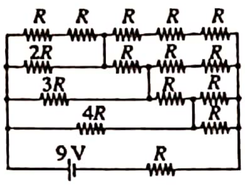

(1) $\frac{4}{\sqrt{3}}$ kg (2) 4 kg (3) $\frac{8}{\sqrt{3}}$ kg
(4) 8 kg (5) $8\sqrt{2}$ kg

09. If a 1 F air-filled parallel plate capacitor is made by using two metal sheets, each of area $A$ separated by 0.9 cm, the area $A$ would be (Take $\varepsilon_0$ as $9 \times 10^{-12}$ F m$^{-1}$)

(1) 1 cm$^2$ (2) 100 cm$^2$ (3) 1000 m$^2$

(4) 100 km$^2$ (5) 1000 km$^2$

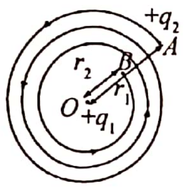
10. Current (in Amperes) drawn from the battery in the given circuit is




(1) $\frac{1}{R}$ (2) $\frac{2}{R}$ (3) $\frac{3}{R}$

(4) $\frac{4}{R}$ (5) $\frac{5}{R}$

11. A point charge of $+q_1$, is held at a point $O$. The points $A$ and $B$ are located at distances $r_1$ and $r_2$ from $O$ respectively. The work done in bringing another point charge of $+q_2$ from the point $A$ to point $B$ along a spiral path of length $l$ as shown in the figure is




(1) $\frac{q_1q_2}{4\pi\varepsilon_0}\left(\frac{1}{r_2}-\frac{1}{r_1}\right)$ (2) $\frac{q_1q_2}{4\pi\varepsilon_0}\left(\frac{1}{r_1^2}-\frac{1}{r_2^2}\right)l$

(3) $\frac{q_1}{4\pi\varepsilon_0}\left(\frac{q_1-q_2}{r_2^2-r_1^2}\right)l$ (4) $\frac{q_1q_2}{4\pi\varepsilon_0}\left(\frac{1}{r_2}+\frac{1}{r_1}\right)$

(5) $\frac{q_1}{4\pi\varepsilon_0}\left(\frac{q_1}{r_2^2}-\frac{q_2}{r_1^2}\right)l$

12. Variation of the displacement ($x$) with time ($t$) for a particle executing a simple harmonic motion over a period ($T$) is shown in figure (a). The variation of the kinetic energy ($K$) of the particle with time (t) over the period is best represented by

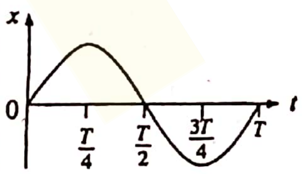
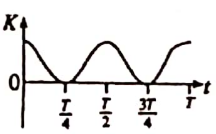
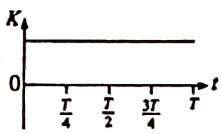


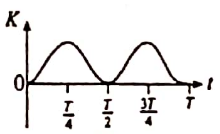

Figure (a)



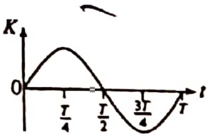
(1)



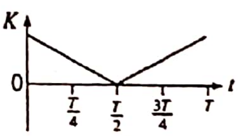
(2)



(3)



(4)

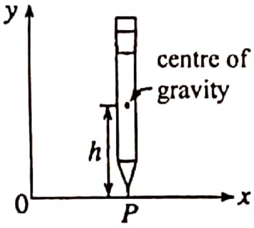


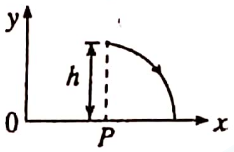
(5)

13. A ball is dropped from a height of 1.8 m onto a rigid surface. The collision between the ball and the surface is perfectly elastic. If the ball continues to bounce on the surface, the motion of the ball is

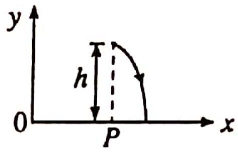
(1) simple harmonic with a period of 1.2 s.
(2) not simple harmonic but periodic with a period of 0.6 s.
(3) not simple harmonic but periOdic with a period of 1.2 s.
(4) simple harmonic with a period of 0.6 s.
(5) simple harmonic with a period of 2.4 s.

14. A pencil is held vertical on its tip on a frictionless table as shown in the figure. When it is allowed to fall freely towards the +x-direction, the path of the centre of gravity of the pencil is best represented by.

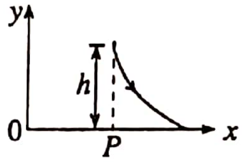


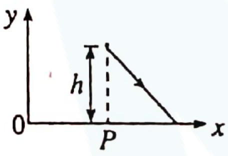
(1)



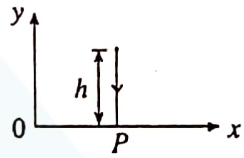
(2)



(3)

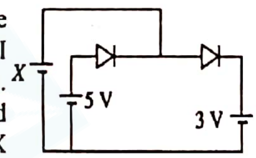


(4)



(5)

15. In the circuit shown, each of the rectifier diodes requires a voltage of I V across it to make it forward biased. In order to make both diodes forward biased, the voltage of the battery X should be




(1) I V (2) 2 V (3) 3 V

(4) 4V (5) 5V

16. $A$, $B$ and $C$ are three metals with threshold wavelengths $\lambda_A$ = 0.30 μm, $\lambda_B$ = 0.28 μm and $\lambda_C$ = 0.20 μm respectively for photoelectric emission. Photons of frequency $1.2 \times 10^{15}$ Hz are incident on each of the metals. Photoelectrons are emitted (The speed of light in vacuum is $3 \times 10^8$m S$^{-1}$.)

(1) only from $A$. (2) only from $B$.

(3) only from $C$. (4) only from $A$ and $B$.

(5) from all $A$, $B$ and $C$.

17. If the velocity ($v$) of an object varies with time ($t$) as shown in figure (a), the corresponding variation of the displacement ($x$) with time ($t$) is best represented by

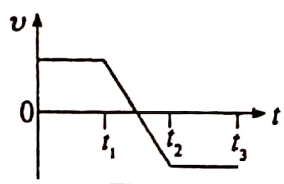
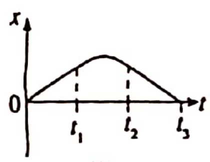
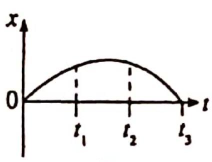


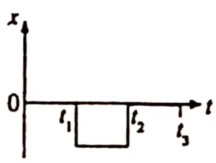

Figure (a)



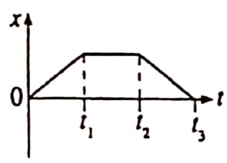
(1)



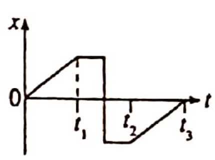
(2)



(3)



(4)



(5)

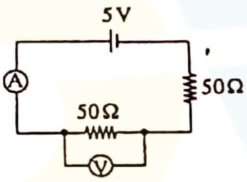
18. When a small object is placed 30 cm in front of a thin lens $L_1$ of focal length 10 cm, an image is formed behind the lens. When another thin lens $L_2$ is placed in contact with $L_1$, the image is formed at infinity. $L_2$ is a

(1) concave lens of focal length 15 cm.
(2) convex lens of focal length 15 cm.
(3) concave lens of focal length 20 cm.
(4) concave lens of focal length 10 cm.
(5) convex lens of focal length 20 cm.

19. The voltage of the 2V- accumulator connected across the two ends of a potentiometer wire is found to be dropping while it is being used to measure the e.m.f. of a cell ($X$). In spite of the reduction of the accumulator voltage, a student has observed that he could obtain a fixed balance point in the potentiometer wire. Which of the following explanations given by the student for this observation can be accepted?

(1) Balance length does not depend on the voltage of the accumulator.
(2) Differences in the errors associated with the two ends of the potentiometer wire could be the reason for achieving a fixed balance point.
(3) Though the voltage of the accumulator was reducing, the cell ($X$) had maintained a constant potential gradient across the wire.
(4) The increase of the temperature of the wire has nullified the effect of the reduction of the voltage of the accumulator.
(5) The voltage of the cell ($X$) too may have been dropping while conducting the experiment.

20. In the given circuit, if the voltmeter $V$ and the ammeter $A$ are interchanged by mistake, the respective readings of the ammeter and the voltmeter would be (Assume $A$ and $V$ to be ideal instruments.)




(1) 0A, 0V
(2) 0A, 5V
(3) 0A, 2.5V
(4) 0.1 A, 0 V
(5) 0.05 A, 2.5 V

21. A straight composite rod is made by connecting end-to-end an $n$ number of rods with identical physical dimensions but having different Young's moduli $Y_1, Y_2, Y_3, \ldots\ldots, Y_n$.
The equivalent Young's modulus of the composite rod is given by

(1) $\dfrac{Y_1+Y_2+Y_3+\ldots\ldots+Y_n}{n}$

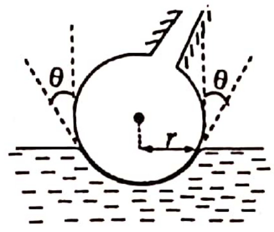
(2) $(Y_1+Y_2+Y_3+\ldots\ldots+Y_n)n$

(3) $\dfrac{1}{\dfrac{1}{Y_1}+\dfrac{1}{Y_2}+\dfrac{1}{Y_3}+\ldots\ldots+\dfrac{1}{Y_n}}$

(4) $\dfrac{n}{\dfrac{1}{Y_1}+\dfrac{1}{Y_2}+\dfrac{1}{Y_3}+\ldots\ldots+\dfrac{1}{Y_n}}$

(5) $(Y_1Y_2Y_3\ldots\ldots Y_n)^{\frac{1}{n}}$

22. Due to surface tension (0.07 N m$^{-1}$) of water, certain small insects are able to walk on water surfaces by pushing down the water surface. The feet of insects can be considered to be approximately spherical as shown in the figure. When an insect is stationary on a water surface, the position of a leg is shown in the figure. Radius of the circular cross-section of the spherical foot at the water level is $r$. The mass of the insect is $5.0 \times 10^{-6}$ kg, and $r = 2.5 \times 10^{-5}$ m. If the weight of the insect is supported by its 6 legs, the value of cos $\theta$ (see figure) is approximately



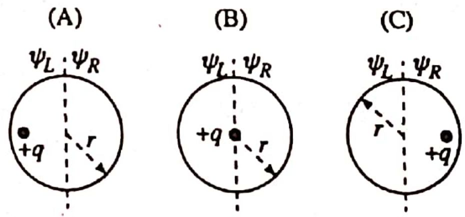

(Take π as 3.)

(1) 0.1 (2) 0.2 (3) 0.4 (4) 0.6 (5) 0.8

23. Paths of three charges moving separately in three uniform fields are shown in figures (A), (B) and (C).
Which of the following responses correctly indicates the static electric field or magnetic field necessary to produce the paths shown?

| | (A)  | (B)  | (C)  |
|---|---|---|---|
| (1) | Electric field | Electric field | Electric field |
| (2) | Magnetic field | Magnetic field | Magnetic field |
| (3) | Electric field | Electric field | Magnetic field |
| (4) | Magnetic field | Magnetic field | Electric field |
| (5) | Magnetic field | Electric field | Electric field |

24. Figures (A), (B) and (C) show three situations where a charge of $+q$ is surrounded by a spherical Gaussian surface of radius $r$. If $\Psi_L$ and $\Psi_R$ are the electric fluxes through the left and right hemispherical sections of the Gaussian surface respectively, which of the following is true regarding $\Psi_L$ and $\Psi_R$




| | (A) | (B) | (C) |
|---|---|---|---|
| (1) | $\Psi_L = \Psi_R = \dfrac{q}{2\varepsilon_0}$ | $\Psi_L = \Psi_R = \dfrac{q}{2\varepsilon_0}$ | $\Psi_L = \Psi_R = \dfrac{q}{2\varepsilon_0}$ |
| (2) | $\Psi_L > \dfrac{q}{2\varepsilon_0} > \Psi_R$ | $\Psi_L = \Psi_R = \dfrac{q}{2\varepsilon_0}$ | $\Psi_L < \dfrac{q}{2\varepsilon_0} < \Psi_R$ |
| (3) | $\Psi_L > \dfrac{q}{\varepsilon_0} > \Psi_R$ | $\Psi_L = \Psi_R = \dfrac{q}{\varepsilon_0}$ | $\Psi_L < \dfrac{q}{\varepsilon_0} < \Psi_R$ |
| (4) | $\Psi_L = \Psi_R = \dfrac{q}{\varepsilon_0}$ | $\Psi_L = \Psi_R = \dfrac{q}{\varepsilon_0}$ | $\Psi_L = \Psi_R = \dfrac{q}{\varepsilon_0}$ |
| (5) | $\Psi_L > \dfrac{q}{2\varepsilon_0} > \Psi_R$ | $\Psi_L = \Psi_R = \dfrac{q}{2\varepsilon_0}$ | $\Psi_L > \dfrac{q}{2\varepsilon_0} > \Psi_R$ |

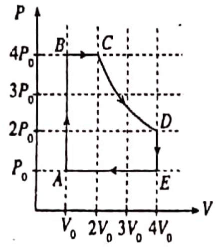
25. An air-filled parallel plate capacitor of plate separation $d$ is fully charged using a battery of voltage $V_0$. Then the battery is removed and the space between the plates of the capacitor is filled with a material of dielectric constant $k$. If the energy stored in the capacitor when it is filled with air is $U_0$, and the electric field intensity across the capacitor, and energy stored in the capacitor when it is filled with the dielectric material are $E$ and $u$ respectively, then

(1) $E = \frac{V_0}{d}$, $U = kU_0$ (2) $E = \frac{V_0}{kd}$, $U = \frac{U_0}{k}$

(3) $E = \frac{V_0}{kd}$, $U = U_0$ (4) $E = \frac{V_0}{kd}$, $U = kU_0$

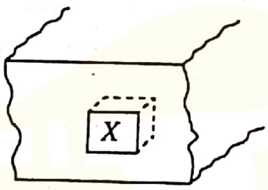
(5) $E = \frac{V_0}{d}$, $U = \frac{U_0}{k}$

26. A fixed mass of an ideal gas undergoes a cyclic process as shown in the P-V diagram. If the temperatures of the points $A, B, C, D$ and $E$ are $T_A$, $T_B$, $T_C$, $T_D$ and $T_E$ respectively, then,




(1) $T_A > T_B > T_C > T_D > T_E$
(2) $T_A = T_B < T_C < T_D = T_E$
(3) $T_C = T_D > T_B = T_E > T_A$
(4) $T_A = T_B > T_C > T_D = T_E$
(5) $T_D = T_C > T_B > T_A = T_E$

27. Figure shows a part of an outdoor brick-structure with a cubical-shrine ($X$) carved in as shown. The shrine is lime plastered and the front is sealed with a sheet of glass. It has been seen very often that water vapour condenses on the inner surface of the glass sheet, and it is found to happen mostly during the evenings. Which of the following deductions made by a student about this situation is most **unlikely?**

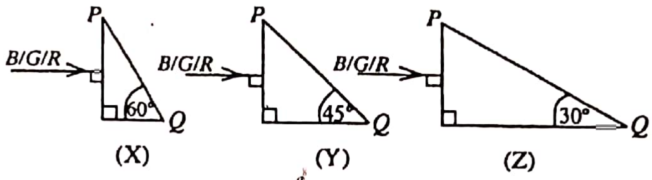



(1) Although the shrine is sealed from the front side, water vapour can enter the shrine from the bulk of the brick structure.
(2) Relative humidity at the vicinity of the inner surface of glass sheet varies during the course of the day.
(3) Atmospheric temperature has no effect on the condensation of water vapour.
(4) The bricks of the structure may have absorbed water during rainy seasons.
(5) Condensation of water vapour can be reduced, if the walls of the shrine are water proofed and front sealed during a dry season.

28. A gymnastic player of mass 50 kg lands on the ground vertically with a velocity of 6 $ms^{-1}$ and with his body straight. As his feet touches the ground he bends his knees while keeping rest of the body vertical, and brings his body to a complete stop in 0.2 s. The average value of the force exerted on the player by the ground during the period of 0.2 s is

(1) 30 N (2) 300 N (3) 1500 N
(4) 1 800 N (5) 3000 N

29. Narrow beams of light consisting of a mixture of three primary colours, blue ($B$), green ($G$) and red ($R$), are incident normally as shown in figures (X), (Y) and (Z) on different glass prisms made from the same material. The critical angles of the material of the prism for blue, green and red are $43^o$, $44^o$ and $46^o$ respectively. When viewed through the faces $PQ$, only red colour can be seen in




(1) X only. (2) Y only. (3) X and Y only.
(4) X and Z only. (5) all X, Y and Z.

30. A wire of radius 1.0 mm made of a material of Young's modulus 4 x $10^{11}$ N $m^{-2}$ is subjected to a tension of 30 N. The magnitude of the ratio $\upsilon_L/\upsilon_T$ of the longitudinal wave velocity ($\upsilon_L$) to transverse wave velocity ($\upsilon_T$) along the wire is (Take $\pi$ to be 3.)

(1) 100 (2) 150 (3) 200
(4) 250 (5) 300

31. The following table shows the binding energies of some nuclei

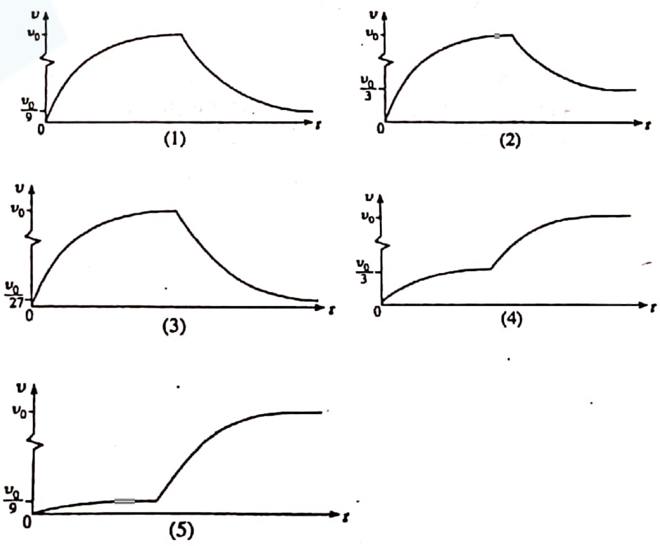
| Nucleus | $^{4}_{2}He$ | $^{20}_{10}Ne$ | $^{40}_{10}Ce$ | $^{60}_{28}Ni$ | $^{238}_{92}U$ |
|---|---|---|---|---|---|
| Binding energy (MeV) | 28.3 | 160.6 | 342.1 | 526.8 | 1802.0 |

Which one of the above nuclei is the most stable nucleus?

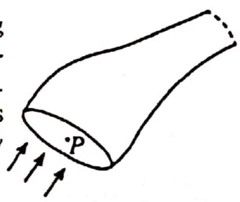
(1) $^{4}_{2}He$ (2) $^{20}_{10}Ne$ (3) $^{40}_{20}Ce$

(4) $^{60}_{28}Ni$ (5) $^{238}_{92}U$

32. Seven identical metal spheres each of radius $R$ and mass $m$ are packed inside a hollow spherical container of mass $20m$ and radius $3R$. When this container is released from rest from the water surface of a calm, deep sea, it moves vertically towards the bottom of the sea. Once the container has reached its terminal velocity $\upsilon_0$, it is opened and the metal spheres are allowed to continue their motion vertically and independently towards the bottom of the sea without any influence from the container. The variation of the velocity ($v$) of a metal sphere with time ($t$) is best represented by




33. Figure shows a flow tube corresponding to a streamline motion of a non-viscous and incompressible fluid. Which of the folowing statements is **not true** with regard to the fluid flow in such a tube?



(1) All particles entering at point $P$ move along the same path in the tube.

(2) Flow velocity at a given point in the tube may vary with time.

(3) Particles moving along a given streamline may have different velocities at different points in the flow tube.

(4) Tangent drawn at any point of a streamline gives the direction of flow velocity at that point.

(5) Mass of fluid in the flow tube is always constant.

34. The variation of the angular acceleration ($\alpha$) of a wheel of a motor vehicle starting from rest with time ($t$) is shown in figure (a). Variation of the angular velocity ($\omega$) of the wheel with time($t$) is best represented by

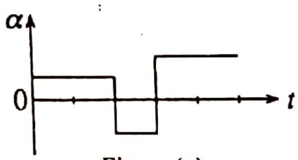
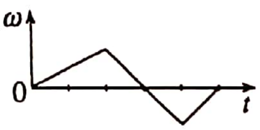
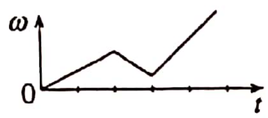


Figure (a)



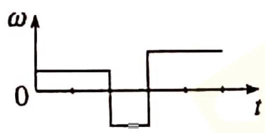
(1)

(2)



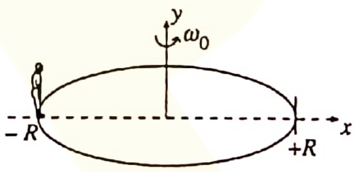
(3)

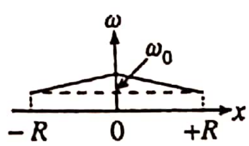
(4)



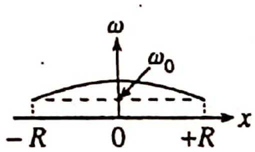
(5)

35. A child is standing at $x = -R$ of a horizontal merry-go-round of radius $R$ in a carnival as shown in the figure. $x$-$y$ is a coordinate system fixed to the merry-go-round with its $y$-axis along the axis of rotation. Using a driving motor, the merry-go-round is set in rotational motion with constant angular velocity $\omega_0$ about its axis on a frictionless bearing, and subsequently allowed to **rotate freely** without the driving motor. Now if the child starts to move in the $x$-direction along the diameter of the merry-go-round to the location $x = +R$, the variation of the angular velocity ($\omega$) of the merry-go-round with position ($x$) of the child is best represented by

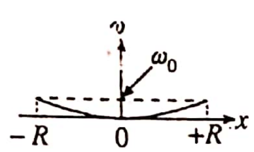




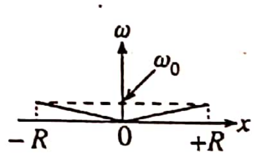
(1)



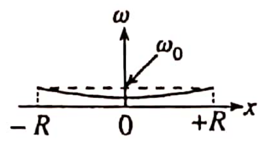
(2)



(3)

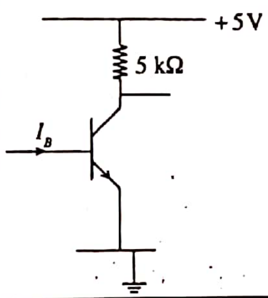


(4)



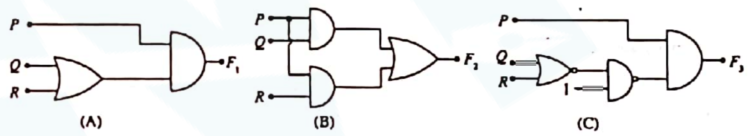
(5)

36. In the circuit shown, the current gain of the transistor is 100. When different $I_B$ values are applied to the base, which of the following is true regarding the mode of operation of the transistor?



| | $I_B$ value applied in μA | Mode of operation of the transistor. |
|---|---|---|
| (1) | 0 | Saturation mode |
| (2) | 5 | Cut off mode |
| (3) | 12 | Active mode |
| (4) | 15 | Cut off mode |
| (5) | 20 | Saturation mode |

37. P, Q and R represent the binary input variables applied to the given circuits (A), (B) and (C).



When outputs $F_1$ $F_2$ and $F_3$ of the circuits for given input combinations are considered

(1) only A and B give the same output.

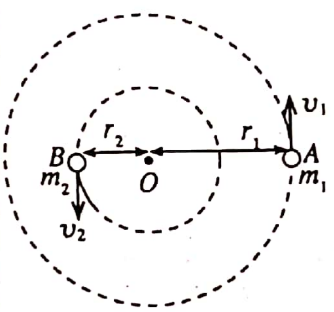
(2) only Band C give the same output.

(3) only A and C give the same output.

(4) all three circuits give the same output.

(5) all three circuits give different outputs . .

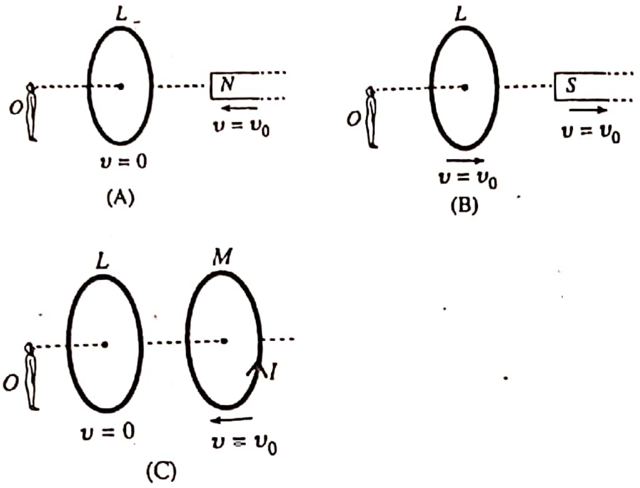
38. Two stars $A$ and $B$ of masses $m_1$ and $m_2$ respectively are in circular motions due to their mutual gravitational attraction, about the point $O$ for which $m_1r_1 = m_2r_2$ so that $AOB$ is always co-linear as shown in the figure. If the speeds of $m_1$ and $m_2$ are $v1$ and $v_2$ respectively, the ratipo $v_1/v_2$ is



(1) $\frac{m_2}{m_1}$ (2) $\frac{m_1}{m_2}$ (3) $\frac{m_2}{m_1 + m_2}$

(5) $\frac{m_1}{m_1 + m_2}$ (6) $\frac{m_1 + m_2}{m_2}$

39. A bar magnet and/or conducting loop/s are arranged separately as shown in figures (A), (B) and (C). As observed by the observed $O$, the magnet and the loop/s move with the velocities $\upsilon$ as indicated. Loop $M$ in the figure (C) carries a current $I$ in the counter-clockwise direction.




As observed by the observer O, the induced current in the loop $L$ is

(1) clockwise in A and B, and zero in C.
(2) clockwise in A and C, and zero in B.
(3) clockwise in A and C, and counter-clockwise in B.
(4) counter-clockwise in A and B, and zero in C.
(5) counter-clockwise in A and C, and zero in B.

40. Voltage waveform shown in figure (a) is applied to the primary of a step down transformer shown in figure (b) and the output waveform from the secondary is observed on an oscilloscope. Which of the following figures shows the waveform on the oscilloscope?

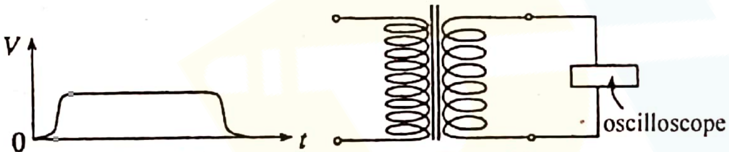
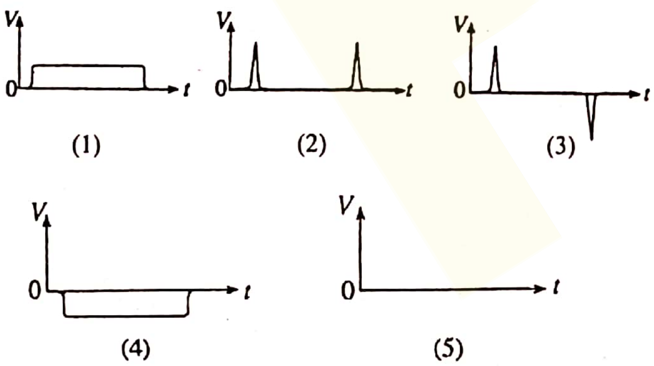



figure (a) figure (b)




41. Two ideal diatomic gases $A$ and $B$ of volumes $V_A$ and $V_B$ respectively with different densities at the same temperature and pressure are mixed together. The mixture is maintained at the above temperature and it can be considered as an ideal diatomic gas. If $u_A$ and $u_B$ are speeds of sound in gas $A$ and gas $B$ respectively at the above temperature and pressure, then the speed of sound in the mixture will be given by

(1) $u_A u_B \sqrt{\dfrac{V_A + V_B}{V_A u_A^2 + V_B u_B^2}}$ (2) $u_A u_B \sqrt{\dfrac{V_A + V_B}{V_A u_B^2 + V_B u_A^2}}$

(3) $\sqrt{\dfrac{V_A u_A^2 + V_B u_B^2}{V_A + V_B}}$ (4) $\sqrt{\dfrac{V_A u_B^2 + V_B u_A^2}{V_A + V_B}}$

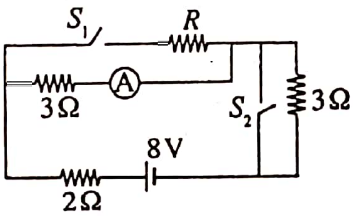
(5) $\sqrt{u_A u_B}$

42. A sonometer wire having mass per unit length of 1.0 g m$^{-1}$ and tension of 40 N is simultaneously sounded with a tuning fork of frequency 320 Hz while varying its vibration length starting from a small value. In this process, if beats of frequency 5s$^{-1}$ can be observed on an oscilloscope, the corresponding vibration lengths (in m) of the sonometer wire are

(1) $\frac{2}{13}, \frac{10}{63}$ (2) $\frac{4}{13}, \frac{5}{8}$ (3) $\frac{4}{13}, \frac{20}{63}$

(4) $\frac{5}{8}, \frac{20}{63}$ (5) $\frac{10}{13}, \frac{4}{13}$

43. In the given circuit, the reading of the ammeter $A$ indicates the same value when the switches $S_1$ and $S_2$ are both closed or both open. If $A$ is an ideal ammeter, the value of the resistor $R$ is

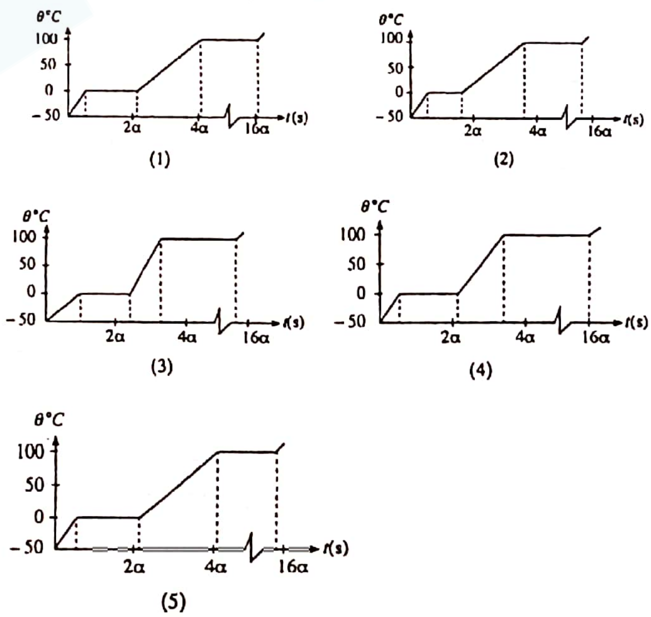



(1) $1\ \Omega$ (2) $2\ \Omega$
(3) $3\ \Omega$ (4) $4\ \Omega$
(5) $6\ \Omega$

44. A piece of ice of mass 0.1 kg at -50°C is heated uniformly by providing heat energy at a constant rate of 10 W. If the specific heat capacity of ice is α, in SI units, the values of the other relevant quantities in terms of α can be given approximately as follows .

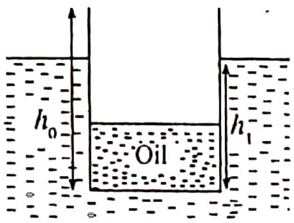
| | | |
|---|---|---|
| Specific heat capacity of water | = | 2α |
| Latent heat of fusion of ice | = | 160α |
| Latent heat of vaporization of water | = | 1 200α |

Which of the following graphs best represents the variation of the temperature ($\theta$) of the system with time ($t$)?




45. A vessel of uniform rectangular cross-section with height $h_0$ and mass $M$ contains a certain amount of oil having mass $m$ and density $\rho_{oil}$ as shown in the figure. The vessel floats vertically in water of density $\rho_\omega$ ($> \rho_{oil}$) with height $h_1$ under water. A certain volume of oil is now replaced by an **equal**

volume of water. If the maximum volume of oil that can be replaced while keeping the vessel floating is $V$ and the initial volume of oil is $V_0$, then the ratio $\frac{V}{V_0}$ is given by (Assume that at the end of the process there is a certain amount of oil left in the vessel.)

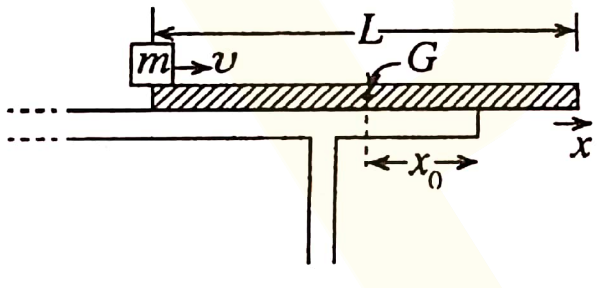



(1) $\frac{(h_0 - h_1)(M+m)P_{oil}}{h_1 m (P_\omega - P_{oil})}$ (2) $\frac{h_0 (M - m) P_{oil}}{h_1 m (P_\omega - P_{oil})}$

(3) $\frac{h_1}{h_0} \cdot \frac{P_\omega}{P_{oil}}$ (4) $\frac{(h_0 - h_1)(M - m)P_{oil}}{h_0 m (P_\omega + P_{oil})}$

(5) $\frac{h_0 (M+m) P_{oil}}{M(h_0 + h_1)(P_\omega + P_{oil})}$

46. A uniform rectangular wooden strip of length $L$ and mass $M$ is placed on a table along the $x$ direction and parallel to one of its edges so that a part of the strip is extended out as shown in the figure Distance from the centre of gravity $G$ of the strip to edge of the table is $x_0$. Now a small block of mass $m$ is placed at the left edge of the strip, and an initial speed of $\upsilon$ is given to it along the strip in the $x$ direction. If the coefficient of kinetic friction between the strip and the block is $\mu$, the minimum speed that can be given to the block to topple the strip is




(1) $\sqrt{2\mu g\left(x_0 + \frac{L}{2} + \frac{Mx_0}{m}\right)}$ (2) $\sqrt{\mu g\left(\frac{L}{4} + \frac{Mx_0}{m}\right)}$

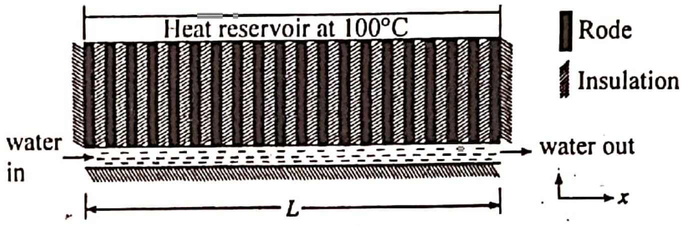
(3) $\sqrt{2\mu g\left(x_0 + \frac{L}{2} + \frac{mx_0}{M}\right)}$ (4) $\sqrt{\frac{\mu g M x_0 L}{\left(\frac{L}{2} + x_0\right)}}$

(5) $\sqrt{2\mu g\left(\frac{x_0}{4} + \frac{ML}{m}\right)}$

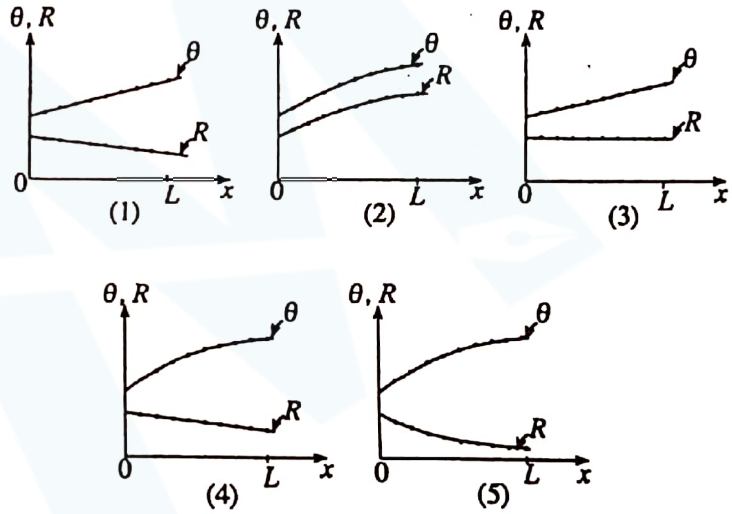
47. During a Tsunami warning, a stationary siren emits sound waves of frequency 1600 Hz while a wind is blowing at a uniform speed of 60 m s$^{-1}$ from the shore towards the land. A person hearing the sound of the siren is driving his car away from the shore towards the land at 30 m s$^{-1}$. If the wind blows in the direction of motion of the car and if the speed of sound in **still air** is 340 m s$^{-1}$, the frequency of the sound of the siren heard by the driver is

(1) 1400 Hz (2) 1480 Hz (3) 1600 Hz
(4) 1740 Hz (5) 1880 Hz

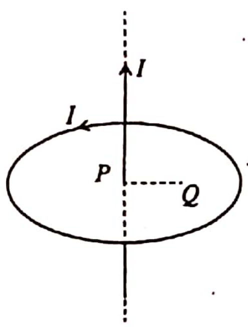
48. Water flows at a uniform rate through a tube of length $L$, which is made of an insulating material. A large number of identical, uniform and insulated metal rods which are equally spaced as shown in the figure is connected between the tube and a large heat reservoir maintained at 100°C to transfer heat from the reservoir to the water in the tube.




If the inlet temperature of water is equal to the room temperature, which of the following graphs best represents the variation of the rate of flow of heat ($R$) through the rods and temperature ($\theta$) of water along the length ($x$) of the tube at the steady state?




49. A long straight wire carrying a current $I$ is held along the axis passing through the centre $P$ and perpendicular to the plane of another circular loop carrying a current $I$ as shown in the figure.




Consider the following statements.

(A) The net force and the net torque on the loop due to the current carrying straight wire are zero.

(B) When the current carrying straight wire is moved to point Q parallel to the axis of the loop, there is a net torque on the loop due to the current carrying straight wire.

(C) When the current carrying straight wire is moved to point Q parallel to the axis of the loop, the net force on the loop due to the current carrying straight wire is **not** zero.

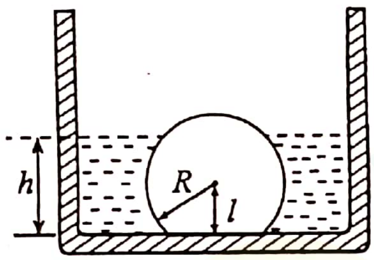
Of the above statements,

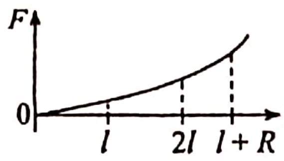
(1) only A is true.  (2) only B is true.

(3) only C is true.  (4) only A and B are true.

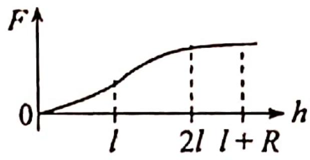
(5) all A, B and C are true.

50. An object in the shape of a truncated solid sphere of radius $R$ is kept at the bottom of a tank as shown in the figure. The distance from the centre of the sphere to the bottom of the tank is $l$. The tank is now slowly filled with water. Assume that the truncated sphere is fixed to the bottom of the tank, so that its bottom **surface does not get wet.** The variation of the vertical upward force $F$, exerted on the object by the water, with the height $h$ of water is best represented by

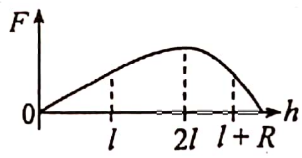


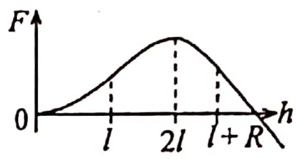

(1)



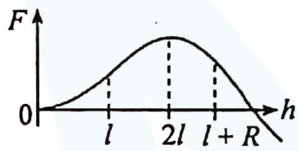

(2)




(3)




(4)



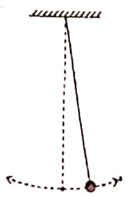

(5)

## PART A - Structured Essay

❖ Answer *all four* questions on this *paper* itself

($g$ = 10 N kg$^{-1}$)

**1.** Figure (1) shows the motion of a simple pendulum of length $l$.



(a) Write down an expression for the period of oscillation $T$ of the simple pendulum in terms of $l$ and acceleration due to gravity, g.

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(b) In the laboratory experiment to find the value of g, using the simple pendulum you are provided with a stop-watch which can measure the time with an accuracy of 0.5 s. If the estimated value of the period $T$ is 2 s, determine the minimum number of oscillations you should take to reduce the percentage error of $T$ down to 1%.

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........................................................................

(c) A student has designed an electrical method to determine the period of oscillation $T$ more accurately by using a 'detector system'.

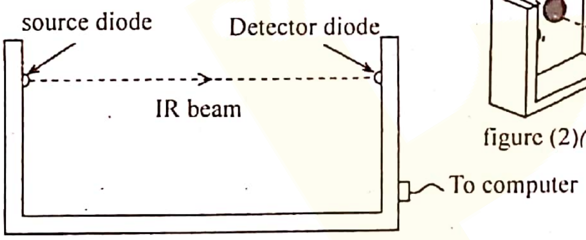


figure (2)(a)

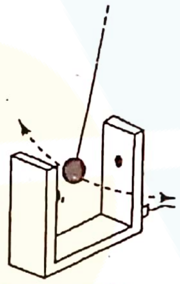

figure (2)(b)

The detector system consists of a source diode and a de tector diode. Source diode, emits a narrow beam of Infra-Red (IR) light with a constant intensity of $I_0$. This light beam is detected by the detector diode, and it also measures the intensity of the beam [see figure (2)(a)]. Detector system is placed in the path of the bob of the simple pendulum. While oscillating, the bob also crosses the IR beam [see figure (2)(b]. Whenever the bob interrupts the IR beam, the detector diode signal becomes zero, otherwise it produces a signal of constant intensity $I_0$. When the bob is oscillating, the computer monitor displays a graph of the variation of the detector signal intensity ($I$) with time ($t$).

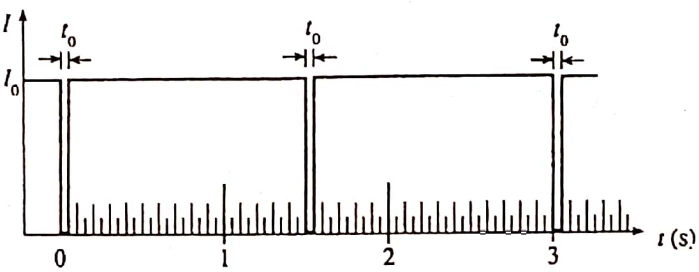


figure (3)

Figure (3) shows such a graph displayed on the computer screen and is taken in a situation where the force due to **air drag is negligible.** The time interval corresponding to the zero detector signal is $t_0$ (see figure).

(i) Value of $t_0$ depends on the speed $\upsilon$ with which the bob crosses the IR beam, and the diameter $D$ of the bob. What will happen to the value of $t_0$ when (1) $\upsilon$ is in creased (2) $D$ is increased?

(1) Related to $\upsilon$: ... .......................... ..........................

........................................................................

(2) Related to $D$ : ..........................................................

........................................................................

(ii) Write down an expression to estimate $\upsilon$ in terms of $D$ and $t_0$.

........................................................................

........................................................................

(iii) What is the value of $T$ according to the graph given in figure (3) above?

........................................................................

........................................................................

(d) Student placed the detector system at the most appropriate position of the path of the bob to determine the **maximum speed** $\upsilon_m$ of the bob, and obtained a graph similar to the graph shown in figure (3).

(i) With respect to figure (1) above, give the position ($A$ or $B$) at which the student should keep the detector system in order to determine $\upsilon_m$. Give a reason for your choice.

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(ii) In order to carry out this experiment, the student says that the cylindrical bob shown in figure (4)($a$) is better than the spherical bob shown in figure (4)($b$). If both bobs have same diameter $D$, give a reason to justify his statement.

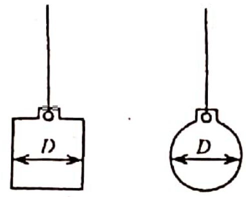


figure (4)($a$) figure (4)($b$)

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........................................................................

(iii) The student decided to calculate $\upsilon_m$ using the graph mentioned above, and the expression in ($c$)(ii). Can he get the **exact** value for $\upsilon_m$ by this method? Explain your answer.

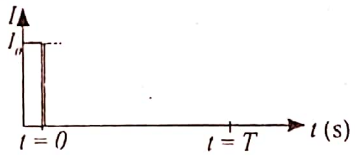
........................................................................

........................................................................

........................................................................

(e) The student observed that in a situation where the force due to air drag is significant, the maximum speed $\upsilon_m$ that he obtained, decreases considerably from oscillation to oscillation and the bob finally comes to rest.

(i) For such a situation, complete the graph of ($I$) with ($t$) that you would expect for a period of time $T$ on the figure given below.




(ii) If the maximum speeds of the bob at $t = 0$ and $t = T$ are 0.44 $ms^{-1}$ and 0.42 $ms^{-1}$ respectively, estimate the energy loss of the pendulum due to air drag during the time $t = 0$ to $t = T$. Mass of the bob is 100 g.

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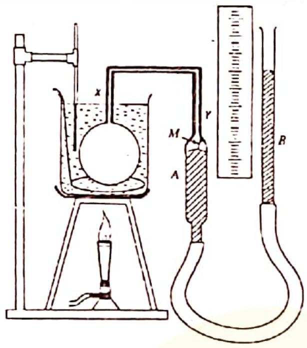


The experimental setup shown in the above figure is used to verify the pressure law for a gas.

(a) The pressure law can be applied to a gas only if two variable quantities pertaining to the gas are kept constant. What are those quantities?

(i) ..........................................................................................

(ii) ..........................................................................................

(b) What is the reason for using the capillary tube $XY$ in this setup?

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(c) Explain why it is necessary to increase the temperature of the water bath slowly in this experiment.

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(d) Even if the temperature of water is maintained at a certain value it does not mean that the temperature of the gas inside the bulb has reached the same value. In this experiment, how would you make sure that the temperature of the gas inside the bulb has reached the temperature of water?

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(e) Write down the **two** main steps used in the experimental procedure to maintain the temperature of water at a suitable value before measuring that temperature in this experiment.

(i) ..........................................................................................

(ii) ..........................................................................................

(f) Write down the main step in the experimental procedure that you would follow before taking the relevant readings to obtain the pressure of the gas.

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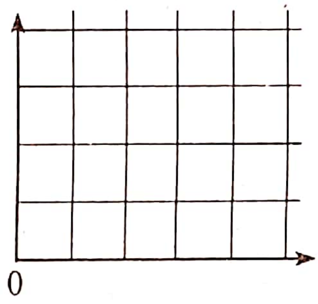
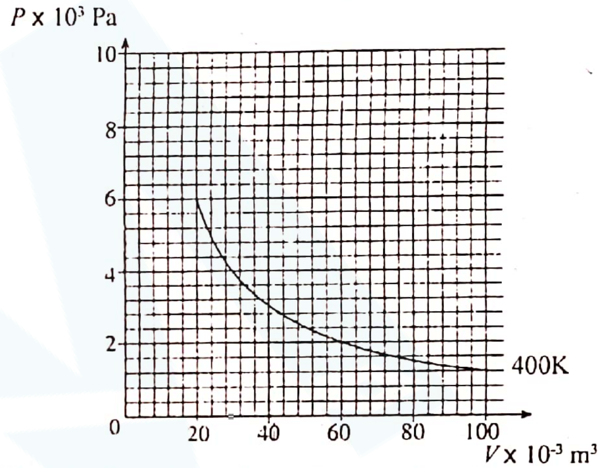
(g) If the atmospheric pressure is $H$ centimetres of mercury and the height difference of the two mercury levels of the tubes $A$ and $B$ is $h$ centimetres, draw a rough sketch of the graph that you would plot in the given diagram in order to verify the pressure law. Label the axes correctly.




($h$) The graph below shows the variation of pressure $P$ with volume $V$ for an ideal gas at temperature 400K.




(i) Calculate the values $P_1$ and $P_2$ of pressures corresponding to the volumes 20 x $10^{-3}$ $m^3$ and 60 x $10^{-3}$ $m^3$ of the gas at temperature 600 K.

$P_1$

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$P_2$

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(ii) Mark the points corresponding to the values that you have obtained in *(h)* (i) above, on the graph given under *(h)* above and draw a rough sketch of a curve to show the variation of the pressure with volume at 600 K of the gas on the same graph.

3. You are asked to determine the focal length of a convex lens experimentally using the no-parallax method. Assume that you are provided with all the items necessary to carry out this experiment.

($a$) Draw a diagram to show how you would setup all the necessary items on the table to carry out this experiment and label the items. (Stands on which the items are mounted should be clearly drawn.)

(b) Before setting up the items for the experiment, it is convenient to know a certain data pertaining to a certain item given. What is this data? Describe a simple method to obtain an approximate value for this data.

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(c) Suppose that when looking at the image after setting up all the items as indicated in (a), you have observed that the image and the observation pin are not in the same vertical line. Give two reasons, one related to the pins and the other related to the lens, as to why this has happened.

(i) Pins : .............................................................................

(ii) Lens: .............................................................................

(d) In this experiment, suppose you have observed that, as the eye is moved sideways across the optical axis, the image moves opposite to the direction of the eye movement. In this situation, state whether the observation pin should be moved towards the eye or away from the eye in order to locate the exact position of the image.

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(e) If the object distance, image distance and the focal length of the convex lens are $u$, $v$ and $f$ respectively, rearrange the lens formula in order to determine the focal length of the lens by plotting a linear graph. State the sign convention that you have used for the lens formula.

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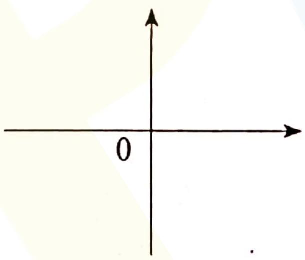
(f) Mark the independent variable of the equation obtained in (*e*) above on the horizontal axis and the dependent variable on the vertical axis of the given diagram.

(g) Draw a rough sketch of the expected graph on the same diagram. Use the signs for the object distance and image distance according to the sign convention used in (*e*).




4. (a) An incomplete diagram of a potentiometer circuit that is being used in the laboratory to determine the internal resistance $r_0$ of a standard cell of e.m.f. $E_0$ ($< E$) is shown in figure (1).

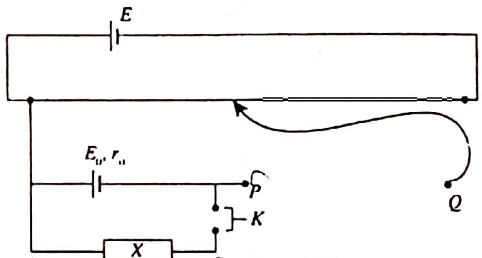



Figure (1)

(i) Complete the section of the circuit between $P$ and $Q$ using **standard circuit symbols.**

(ii) What is the item used in the laboratory for $X$ to obtain a resistance. $R$?

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(iii) If $\ell$ is the balance length of the potentiometer wire, and $k$ is the potential drop per unit in this length of the potentiometer wire, derive an expression for the product $k\ell$ in terms of $E_0$, $r_0$ and $R$.

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(b) A student decided to modify the above setup to determine the resistance per unit length ($m_0$) of a nichrome wire by replacing the item $X$ of the circuit with the nichrome wire of length $\ell_1$.

(i) If the balance length of the potentiometer wire in this case is $\ell_2$, modify the expression that you have given under (*a*)(iii), and write down an expression for product $k\ell_2$ in terms of $E_0$, $m_0$, $\ell_1$, and $r_0$.

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(ii) Rearrange the expression that you have given under (*b*) (i) in a suitable manner to plot a graph between $1/l_2$ and $1/l_1$, taking $1/l_1$ as the independent variable.

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(iii) How would you determine $m_0$ using the data obtained from the graph mentioned in (*b*)(ii) above and the value of $r_0$?

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(iv) If the nichrome wire provided to the student has a diameter of $1.6 \times 10^{-4}$ m, calculate the length of the wire necessary to obtain a resistance of 50 Ω. Resistivity of nichrome is $10^{-6}$ Ω m. (Take π as 3)

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(v) The nichrome wire of resistance 50 Ω is fixed onto a metre ruler. You are asked to obtain a set of measurements from the potentiometer to determine $m_0$ using the graph mentioned in (*b*)(ii) above. By completing the circuit in figure (2) given below, show as to how you would connect the nichrome wire to the potentiometer in order to obtain the relevant measurement for a wire length approximately corresponding to 25 Ω.

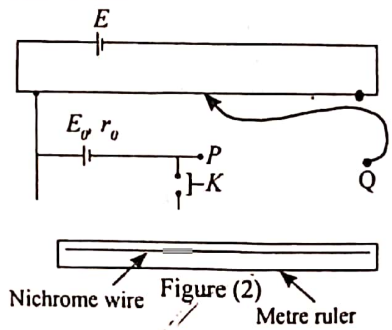


Figure (2)

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# General Certificate of Education (Adv.Level) Examination, August 2015

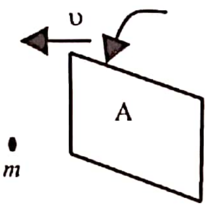
## Physics II

## PART B - ESSAY

*Answer **four** questions only.*

(g = 10 N kg-1)

5. *(a)* A vertical flat board of cross-sectional area A moves in still air at a constant speed $\upsilon$ as shown in the figure. Consider the relative motion of the board and the air molecules. Under this condition, assume that the air molecules collide with the surface of the board perpendicularly and after colliding, bounce back in the opposite direction with the same speed $\upsilon$ with respect to the board.




(i) If $m$ is the mass of an air molecule, write down an expression for the change in momentum of the molecule.

(ii) Considering the number of air molecules colliding with the board per unit time or otherwise, show that the magnitude of the force $F$ exerted on the board by the air can be given by $F = 2Ad\upsilon^2$, where $d$ is the density of air. **This force is known as the drag force.**

*(b)* The drag force $(F_D)$ on an object moving in a fluid depends on the shape of the object. A more accurate expression for $F_D$ can be given as $F_D = KAd\upsilon^2$, where K is a constant which depends on the shape of the object. Drag force plays an important role in the design of the external shape of vehicles.

Consider a motor vehicle moving in still air on a flat road with a constant speed $\upsilon$. Take $K = 0.20$, $A = 2.0\ m^2$ for the motor vehicle and $d = 1.3\ kg\ m^{-3}$.

(i) Write down an expression for the power $(P)$ needed to overcome the drag force $F_D$.

(ii) Calculate the power P when the motor vehicle is moving with a speed of 90 km $h^{-1}$ (= 25 m $s^{-1}$).

(iii) If the power needed to overcome other external frictional forces acting on the motor vehicle is **constant** and is 6 kW, what should be the total power supplied by the drive wheels of the motor vehicle in order to maintain a constant speed of 90 km $h^{-1}$?

(iv) If the speed of the motor vehicle has been increased from 90 km $h^{-1}$ to 126 km $h^{-1}$ (= 35 m $s^{-1}$), calculate the **additional power** required to maintain the speed of the motor vehicle at that value.

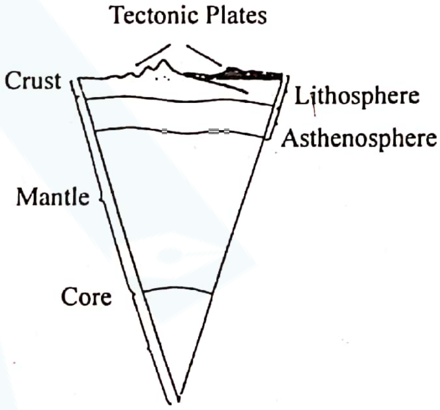
(v) If the motor vehicle climbs at a constant speed of 90 km $h^{-1}$ on a road of slope of 3°, calculate the **additional power** that should be supplied by the drive wheels. Consider that the mass of the motor vehicle is 1 200 kg. (Take $\sin 3° = 0.05$)

*(c)* Consider a motor vehicle moving on a flat road as described in (b)(iii) above. Consider that the energy released by burning one litre of petrol is $4 \times 10^7$ J and only 15% of this energy is used to drive the wheels. Under following conditions, calculate the fuel efficiency of this motor vehicle in kilometres per litre.

(i) When it moves in still air.

(ii) When it moves in opposite direction to a wind blowing at constant speed of 36 km $h^{-1}$ (= 10 m $s^{-1}$).

6. Read the following passage and answer the questions.




Earthquakes are one of the powerful natural phenomena on Earth. The internal structure of the Earth is one of the important parameters needed to understand the major seismic activities around the globe. The Earth may be considered to have three major concentric parts, namely the crust, the mantle and the core [see figure (1)]. The lithosphere and asthenosphere are the two outer layers of the Earth. The lithosphere consists of 10 major rigid lithospheric plates called tectonic plates which are considered to be floating on the asthenosphere.

Heat is transferred towards asthenosphere due to the high temperature in the core. The convection currents thus produced in the asthenosphere cause the movements of tectonic plates. When two tectonic plates move with respect to each other, friction sometimes causes two plates to get stuck. When this happens elastic strain energy builds up, until eventually the plates give way creating an earthquake. This stored energy is released creating energetic waves called seismic waves. These seismic waves travel in all directions from the point where the energy is released, and this point is known as the focus of ther earthquake. The corresponding point on the Earth's surface, directly above the focus, is called epicenter of the earthquake.

The Earh's crust supports propagation of travelling waves. The waves travel through the crust are called body waves and those travel on the surface are called surface waves. The body waves consist of P (primary) waves and S (Secondary) waves. *P* waves are longitudinal whereas the *S* waves are transvers. Since any material, solid or fluid, can be subjected to compression, the *P* waves can travel through any king of material. However, *S* waves which depend upon shear force, do not exist in a fluid. The absence of $S$ waves at large distances from an earthquake was the first indication that the Earth has a liquid region also. The $P$ waves from and earthquake arrive at a given location befor the $S$ waves and suface waves.

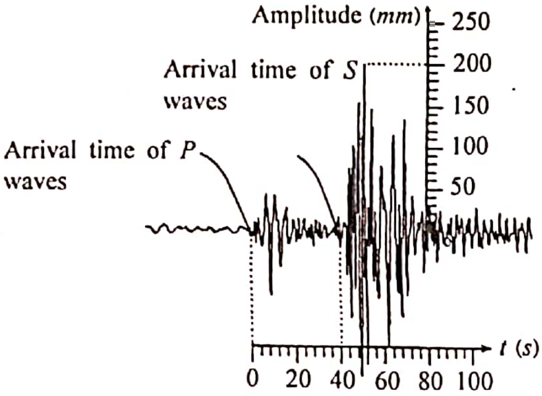



Figure (2)

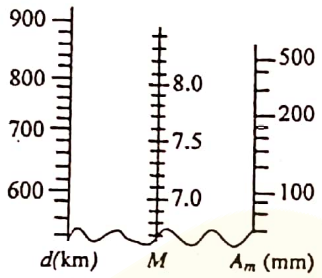



Figure (3)

There is a large number of seismic data recoding stations throughout the world. In order to find the distane $d$ from such a station to the epicentre, one needs to measure the difference in arrival times $\Delta t$ of $P$ and $S$ waves of the station [see figure (2)]. The distance

$d$ is given by $d = \left[\dfrac{\upsilon_P \upsilon_S}{\upsilon_P - \upsilon_S}\right] \Delta t$ , where $\upsilon_P$ and $\upsilon_S$ are speeds

of $P$ and $S$ waves respectively. The location of the epicentre can be found using the $d$ values from at least theree recording stations. By drawing three circles with radii correspoding to the disances ($d$ values) measured, and using the common point of intersection of the circles (tringulation), one can find the location of the epicentre.

Richter scale is the most accepted method used to estimate the strength of an earthquake. Distance $d$ of the epicentre from the station and the **maximum** amplitude $A_m$ of the seismic waves recoded at the station can be used to estimate the Richter scale magnitude $M$ of earthquake using the nomorgam shown in figure (3). The magnitude $M$ of an earthquake is related to the related to released energy $E$ (in joules) by the equation, $\log_{10} E = 4.4 + 1.5M$.

*(a)* What are The **three** major parts of interior of the Earth?

*(b)* Explain, why the tectonic plates are in continuous motion?

*(c)* What is the relationship between focus and epicentre of an earthquake?

*(d)* Even though $P$ waves can travel through any part of the Eaths, $S$ waves can only travel in the soild parts of the Earth. Explain why?

*(e)* Draw **two** separate diagrams for the propagation of $P$ and $S$ waves indicationg the direction of propagation and the direction of vibration of particles in the medium by arrows. Label them clearly.

*(f)* What was the first experimental obsrvation which indicates the existence of a liquid region in the internal structure of the Earth?

*(g)* Using an appropriate diagram, illustrate the triangulation method used in seismology. Clearly mark the location of the epicentre as point $O$ and $S_1$, $S_2$ and $S_3$ as the locations of the corresponding stations in your diagram.

*(h)* If the graph in figure (2) is a seismogram obtainded by a certain station with regard to the recent earthquake in Nepal, find the value of $\Delta t$ in seconds, and calculate the value of d in kilometres for this station. Take $\upsilon_P = 5\ \text{km s}^{-1}$ and $\upsilon_S = 4\ \text{km s}^{-1}$.

*(i)* Using the nomogram in figure (3) above, estimate the Richter scale magnitude $M$ of the earthquake mentioned in *(h)* above.

**Hint:** Mark the values of $d$ $A_m$ on the correct axes. Draw the line connecting the two points ($d$ and $A_m$) and read the value of the point of intersection of the line with the $M$ axis. You **do not need** to copy the nomogram to your answer script.

(j) Claculate the total energy $E_N$ released from the earthquake in Nepal in joules.

(k) If $E_S$ is the total energy relased and $M = 9.1$ for 2004 Sumatra earthquake, calculate the ratio, $\dfrac{E_S}{E_N}$ Take $10^{1.8} \approx 63$.

07. (a) In the human body, if the length of a bone is larger than is width then it is classified as a 'long bone' The tensile stress $\left(\dfrac{F}{A}\right)$ - strain $\left(\dfrac{\Delta \ell}{\ell}\right)$ curve for a certain 'long bone' is shown figure (1). Here, all the symbols have their usual meaning.

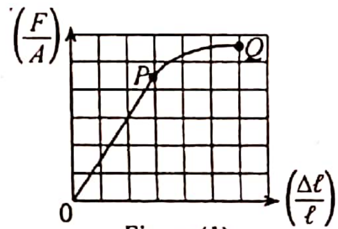



Figure (1)

(i) Identify the points $P$ and $Q$ marked on the curve shown in figure (1).

(ii) Assume that the 'long bone' is a uniform rod of area of cross-section $3 \times 10^{-4}\ \text{m}^2$. If a tensile force of magnitud $4.5 \times 10^3$ N is applied, calculate the tensile stress on the bone.

(iii) If the Young' s modulus of the 'long bone' is $1.5 \times 10^{10} N\ m^{-2}$, calulate the tensile strain of the bone.

(iv) If the intial length of the 'long bone' is 25cm, what is the length when the tensile force is applied?

(b) Table given below shows the elastic characteristics of one of the long bones of human body; the femur (the long bone in the thigh), obtained under tension and compression.

| Elastic characteristics | Tensile value | Compressive value |
|---|---|---|
| Young's Modulus | $1.60 \times 10^{10}$ N m$^{-2}$ | $1.00 \times 10^{10}$ N m$^{-2}$ |
| Stress corresponding to the fracture point | $1.20 \times 10^{8}$ N m$^{-2}$ | $1.65 \times 10^{8}$ N m$^{-2}$ |
| Strain corresponding to the facture point | $1.50 \times 10^{-2}$ | $1.75 \times 10^{-2}$ |

(i) Using the values given in the table above for a femur, show that same value of stress, the compressive strain is 1.6 times the tensile strain.

(ii) Under which condition (tension or compression) the femur is more susceptible to fracture? Use the values given in the table above to justify your answer.

(c) When a person stands on a single leg the total weight of the person creates a compressive effect on the leg. Consider a situation that the femur is a thick-walled cylinder of uniform cross-section with an inner cavity. Its outer and inner radii are 1.5 cm and 0.5 cm respectively. For the following calculations, use the values given in the table above.

(i) When the person stands on a single leg, find the compressive stress applied to his femur.

(Take $\pi$ as 3)

(ii) Find the strain corresponding to the situation in (*c*) (i) above.

(iii) For a human to stand on a single leg without feeling uncomfortable under ordinary standing conditions, the strain on the femur must be less than 1% of the value of the strain indicated in the table above. Hence show that when the above mentioned person stands on one leg he does **not** feel uncomfortalble.

(iv) Consider a person having all body dimensions doubled including all bones compared to an ordinary person. Let the mass of such a person 600 kg. If the scaled-up person now stands on one leg, does he feel uncomfortable? Justify your answer. Assume that the classtic characteristics given in the table above remain unchanged for the situation.

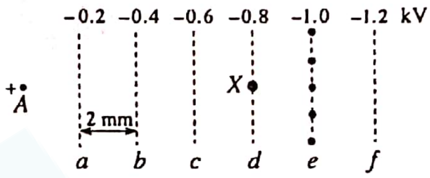
8. (a) A long thin conducting straight cylindrical wire A of radius *a* has a charge per unit length $+\lambda$. Practically this can be done by connecting the wire to a positive potential with respect to ground.

(i) Where does the given charge of the wire physically reside?

(ii) Considering an appropriate Gaussian surface around the wire, show that the magnitude of the Intensity of the electric field *E* at distance *r* ($\geq a$) form the axis of the wire is given by dy $E = \dfrac{\lambda}{2\pi\varepsilon_0 r}$, where $\varepsilon_0$ is the permittivity of free space.

(iii) Draw a cross-section of the wire, and draw the equipotential lines around it.

(iv) If $a = 10\mu m$ and $\lambda = 8.1 \times 10^{-8} C\ m^{-1}$, calculate the magnitude of the intensity of the electric field on the surface of the wire, (Take $\varepsilon_0$ to be $9 \times 10^{-12}$ F m$^{-1}$, and $\pi$ as 3.)




(v) This wire *A* is now brought close to a region of a uniform electric field in which the equipotential sufaces are planar and normal to the plane of the paper. The axis of the wire is also normal to the plane of the paper. The dashed lines *a*, *b*, *c*, *d*, *e*, and *f* shown in figure represent the cross-sections of the above mentioned equipotential surfaces as seen on the plane of the paper. These dashed lines represent the equipotential lines corresponding to the electric field, and the respective voltages (in kV) of these equipotential lines are also shown in the figure. Distance between any two equipotential lines in 2 mm.

In this arrangement the wire *A* is connected to a positve potential with respect to the ground, and can be considered as an anode.

(1) Copy the anode and the equipotential lines to the answer script and draw the electric field lines from the positions marked with dots on the equipotential line *e* up to the anode wire *A*.

(2) Calculate the intensity of the electric field $E_0$ between two equipotential lines.

(b) Part of an arrangement used for the detection of high energy particles and photons is similar to the one described in part (*a*) (*v*) above. Suppose that such an arrangement with an anode A having a chargre per unit length $+\lambda = 8.1 \times 10^{-8}$ C m$^{-1}$ is housed in a chamber filled with an inert gas (Argon) at atmospheric pressure.

Consider a situation in which a photon enters the chamber and collides with an argon atom at *X* creating a photoelectorn and an argon ion. Such and electron called a primary electron. The energy needed to creat one such electron-ion pair in argon gas is 30eV. (1eV=$1.6 \times 10^{-19}$ J, charge of an electron $e = 1.6 \times 10^{-19}$ C).

(i) Write down an expression for the magnitude of the initial acceleration of the primary photoelectron due to the electric field mentioned in (*a*)(v)(1) above in terms of m, e, and $E_0$ where m and *e* are the mass and charge of an electron respectively.

(ii) Explain, why the electron moves towards anode $A$ with a drift velocity $\upsilon_d$ without accelerating continuously.

(iii) Suppose that the primary electron which started from rest is moving along the electric field mentioned in ($a$)(v)(1) above. If the average distance moved by the primary electron between two successive collisions with argon atoms is 0.5 μm, calculate the increase in kinetic energy of the primary electron between two collisions in eV due to the electric field between two collisions, and show that the primary electron having this energy is unable to remove another electron upon colliding with another argon atom. (Consider that the energy required for an electron to remove an electron from an argon atom is 30 eV.)

(iv) When this primary electron is close to the anode it experiences a high electric field given by the expression stated in ($a$)(ii) above. Under this condition, the primary electron gains sufficient energy between collisions to create electron-ion pairs and the secondary electrons produced in this manner in turn creat more electron-ion pairs before getting collected at the anode. Total number of secondary electrons produced by a single primary electron in this manner is called the **amplification factor** for the gas. Ability to collect charges by the anode wire indicates that is has the property of capacitance. a small voltage is generated across this capacitor.

If the detector capacitance is 5 pF and the volatage generated across this capacitor due to secondary electrons produced by the primary electrons is 0.96 mV find the charge collected by the anode.

(v) Hence find the amplification factor for the gas.

**9. Answer either part (A) or part (B) only.**

(A) (a) In the circuit shown in figure (1), $X$ is an accumulator of e.m.f. $E$ and internal resistance r, L is an electric lamp connected across $AB$, and the current through the lamp is $I$.

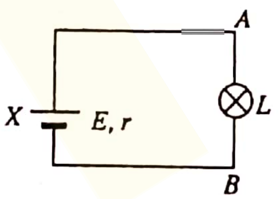



Figure (1)

(i) Show that the power $P$ consumed by the electic lamp can be given as

$P = EI - I^2r$.

(ii) Using the definitions for $E$ and $I$, explain why the product $EI$ us equal to the power generated by the accumulator.

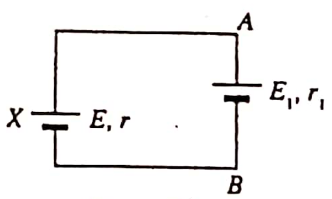



Figure (2)

(iii) Electric lamp in the figure (1) is now replaced by another accumulator of e.m.f $E_1$ and internal resistance $r_1$ as shown in figure (2) $E > E_1$ and the current in the circuit is now. $I_1$.

(1) Show that $EI_1 - I_1^2 r = E_1 I_1 + I_1^2 r_1$.

(2) Physically what quantities do the products $EI_1$ and $E_1 I_1$ in the above expression represent? Explain your answer.

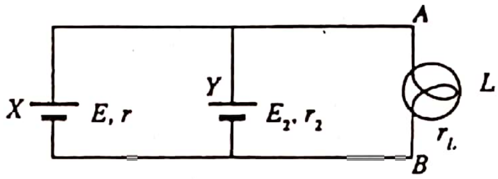



figure (3)

(b) A circuit similar to the one given in figure (2) above can be used to re-charge a run-down rechargeble battery. In this context X is a source capable of delivering a constant power output, and is known as the battery charger. $Y$ represents the run-down battery. Consider such a circuit shown in figure (3).

$X$ is a 12 V battery charger. For the purpose of calculations consider it as a constant power source with e.m.f 12 V, and internal resistance r = 2 Ω. $L$ is indicator lamp of resistance $r_L$ = 2 Ω connected across the battery charger. $E_2$ and $r_2$ represent the e.m.f of the battery $Y$ and its internal resistance at a **Particular instant** in the charging proccess. If $r_2$ = 1 Ω and the current through $Y$ is 1 $A$ at that instant,

(i) calculate the e.m.f $E_2$ of the battery $Y$ at that instant.

(ii) calculate the power generated by the battery charger, and the power dissipated in r, $r_2$ and $r_L$ that instant.

(iii) apply the principle of conservation of energy to the charging process at that instant, and explain what has happened to the excess power generated by the battery charger.

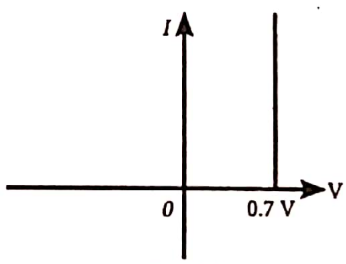



Figure (1)

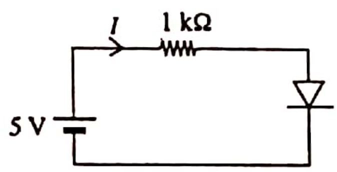



Figure (2)

(B) (a) Draw current $(I)$ - voltage $(V)$ characteristic for a silicon diode, indicating its forward bias voltage of 0.7 V on the voltage axis.

(b) Instead of the characteristic you have drawn under (a), hypothetical diode characteristic given in figure

(1) is also used frequently in the analysis and design of circuits with silicon diodes. According to the figure (1), current through the diode is zero until its voltage becomes 0.7 V at which the current increases sharply parallel to the *I*-asis.

**Also use the characteristic given in figure (1) above to answer all the folling questions.**

(c) In the figure (3) shown, $D_1$ and $D_2$ are silicon diodes, and the input volatages *A* and *B* can have either 5 V or 0 V.

(i) Find the voltage ($V_F$) at the output F for various combinations of the input voltages and fill in the follownig table (Copy the table on to your answer script for this purpose)

| A(V) | B(V) | $V_F$(V) |
|---|---|---|
| 0 | 0 | |
| 5 | 0 | |
| 0 | 5 | |
| 5 | 5 | |

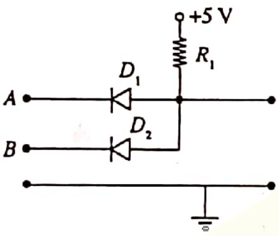



Figure (3)

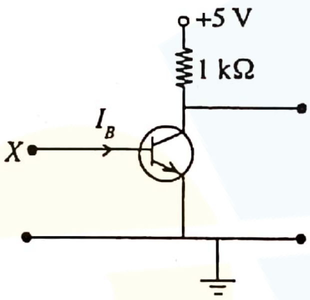



Figure (4)

(ii) As far as F output is considered, if 0.7 V reperesents binary 0 and 5 V represents binary 1, identify the gate corresponding to the circuit given in figure (3) and write down its truth table.

(iii) Calculate a suitable value for $R_1$ which will limit the sum of the cuerrents thorugh both diodes to 0.5 mA.

(d) Suppose the terminal *X* of the circuit shown in figure (4) is now connected to the output *F* of the circult shown in figure (3).

(i) When the inputs *A* and *B* represent binary 1, what is the base current $1_B$ ?

(ii) Show that the transistor operates as a closed switch under the input conditions given in (d)(i) above. Assume that that the cuurrent gian β, of the transistor is 50.

(iii) Show that the tranistor, however, does not operate as a open switch when *F* in figure (3) represents binary 0.

(iv) With the aid of a circuit diagram, show how you would convert the composite circuit consisting of circuits given in figures (3) and (4) to perform as a NAND gate by inserting another silicon diode at an appropriate place in the circuit given in figure (4) above.

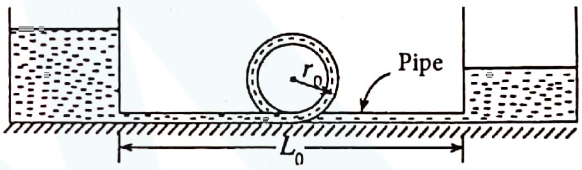
**10. Answer either part (A) or part (B) only.**

(A) (a) A pipe made of copper having a length $L_0$ at room temperature $\theta_0$ is heated to temperature $\theta$. Write down an expression for the increase in length of the pipe. Linear expansivity of copper is α.

**When answering the following questions always consider steady conditions.**

(b) An insulated straight copper pipe of length $L_0$ and internal area of cross-section $A_0$ at room temperature $\theta_0$ is laid between two oil tanks separated by a large distance to transport heated oill from one tank to the other tank.

If the distance between the tanks is kept fixed at $L_0$, a compressive stress builds-up in the pipe when heated oil is sent through it. write down an expression for the maximum temperate $\theta_M$ of the oil that can be sent through the pipe without exceeding the compressive elastic limit for copper. Assume that the compressed length corresponding to the elastic limit of cooper is $\Delta L_0$.




(c) In order to avoid the compression of pipe as stated in *(b)* and use it to transport oil at a higher temperature $\theta_H$ ($>\theta_M$) it was decided to modify the pipe by introuducing an additional small circular section made of copper with mean radius $r_0$ at room temperature $\theta_0$ so that is forms a part of the pipe as shown in the figure.

(i) Explain how such a modification would avoid the compression of the tube with temperature as stated in *(b)* above.

(ii) What is the total length of pipe at room temperature $\theta_0$?

(iii) Derive an expression for the total length ($L_H$) of the pipe when oil at temperature $\theta_H$ is sent through it.

(iv) Derive an expression for the new mean radius ($R_H$) of the circular section when oil at temperature $\theta_H$ is sent through the pipe. Assume that the shape of circular section remains as circular.

(v) Derive an expression for the increase in the volume of oil in the pipe at $\theta_H$ when compared to the volume at room temperatur $\theta_0$.

(vi) If the variations of the area of cross-sèction of the inlet of the pipe and the density of oil with temperature are negligible, derive an expression for the ratio, $\left(\frac{\text{Flow speed of oil at } \theta_H}{\text{Flow speed fo oil at } \theta_H}\right)$ in the pipe when its temperature is incresed from room temperature $\theta_0$ to $\theta_H$ Assume that the pressure difference of oil between the inlet and outlet of the pipe is constant.

(vii) Even if the pipe is insulated, suppos there is a small **linear** drop in temperature $\theta_H$ across the entire length of the pipe. If the drop is $\Delta\theta$ drive an experession for the mean radius of the circular section. Assume that the circular section is located at the middle of the pipe and neglect tmperature variation of that section.

(B) (a) Using the Einstein's mass-energy relation, determine the energy equivalence of the atomic mass unit (1 u) in MeV. (1 MeV = $1.6 \times 10^{-13}$ J, 1u = $1.66 \times 10^{-27}$ kg, and speed of light = $3 \times 10^8 ms^{-1}$)

(b) ${}^{235}_{92}U$ nucleus undergoes fission when neutron is absored. One of the modes of fission is given in the following reaction.

$$n + {}^{235}_{92}U \longrightarrow {}^{96}_{37}Rb + {}^{138}_{55}Cs + 2n$$

The masses of ${}^{235}_{92}U$, ${}^{96}_{37}Rb$, ${}^{138}_{55}Cs$ and a neutron are approximately, 235.0440 u, 95.9343 u, 137.9110 u and 1.0087 u respectively.

(i) Find the mass loss of the above fission reaction in terms of atomic mass units.

(ii) Hence determine the energy released in the above fission reaction in MeV.

(c) In a large nuclear reactor the thermal power generated due to the fission of ${}^{235}_{92}U$ fuel is 3200 MW. The corresponding electrical power generated is 1000 MW. Different modes of fission reactions release different amounts of energy as heat. In these fission reactions the average heat energy generated per fission is 200 MeV.

(i) Determine the efficiency of the nuclear reactor.

(ii) Determine the number of fissions per second (fission rate) at the steady state of nuclear reactor.

(iii) hence find the ${}^{235}_{92}U$ consumption rate in kg per year of the nucler reactor. (Take Avgadro number as $6.0 \times 10^{23}$ mol$^{-1}$

(d) Natural uranium contains 0.7% of ${}^{235}_{92}U$ and 99.3% of ${}^{238}_{92}U$ by weight. only ${}^{235}_{92}U$ is required as fuel for the above nuclear reactor to generate electricity. The above rector uranium fuel of 2% enriched uranium uranium fuel consisting of 2% ${}^{235}_{92}U$ by weight).

Determine the 2% enriched uranium fuel required to run the 1000 M W reactor mentioned under (c) above for one year.

(e) In coal power plants, buring of carbon produces the heat energy required to produce electricity.

$$C + O_2 \longrightarrow CO_2 + 4eV$$

The efficiency of a coal power plant is mostly the same the efficiency of a nuclear power plant. Determine the amount of carbon in kg required to run a 1000 M W coal power plant for one year. Assume that the efficiency of the coal power plant is same as efficiency determined in (c) (i) above.

(Molar mass of C = 12 g mol$^{-1}$)

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# General Certificate of Education (Adv.Level) Examination, August 2015

# Physics - I

## 2015 Answers

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 01 | | | | X | |
| 02 | | | | X | |
| 03 | X | | | | |
| 04 | | X | | | |
| 05 | X | | | | |
| 06 | | | | | X |
| 07 | | | | X | |
| 08 | | | X | | |
| 09 | | | | | X |
| 10 | | | | X | |
| 11 | X | | | | |
| 12 | X | | | | |
| 13 | | | X | | |
| 14 | | | | | X |
| 15 | | | | X | |
| 16 | | | | X | |
| 17 | X | | | | |
| 18 | X | | | | |
| 19 | | | | | X |
| 20 | | X | | | |
| 21 | | | | X | |
| 22 | | | | | X |
| 23 | | | | | X |
| 24 | | X | | | |
| 25 | | X | | | |
| 26 | | | X | | |
| 27 | | | X | | |
| 28 | X | X | X | X | X |
| 29 | | X | | | |
| 30 | | | X | | |
| 31 | | | | X | |
| 32 | X | | | | |
| 33 | | X | | | |
| 34 | | | X | | |
| 35 | | X | | | |
| 36 | | | | | X |
| 37 | | | | X | |
| 38 | X | | | | |
| 39 | | X | | | |
| 40 | | | X | | |
| 41 | | X | | | |
| 42 | | | X | | |
| 43 | | X | | | |
| 44 | X | | | | |
| 45 | X | | | | |
| 46 | X | | | | |
| 47 | | X | | | |
| 48 | | | | | X |
| 49 | | | | X | |
| 50 | | | | X | |

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# General Certificate of Education (Adv.Level) Examination, August 2015

# Physics - II

## 2015 Answers

## Part A

01. (a) $T=2\pi\sqrt{l/g}$ (Mark 01)

(b) $\frac{\Delta T}{T} = \frac{0.5/n}{2} = \frac{1}{100}$

$\frac{0.5}{2n} = \frac{1}{100}$ (Mark 01)

$n = 25$

(c) (i). (1) Related value $\upsilon$ : Value of $t_0$ decreases

(2) Related value D : Value of $t_0$ increases

(Any correct Answer Mark 01)

(ii) $\upsilon = D/t_0$ OR $D = V t_0$ (Mark 01)

(iii) $T = 3s$ (Mark 01)

(d) (i) Answer : A

Reason : Pendulum bob has the maximum Velocity/ Speed/ kinetic energy at point A/. at the lowest point of the path. (Mark 01)

(ii) The diameter / D of the cylindrical bob is uniform throughout

It is easy to align the beam through the diameter / D of the cylindrical bob.

The diameter of the spherical bob is D only at one location. It is difficult to align the beam through the diameter /D of the cylindrical bob.

IR beam is not visible therefore; it is difficult to align the beam through the diameter /D

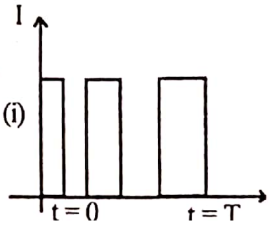
Distance through which the beam is blocked by the cylinder becomes D throughout.

(Any correct reason 01)

(iii) Answer : No (Mark 01)

Reason : $\upsilon_m$ is an instantaneous at the lowest point of the path/ the calculated value is an average value/ approximate value for $V_m$.

(e) (i)




(Width of the zero intensity should increase with time) (Mark 01)

(f) Energy loss $= 1/2\, m\,(V_1^2 - V_2^2)$

$= 1/2 \times (0.1)(0.44^2 - 0.42^2)\ 8.6 \times 10^{-4} J$

(Mark 01)

02. (a) (i) mass/ number of moles.

number of molecules. (both correct 01)

(ii) Volume

(b) To minimize / neglect the amount of gas outside the bulb

OR to minimize / neglect the amount of the gas not in the required / measured temperature. (Mark 01)

(c) To ensure that the temperatures of the gas inside the bulb and the water bath are equal.

OR to ensure that the therometer reading closely follows the temperature of the gas in the bulb.

(Mark 01)

(d) Ensuring a steady/ unchanged mercury level in tube A/B

(e) (i) Stirring the water in the water bath

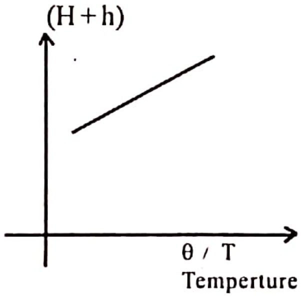
(ii) Moving the Bunsen burner in and out of the water bath.

OR adjusting the flame high and low.

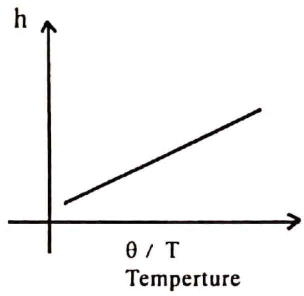
(both are correct 01)

(f) by moving the tube B up or down until the mercury level in tube A touches the tip of M/ fix mark or pointer (Mark 01)

(g)




OR




(h) (i) Pressure law $\Rightarrow$

$\frac{P_1}{T_1} = \frac{P_2}{T_2} \Rightarrow P_2 = \frac{P_1 T_2}{T_1}$ (Mark 01)

OR

gas law $\Rightarrow$

$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$ , $V_1 = V_2 \Rightarrow P_2 = \frac{P_1 T_2}{T_1}$

(Mark 01)

For $V = 20 \times 10^{-3}\,m^3$

$P_1 = \dfrac{6 \times 10^3}{400} \times 600$

$P_1 = 9 \times 10^3\,Pa$

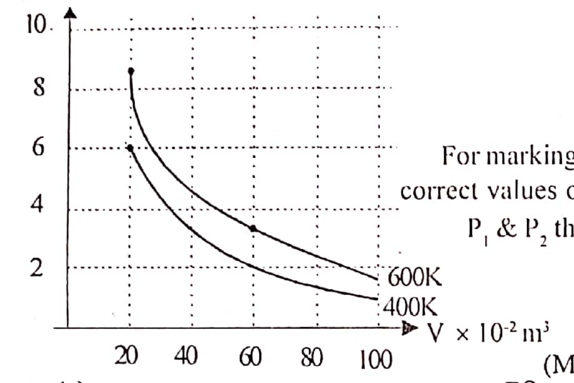
For $V = 60 \times 10^{-3}\,m^3$

$P_2 = \dfrac{2 \times 10^3}{400} \times 600$

$P_2 = 3 \times 10^3\,Pa$

(one P value correct 01)

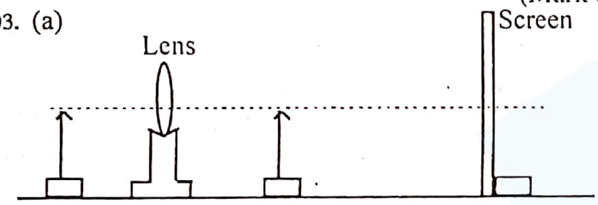
(ii)




For marking the two correct values of points $P_1$ & $P_2$ the graph.

(Mark 01)

03. (a)




(Labeling all four items 01)
(Items with stands all four item 01)

(b) Approximate focal length of the lens (Mark 01)
Estimate the focal length by focusing an image of a distant object onto a wall/ board (Mark 01)

(c) (i) Pins : Pins are not on optical principal axis (Mark 01)

(ii) Lens : Lens is tilted (Mark 01)

(d) Observation pin should be moved towards the eye (Mark 01)

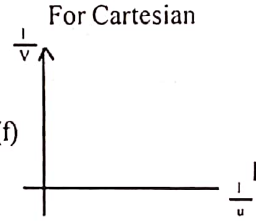
(e) $\dfrac{1}{V} - \dfrac{1}{U} = \dfrac{1}{f}$ OR $\dfrac{1}{V} + \dfrac{1}{U} = \dfrac{1}{f}$

$\dfrac{1}{V} = \dfrac{1}{U} + \dfrac{1}{f}$ $\qquad \dfrac{1}{V} = \dfrac{-1}{U} + \dfrac{1}{f}$

For Cartesian

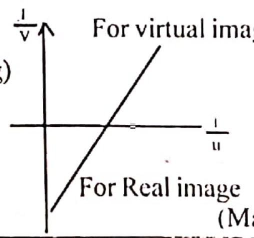
for Real – Positive 01
Virtual – negative

(f)




For correct labeling of both axis

(g)

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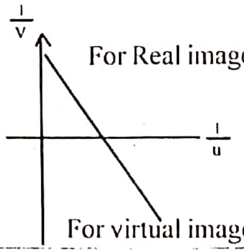
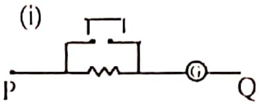



(Mark 01)

04. (a) (i)

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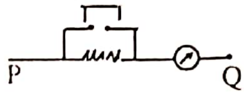



(Mark 01)

[other possible switch symbols]

(ii) Resistance box (Mark 01)

(iii) $V_{AB} = \dfrac{E_0 R}{r_0 + R}$ (Mark 01)

$K\,l = \dfrac{E_0 R}{r_0 + R}$ (Mark 01)

(b) (i) $K\,l_2 = \dfrac{E_0 m_0 l_1}{r_0 + m_0 l_1}$ (Mark 01)

(ii) $\dfrac{1}{K l_2} = \dfrac{r_0}{E_0 m_0 l_1} + \dfrac{m_0 l_1}{E_0 m_0 l_1}$

$\dfrac{1}{l_2} = \left(\dfrac{k r_0}{E_0 m_0}\right) \dfrac{1}{l_1} + \dfrac{k}{E_0}$ (Mark 01)

$y = m \times +C$

(iii) $m_0 = \dfrac{\text{Intercept}}{\text{Gradient}}\, r_0$ OR

$\dfrac{m_0}{r_0} = \dfrac{\text{Intercept}}{\text{Gradient}}$ (Mark 01)

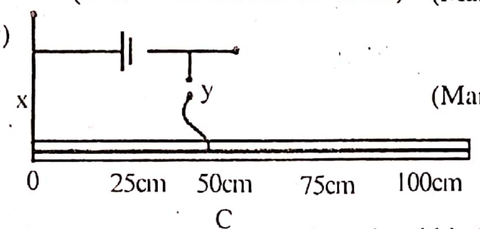
(iv) $R = \rho l / A$ OR $l = \dfrac{RA}{\rho}$ OR

$l = \dfrac{50 \times (3\,(0.8 \times 10^{-4})^2)}{10^{-6}}$ (Mark 01)

$l = 0.96\,m$ OR $96\,cm$

(if $\pi = 3.14$ the answer is 1m) (Mark 01)

(v)

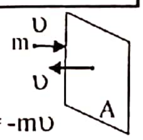



(Mark 01)

(Accept any point approximately within 25 cm and 75cm marks of the ruler as a correct point For C)

## Part B

05. (a) (i) Initial momentum of an air molecule $= m\upsilon$




Final momentum after collision with the board $= -m\upsilon$

Change in momentum per molecule $= m\upsilon - (-m\upsilon) = 2m\upsilon$ (Mark 01)

(ii) Total mass of molecules colliding With the board per unit time $= A\upsilon d$ (Mark 01)

Rate of change of momentum of air mass = 2 (aυd)
(Mark 01)

$F = 2A\upsilon^2 d$

(b) (i) $P = F_D V^3$ (Mark 01)

(ii) $P = KAd \times v^3$

$P = (0.2)\times(2)\times(1.3)\times(25)^3$ (Mark 01)

$= 8125$ W (8120W - 8125W) (Mark 01)

(iii) Total power = 8125W + 6000W

= 14125W [14120 W - 14125W]
(Mark 01)

(iv) Power required to maintain the speed at $126kmh^{-1}$ ($35ms^{-1}$)

$P = KAdv^3$

$= (0.2)\times(2)\times(1.3)\times(35)^3$ (Mark 01)

$= 22295W$

[22290 - 22295W]

Additional power required = (22295 - 8125)W

= 14170W

[14165W - 14175W]

(Mark 01)

**Alternator method (i)**

$P \propto V^3$

Additional Power required to maintain at $126kmh^{-1}$ ($35ms^{-1}$)

$\left[8125\left(\frac{35}{25}\right)^3 - 8125\right]$ (Mark 01)

= 14170 W [14165 - 14175W] (Mark 01)

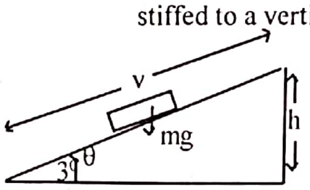
**Method (ii)**

Additional Power required to maintain at $126kmh^{-1}$ ($35m^{-1}$)

$= (0.2)\times 2\times(1.3)(35^3 - 25^3)$ (Mark 01)

= 14170W [14165W - 14175W] (Mark 01)

(v) Vehicle travels a distance υ in unit time stiffed to a vertical height = $\upsilon\sin 3^0$




$P = Fv$

$P = (mg\sin 3^0)\times\upsilon$

Required additional power

$= mg\,\upsilon\sin 3^0$ (Mark 01)

$= 1200\times 10\times 25\times 0.05$

$= 15000W$ (Mark 01)

(c) Amount of energy used for driving the wheels by burning 1 litre of petrol

$= (4\times 10^7)\times\frac{15}{100} = 6\times 10^6\,Jl^{-1}$

(i) Energy required per second to maintain a speed of $90kmh^{-1}$ $= 14125\,Js^{-1}$ $(14120 - 14125)Js^{-1}$

Total time that the vehicle can be driven by burning litre of petrol $= \frac{6\times 10^6}{14125}$ (Mark 01)

$= 424.8sl^{-1}$

Distance travelled in 424.85 $= 25\times 10^{-3}\times 424.8$

Fuel efficiency $= 10.6\,kml^{-1}$ (Mark 01)

**Alternative method**

Energy required per second to maintain a speed of $90kmh^{-1}$

$= 14125Js^{-1}(14120 - 14125)Js^{-1}$

Time taken to travel 1 km (in second) $= \frac{90}{60\times 60}$

Distance traveled using 1 litre of petrol $\frac{6\times 10^6}{14125}\times\frac{90}{60\times 60}$
(Mark 01)

Fuel efficiency $= 10.6\,kml^{-1}$ (Mark 01)

(ii) Speed of the vehicle with respect to wind

$= (90+36)\,kmh^{-1}$

$= 126\,kmh^{-1}$

Total power required to maintain a speed $126\,kmh^{-1}$ ($35ms^{-1}$) $= 15925 + 6000$

$= 21925W$ (21920 - 21925W)
(Mark 01)

Fuel efficiency $= \frac{10.6}{21925}\times 14125$

$= 6.8\,kml^{-1}$ (Mark 01)

**Alternative method**

Total power required to maintain a speed $126kmh^{-1}$ ($35ms^{-1}$)

$= [0.2\times 2\times 1.3\times(35^2\times 25] + 6000$

$= 21925W$ (21920 - 21925W) (Mark 01)

Fuel efficiency $= \frac{10.6}{21925}\times 14125$

$= 6.8\,kml^{-1}$ (Mark 01)

06. (a) the crust, the core and the mantle (Mark 01)

(b) due to the convection currents within the a sthenosphere (Mark 01)

(c) the point on the earth's surface directly above the focus is earthquake's epicenter. (Mark 01)

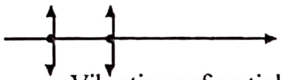
(d) P Wave are compressional waves which can travel through any part of the earth (solid or liquid) However, S waves depend upon shear force which does not exist in a fluid. (Mark 01)

(e) P – waves




Vibrations of particles in the medium (Mark 01)

S – waves

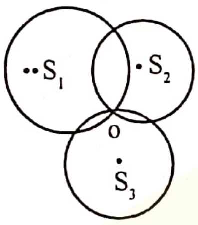



Vibrations of particles in the medium

(at least on diagram should be labeled properly)

(f) The absence of S waves on seismogram at large distances from earthquakes. (Mark 01)

(g)




01 – three circles with a common point of intersection

01 – for the correct point

(Mark 02)

(h) $\Delta t = 40\text{ S}$ (Mark 01)

$$d = \left[\frac{5\text{ kms}^{-1} \times 4\text{ kms}^{-1}}{5\text{ kms}^{-1} - 4\text{ kms}^{-1}}\right] 40$$

$d = 800\text{ km } (8 \times 10^5\text{m})$ (Mark 01)

(i) $M = 7.9$ (Mark 01)

(j) $\log E_N = 4.4 + 1.5 \times 7.9$ Ⓐ

(for substitution (Mark 01)

$log_{10} E_N = 16.25$

$E_N = 10^{16.25}$

$\left[\begin{array}{c}\text{Andoly } [0.2500] \\ 1.784\end{array}\right]$

$E_N = 10^{16} \times 1.780$

$E_N = 1.784 \times 10^{16}\text{J}$ (Mark 01)

$[(1.78 - 1.8) \times 10^{16}]$

(k) $log\, E_s = 4.4 + 1.5 \times 9.1$ —— Ⓑ

Ⓑ-Ⓐ $log\, E_S - log\, E_N = 1.5\,(9.1 - 7.9)$ (Mark 01)

$$log\left[\frac{E_S}{E_N}\right] = 1.8$$

$$\frac{E_S}{E_N} = 10^{1.8}$$

$$\frac{E_S}{E_N} = 63$$

07. (a) (i) P - Proportionality limit (Mark 01)

Q - Breaking point / Fracture point (Mark 01)

(ii) Tensile Stress $= \dfrac{F}{A}$

$= \dfrac{4.5 \times 10^3}{3 \times 10^{-4}}$

$= 1.5 \times 10^7\text{ Nm}^{-2}$ (Mark 01)

(iii) Tensile strain $= \left(\dfrac{\Delta l}{l}\right) = \dfrac{(F/A)}{E} = \dfrac{1.5 \times 10^7}{1.5 \times 10^{10}}$

$= 10^{-3} = 0.001$ (Mark 01)

(iv) New length $l' = (l + \Delta l)$

$= l\left(1 + \dfrac{\Delta l}{l}\right)$

$= 25\,(1 + 0.001)$

$= 25.025\text{ cm } / \ 0.25025\text{ m}$

(Mark 01)

(b) (i) $\dfrac{\left(\frac{\Delta l}{l}\right)_{Compressive}}{\left(\frac{\Delta l}{l}\right)_{Tensile}} = \dfrac{E_{Tensile}}{E_{compressive}} = \dfrac{1.6 \times 10^{10}}{1.0 \times 10^{10}}$ (Mark 01)

$= 1.6$

(ii) Under Tension

Stress Corresponding to the fracture point, Under compression $(1.65 \times 10^8\text{Nm}^{-2}) >$ under Tension $(1.2 \times 10^8\text{ Nm}^{-2})$

OR

Strain corresponding to the fracture point

Under compression $(1.75 \times 10^{-2}) >$ under tension $(1.5 \times 10^{-2})$

(answer & correct Justifications)
(Mark 01)

(c) (i) Compressive stress $= \dfrac{75 \times 10}{\pi\,(1.5^2 - 0.5^2) \times 10^{-4}}$

(Mark 01)

$= 1.25 \times 10^6\text{ Nm}^{-2}$

$(\pi = 3.14,$ answer $1.19 \times 10^6\text{ Nm}^{-2})$ (Mark 01)

(ii) Compressive strain $\left(\dfrac{\Delta l}{l}\right) = \dfrac{1.25 \times 10^6}{1 \times 10^{10}}$

$= 1.25 \times 10^{-4}$

$(\pi = 3.14,$ answer $1.19 \times 10^{-4})$ (Mark 01)

(iii) 1% of the maximum strain =

$= 1.75 \times 10^{-2} \times \dfrac{1}{100}$

$= 1.75 \times 10^{-4}$

(Mark 01)

$\therefore \left(\frac{\Delta l}{l}\right)$ in $1.25 \times 10^{-4} < 1\%$ of the maximum strain ($1.75 \times 10^{-4}$)

(part iii is wrong. do not award this mark)

(iv) Compressive strain on scaled – up person

$$\left(\frac{\Delta l}{l}\right)_{new} = \left[\frac{6000}{4\pi(1.5^2 - 0.5^2) \times 10^{-4}} \Big/ 1 \times 10^{10}\right]$$

(Mark 01)

$$= \frac{6000}{4 \times 3 \times (1.5 + 0.5)(1.5 - 0.5) \times 10^{10} \times 10^{-4}}$$

$$= \frac{6000}{12 \times 2 \times 10^{6}}$$

$$\left(\frac{\Delta l}{l}\right)_{new} = 2.5 \times 10^{-4}$$ (Mark 01)

($\pi = 3.14$, answer is $2.38 \times 10^{-4}$)

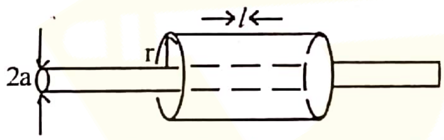
$\left(\frac{\Delta l}{l}\right)_{new}$ ($2.5 \times 10^{-4}$) > 1% of the maximum stram ($1.75 \times 10^{-4}$)

$\therefore$ Does feel uncomfortable

(answer and justification correct 01 mark)

08. (a) (i) The given charge stays on the surface of the wire (Mark 01)

(ii)

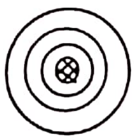



Cylindrical Gaussian surface of radius r and length $l$ drawn co – axially with the wire. (Mark 01)

$$E \times 2\pi r l = \frac{\lambda l}{\epsilon_0}$$ (Mark 01)

$$E = \frac{\lambda}{2\pi \epsilon_0 r}$$

(iii)



(Mark 01)

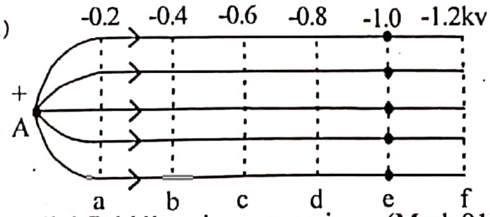
(at least two circles should be drawn)

(iv) $E = \frac{\lambda}{2\pi \epsilon_0 r}$

$r = a \quad E = \frac{8.1 \times 10^{-8}}{2 \times 3 \times (10 \times 10^{-6}) \times (9 \times 10^{-12})}$

$E = 1.5 \times 10^{8}\ Vm^{-1}$ (Mark 01)

(v) (1)




Parallel field lines in a – e region (Mark 01)

At least three lines converging towards Wire A

(2) $E_0 = \frac{\Delta V}{\Delta d} = \frac{0.2 \times 10^{3}}{2 \times 10^{-3}}$

$= 10^{5} Vm^{-1}$ (Mark 01)

(b) (i) $eE_0 = ma$

$a = \frac{eE_0}{m}$ (Mark 01)

(ii) Electron makes collisions with argon atoms and thereby loses its kinetic energy (Mark 01)

(iii) Kinetic energy gained by the electron between two successive collisions = work done on the electron by the electric field over a distance S

$= eE_0 \times S \qquad eV(W = Fs)$

$= (1.6 \times 10^{-19} \times 10^{5} \times 0.5 \times 10^{-6})$

$= \frac{8 \times 10^{-21}}{1.6 \times 10^{-19}}$ eV (Mark 01)

$= 0.05\ eV$ (Mark 01)

$= 0.05\ eV < 30eV$

| |
|---|
| $W = e E_0 S$ (Mark 01)<br>$= e \times 10^{5} \times 0.5 \times 10^{-6}$ (Mark 01)<br>$= 0.05\ eV$ |

(Mark 01)

(iv) $Q = CV$

$= 5 \times 10^{-12} \times 0.96 \times 10^{-3}$

$= 4.8 \times 10^{-15}\ C$ (Mark 01)

(v) Amplification Factor $= \frac{4.8 \times 10^{-15}}{1.6 \times 10^{-19}}$

$= 3 \times 10^{4}$ (Mark 01)

09. (a) (i) $V_{AB} = E - Ir$

$P = V_{AB} I$

$\therefore V_{AB} I = EI - I^2 r$ (for path expressions

$P = EI - I^2 r$ correct 01)

(ii) E. m. f, E is the work done in bringing a unit (positive) charge (or 1C) from the negative electrode which is at a lower potential to the positive electrode which is at a higher potential (internally). It is stored as energy in the accumulator. (Mark 01)

$I = Q/t$

Energy generated per unit time by the accumulator.

$= E \times Q/t$

$= EI$

(iii) Method 1. Applying Kirchhoff's law.

$E - E_1 = I_1 (r + r_1)$ (Mark 01)

$EI_1 - E_1 I_1 = I_1^2 (r_1 + r_2)$

$EI_1 - I_1^2 r = E_1 I_1 + I_1^2 r_1$

Method 2

Power supplied by the accumulator $x = EI_1 - I_1^2 r$

Power consumed by the accumulator of e.m.f

$E_1 = E_1 I_1$

Power dissipated by the internal resistance of the accumulator of e. m. f. $E_1 = I_1^2 r_1$

Argument using the principle of conservation of energy (mark 01)

$EI_1 - I_1^2 r = E_1 I_1 + I_1^2 r_1$

Method 3

Considering accumulator x; $V_A - V_B = V_{AB} = E - I_1 r$

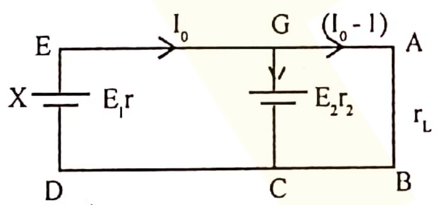
Considering accumulator with e. m. f

$E_1; V_A - V_B = E_1 + I_1 r_1 (V_{AB})$ (mark 01)

$E + I_1 r = E_1 + I_1 r_1$

$EI_1 - I_1^2 r = E_1 I_1 + I_1^2 r_1$

(b) (i)




$E = 12V$ $\quad r = 2\Omega$

$r_2 = 1\Omega$ $\quad r_L = 2\Omega$

FA BCF Applying Kirchhoff's law

$E_2 = -r_2 + r_L(I_0 - 1)$ (mark 01)

$E_2 = r_L I_0 - r_L - r_2$

$E_2 = 2I_0 - 2 - 1$

$E_2 = 2I_0 - 3$ —— (A) (mark 01)

EFCDE Applying Kirchhoff's law

$E - E_2 = rI_0 + 1r_2$ (mark 01)

$12 - E_2 = 2I_0 + 1$

$2I_0 + E_2 = 11$ —— (B) (mark 01)

(B)&(A) $\Rightarrow 2I_0 + 2I_0 - 3 = 11$

$4I_0 = 14$

$I_0 = \frac{14}{4}$

(A) $\Rightarrow E_2 = \cancel{2} \times \frac{14}{\cancel{4}2} - 3$

(Battery y) $\Rightarrow E_2 = 4V$ (Mark 01)

(ii) power generated by the battery charger

$= EI_0$

$= 12 \times \frac{14}{4}$

$= 42\ W$ (Mark 01)

Power disspated in r $= I_0^2 r$

$= \left(\frac{14}{4}\right)^2 \times 2$

$= 24.5W$ (Mark 01)

Power disspated in $r_2$ $= 1^2 \times 1$

$= 1W$ (Mark 01)

Power disspated in $r_L$ $= \left(\frac{10}{4}\right)^2 \times 2$

$= 12.5W$ (Mark 01)

$\boxed{(I_0 - 1) \quad \left(\frac{14}{4} - 1\right) \quad \frac{10}{4} A}$

(iii) total power disspated by the circuit elements

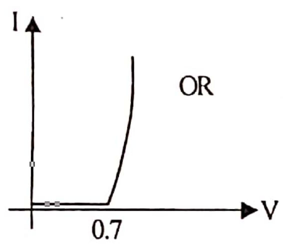
$= 38W$ $\boxed{[12.5 + 1 + 24.5] = 38W}$

Difference between the genarated power and the power dissipated $= [42 - 38]W$

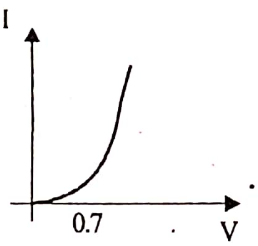
$= 4W$ (Mark 01)

This power is being stored in the battery of e.m.f $E_2$ OR This power is used to do work against the e.m.f of battery of emf $E_2$ (Mark 01)

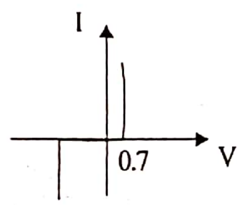
(B) (a)



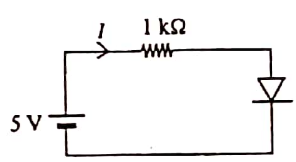

OR




OR




(b)




$V = IR$

$5 = 10^3 I + 0.7$ (Mark 01)

$I = 4.3 \times 10^{-3}A$ / $4.3mA$

(Mark 01)

(c)(i)

| A(v) | B(V) | F(V) |
|---|---|---|
| 0 | 0 | 0.7 |
| 5 | 0 | 0.7 |
| 0 | 5 | 0.7 |
| 5 | 5 | 5 |

(for fully correct column F - Mark 01)

(ii) AND gate (Mark 01)

| A | B | F |
|---|---|---|
| 0 | 0 | 0 |
| 1 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 1 | 1 |

(truth table 01)

(iii) $R_1 = \frac{5-0.7}{0.5 \times 10^{-3}}$ (Mark 01)

$R1 = 8.6k\Omega$ OR $8.6 \times 10^3\Omega$ (Mark 01)

(d) (i) When A = 1&, B = 1 the two diodes do not conduct However j since +5V appears across the series combination of $R_1$ and the base – emitter Junction (B – E Junction) of the transistor, the B – E Junction will become forward biased and therefore the voltage at X will become 0.7V (Mark 01)

$\therefore I_B = \frac{5-0.7}{8.6 \times 10^3}$

$= 0.5 \times 10^{-3}$ A / 0.5 mA (Mark 01)

(ii) $I_B = 0.5$mA, $\beta I_B = 50 \times 0.5$ mA

$= 25 \times 10^{-3}$A OR 25mA (Mark 01)

Maximum value of the collector

current $(Ic)_{max} = \frac{5V}{10^3\Omega}$

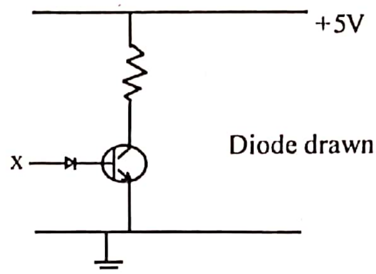
$= 5 \times 10^{-3}$ A OR 5mA

(Mark 01)

$\therefore \beta I_B > I_C$ or the transistor is saturated (Mark 01)

(iii) $V_F = 0.7$V, this voltage is sufficrent to make the base – emitter Junction of the transistor forward biased and therefore the transistor does not operate as open switch. (Mark 01)

(iv) In order to operate the combined errcuit as a NAND gate the transistor should operate as an open switch when A ≠ 1 and /or B ≠ 1. so its output is 1 under such situations.




Diode drawn in the base circuit

(Mark 01)

10. (A) (a) $L_\theta = L_0 [1 + \propto (\theta - \theta_0)]$

Increase in length $\Delta L = L_0 \propto (\theta - \theta_0)$

(Mark 01)

(b) $\Delta L_0 = L_0 \propto (\theta_M - \theta_0)$ (Mark 01)

$\theta_M = \frac{L_0 \propto \theta_0 + \Delta L_0}{L_0 \propto}$ OR $\theta_0 + \frac{\Delta L_0}{L_0 \propto}$ (Mark 01)

(c) (i) The circular section allows the pipe to expand freely increasing its radius

OR

The Circular Section absorbs the expansion

(Mark 01)

(ii) Total length $= L_0 + 2\pi r_0$ (Mark 01)

(iii) $L_H = (L_0 + 2\pi r_0) \times (1 + \propto (\theta_H - \theta_0)]$

(Mark 01)

(iv) Circumference of the circular section

$= L_H - L_0$ OR

$2\pi r_0 [1 + \propto (\theta_H - \theta_0)] + L_0 \propto (\theta_H - \theta_0)$ (Mark 01)

$R_H = \frac{L_H - L_0}{2\pi}$ OR

$R_H = \frac{2\pi r_0 [1 + \propto (\theta_H - \theta_0)] + L_0 \propto (\theta_H - \theta_0)}{2\pi}$

(Mark 01)

(v) Volume of the pipe at $\theta_0$ ; $V_\theta = A_0(L_0 + 2\pi r_0)$

(Mark 01)

Length of the pipe at $\theta_H = L_H$

$\therefore$ Volume of the pipe at $\theta_H$ ; $V_H = A_H L_H$

$= A_0 L_H [1 + 2\propto (\theta_H - \theta_0)]$ (Mark 01)

Increase in volume $\Delta V = V_H - V_\theta$

$\Delta V = A_0 L_H [1 + 2\propto (\theta_H - \theta_0)] - A_0(L_0 + 2\pi r_0)$

OR

$\Delta V = \{A_0[L_0 + 2\pi r_0 [1 + \propto (\theta_H - \theta_0)] + L_0 \propto (\theta_H - \theta_0)] X$

$[1 + 2\propto (\theta_H - \theta_0)]\}$

$- A_0 (L_0 + 2\pi r_0]$ (Mark 01)

(vi) Volume flow rate of oil at $\theta_0 = A_0 \upsilon_0$,

$V_o$ flow speed

Volume flow rate of oil at

$\theta_H = A_H \upsilon_H = A_0\upsilon_H [1 + 2\propto (\theta_H - \theta_0)]$

Using continuty eq (Mark 01)

$A_0\upsilon_0 = A_0\upsilon_0$

$$\frac{\upsilon_H}{\upsilon_0} = \frac{A_0}{A_H} \quad \left(\frac{\text{flow speed of 0.1 at } \theta_H}{\text{How speed of 0.1 at } \theta_0}\right)$$

$$= \frac{1}{1+2\propto(\theta_H - \theta_0)}$$ (Mark 01)

(vii) Mean Temperature at the middle of the pipe

$= (\theta_H - \frac{\Delta\theta}{2})$ OR

Identification of $\frac{\Delta\theta}{2}$ as the correct temperatue (Mark 01)

Mean radius of the circular section

$$= \frac{2\pi r_0 [1 + \propto (\theta_H - \frac{\Delta\theta}{2} - \theta_0)] + L_0 \propto (\theta_H - \frac{\Delta\theta}{2} - \theta_0)}{2\pi}$$

(B) (a) energy equivalence of 1U $= (1.66 \times 10^{-27}) \times (3 \times 10^8)^2$ (Mark 01)

$= 1.494 \times 10^{-10}$J

$= \frac{1.494 \times 10^{-10}}{1.6 \times 10^{-19}}$

$= 933.7$ MeV (Mark 01)

$(933 - 934)$

(b) (i) mass before the reaction

$= 1.0087 + 235.0440 = 236.0527$u

OR after the reaction

$= 95.9343 + 137.9110 + 2 \times 1.0087$u

$= 235.8625$u

Mass los $= 236.0527\text{u} - 235.8625\text{ u}$ (Mark 01)

$= 0.19$u (Mark 01)

(ii) Energy released $= 0.19 \times 934$

$= 177.5$ Mev $(177.2 - 177.5)$ (Mark 01)

(c) (i) Efficiency $= \frac{1000}{3200} \times 100$

$= 31.25\%$ (Mark 01)

(ii) Heat energy produced per second $= 3200 \times 10^6$J

A verge beat energy produced per fission

$= (200) \times (16\ 10^{-13})$ (Mark 01)

$= 3.2 \times 10^{-11}$J

Number of fissions per second $= \frac{3200 \times 10^6}{3.2 \times 10^{-11}}$

$= 10^{20}$ (Mark 01)

(iii) mass of one $^{235}$U atom $= \frac{235}{6.0 \times 10^{23}}$ (Mark 01)

$= 39.2 \times 10^{-23}$ g $= 39.2 \times 10^{-26}$ kg

$^{235}$U consumption rate $= (1 \times 10^{20})(39.2 \times 10^{-26})$ (Mark 01)

$= 3.92 \times 10^{-5}$kgs$^{-1}$

$^{235}$U Consumption per year $= (3.92 \times 10^{-5} \times 3600 \times 24 \times 365)$

$= 1.24 \times 10^3$ kgyr$^{-1}$ $(1.235 \times 10^3$ kgyr$^{-1})$ (Mark 01)

(d) 2% enriched uranium fuel required

$= \frac{(1.24 \times 10^3)}{2\%}$

$= 62000$kgyr$^{-1}$ (Mark 01)

(61150kgyr$^{-1}$)

(e) Energy produced by burning one atom of carbon

$= 4$eV

$= 4 \times 1.6 \times 10^{-19}$

$= 6.4 \times 10^{-19}$J

Carbon Consumption rate $= \frac{3200 \times 10^6}{6.4 \times 10^{-19}}$ (Mark 01)

$= 5 \times 10^{27}$ atoms s$^{-1}$

Mass of one carbon atom $= \frac{12}{6 \times 10^{23}}$

$= 2 \times 10^{-23}$g,

$= 2 \times 10^{-26}$kg

Carbon Consumption per year

$= 5 \times 10^{27} (2 \times 10^{-26} \times (3600 \times 24 \times 365)$

$= 3.2 \times 10^9$kgyr$^{-1}$ (Mark 01)