2.1.2. Paper I

1. Electron volt (eV) is a unit of
   (1) charge. (2) potential. (3) capacitance.
   (4) energy. (5) electric field intensity.

2. 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

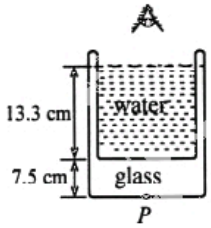
	A	B	C
(1)	Vernier calliper	Vernier calliper	Micrometer screw gauge
(2)	Metre ruler	Metre ruler	Vernier calliper
(3)	Metre ruler	Micrometer screw gauge	Travelling microscope
(4)	Metre ruler	Vernier calliper	Micrometer screw gauge
(5)	Vernier calliper	Metre ruler	Travelling microscope

3. Radii of capillary tubes of two mercury-in-glass thermometers A and B having equal volumes of mercury inside their bulbs are r and $\frac{r}{3}$ 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) $\frac{1}{9}$ (2) $\frac{1}{3}$ (3) 1 (4) 3 (5) 9

4. By what factor does the sound intensity increase if the sound intensity level increases by 1dB?
   (1) 1 (2) $10^{0.1}$ (3) 10^{1} (4) 10^{10} (5) 10^{12}

5. Consider the following statements made regarding 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.

6. A cylindrical glass vessel with a 7.5 cm 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 cm



7. 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

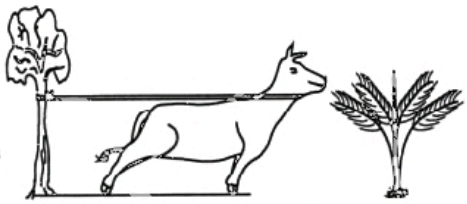
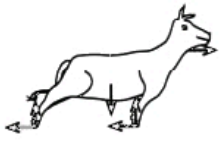
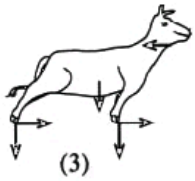


Figure (a)


(1)

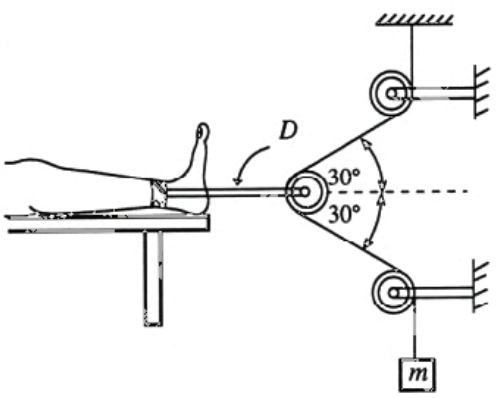

(2)


(3)


(4)


(5)

8. 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 $\left(\cos 30° = \frac{\sqrt{3}}{2}\right)$



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

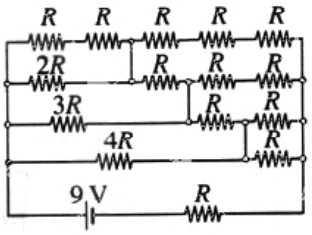
(3) $\frac{8}{\sqrt{3}}$ kg (4) 8 kg

(5) $8\sqrt{2}$ kg

9. 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 ε_0 as 9×10^{-12} F m^{-1})

(1) 1 cm^2 (2) 100 cm^2 (3) 1 000 m^2 (4) 100 km^2 (5) 1 000 km^2

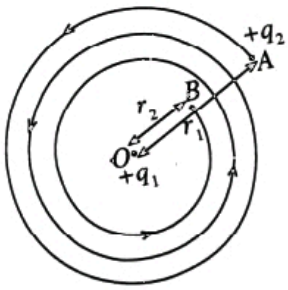
10. Current (in Amperes) drawn from the battery in the given circuit is



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

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

(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

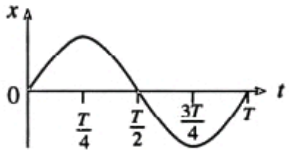
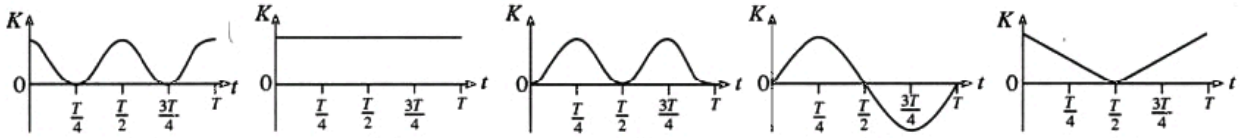


Figure (a)

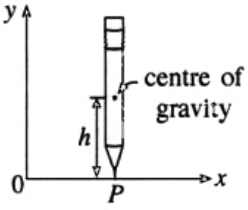


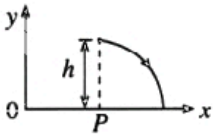
(1) (2) (3) (4) (5)

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

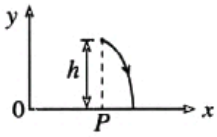
(1) simple harmonic with a period of 1.2 s.
(2) not simple harmonic but periodic with a period of 0.6 s.
(3) not simple harmonic but periodic with a period of 1.2 s.
(4) simple harmonic with a period of 0.6 s.
(5) simple harmonic with a period of 2.4 s.

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.

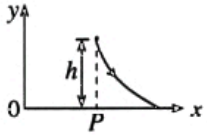




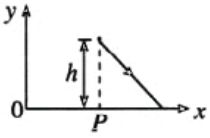
(1)



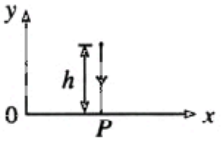
(2)



(3)



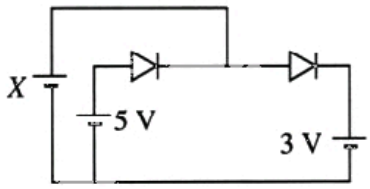
(4)



(5)

15. In the circuit shown, each of the rectifier diodes requires a voltage of 1 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) 1 V (2) 2 V (3) 3 V
(4) 4 V (5) 5 V



16. A, B and C are three metals with threshold wavelengths λ_A = 0.30 μm, λ_B = 0.28 μm and λ_C = 0.20 μm respectively for photoelectric emission. Photons of frequency 1.2×10^{15} Hz are incident on each of the metals. Photoelectrons are emitted (The speed of light in vacuum is 3×10^8 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

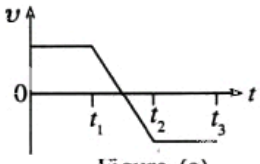
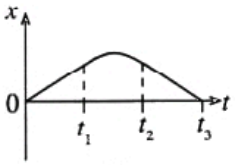
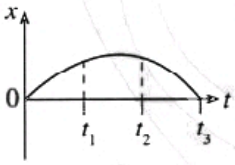


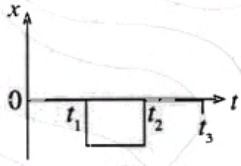
Figure (a)



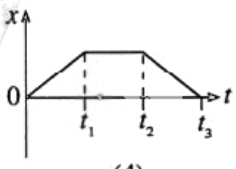
(1)



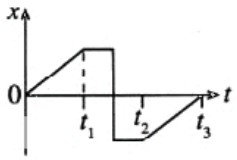
(2)



(3)



(4)



(5)

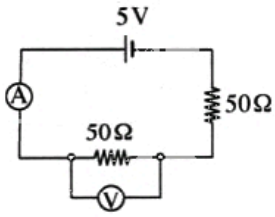
18. When a small object is placed 30 cm in front of a thin lens L_1 of focal length 10 cm, an image is formed behind the lens. When another thin lens L_2 is placed in contact with L_1, the image is formed at infinity. L_2 is a

(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 2 V–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.)



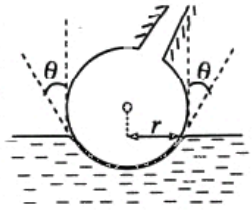
(1) 0 A, 0 V (2) 0 A, 5 V (3) 0 A, 2.5 V
(4) 0.1 A, 0 V (5) 0.05 A, 2.5 V

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 $Y_1, Y_2, Y_3, \ldots, Y_n$.
The equivalent Young's modulus of the composite rod is given by

(1) $\frac{Y_1 + Y_2 + Y_3 + \cdots + Y_n}{n}$ (2) $\left(Y_1 + Y_2 + Y_3 + \ldots + Y_n\right) n$

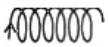
(3) $\frac{1}{\frac{1}{Y_1} + \frac{1}{Y_2} + \frac{1}{Y_3} + \cdots + \frac{1}{Y_n}}$ (4) $\frac{n}{\frac{1}{Y_1} + \frac{1}{Y_2} + \frac{1}{Y_3} + \cdots + \frac{1}{Y_n}}$ (5) $\left(Y_1 Y_2 Y_3 \cdots Y_n\right)^{\frac{1}{n}}$

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 5.0×10^{-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.)

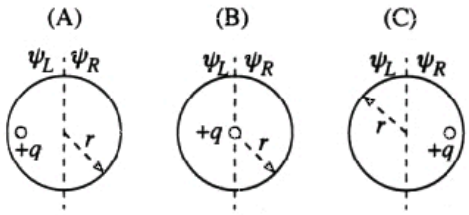


(1) 0.1 (2) 0.2 (3) 0.4 (4) 0.6 (5) 0.8

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 ψ_L and ψ_R are the electric fluxes through the left and right hemispherical sections of the Gaussian surface respectively, which of the following is true regarding ψ_L and ψ_R?



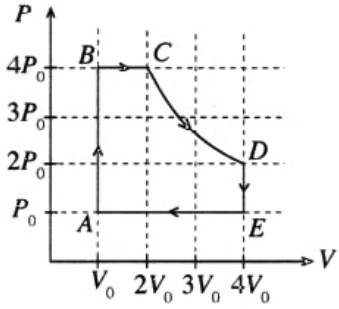
	(A)	(B)	(C)
(1)	$\psi_L = \psi_R = \frac{q}{2\varepsilon_0}$	$\psi_L = \psi_R = \frac{q}{2\varepsilon_0}$	$\psi_L = \psi_R = \frac{q}{2\varepsilon_0}$
(2)	$\psi_L > \frac{q}{2\varepsilon_0} > \psi_R$	$\psi_L = \psi_R = \frac{q}{2\varepsilon_0}$	$\psi_L < \frac{q}{2\varepsilon_0} < \psi_R$
(3)	$\psi_L > \frac{q}{\varepsilon_0} > \psi_R$	$\psi_L = \psi_R = \frac{q}{\varepsilon_0}$	$\psi_L < \frac{q}{\varepsilon_0} < \psi_R$
(4)	$\psi_L = \psi_R = \frac{q}{\varepsilon_0}$	$\psi_L = \psi_R = \frac{q}{\varepsilon_0}$	$\psi_L = \psi_R = \frac{q}{\varepsilon_0}$
(5)	$\psi_L < \frac{q}{2\varepsilon_0} < \psi_R$	$\psi_L = \psi_R = \frac{q}{2\varepsilon_0}$	$\psi_L > \frac{q}{2\varepsilon_0} > \psi_R$

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) $T_D = T_C > T_B > T_A = T_E$

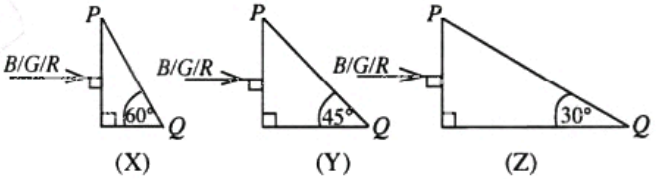
27. Figure shows a part of an outdoor brick-structure with a cubical-shrine (X) carved in as shown. The shrine is lime plastered and the front is sealed with a sheet of glass. It has been seen very often that water vapour condenses on the inner surface of the glass sheet, and it is found to happen mostly 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 m s^{-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) 1 500 N (4) 1 800 N (5) 3 000 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°, 44° and 46° respectively. When viewed through the faces PQ, only red colour can be seen in



(X) (Y) (Z)

(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 4×10^{11} N m^{-2} is subjected to a tension of 30 N. The magnitude of the ratio $\frac{v_L}{v_T}$ of the longitudinal wave velocity (v_L) to transverse wave velocity (v_T) along the wire is (Take π to be 3.)

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

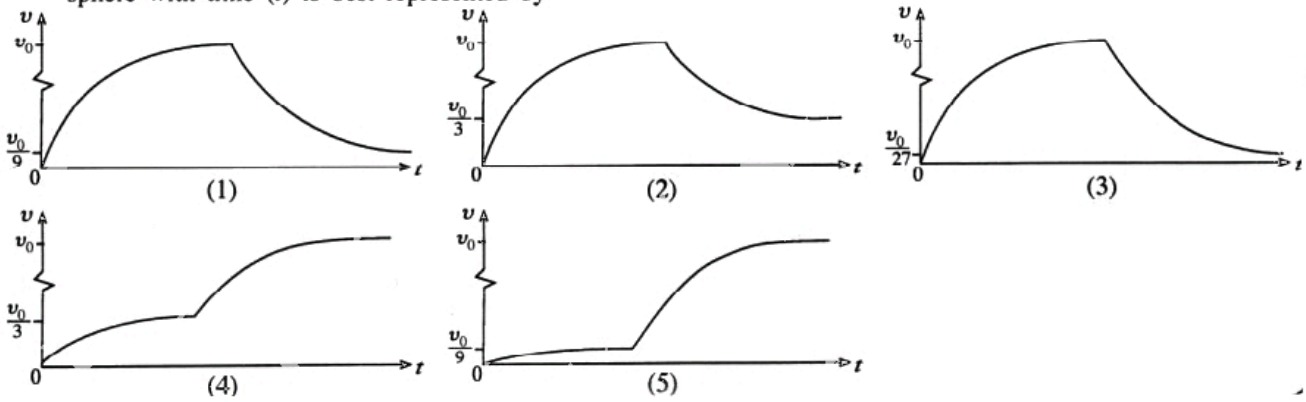
31. The following table shows the binding energies of some nuclei.

Nucleus	$^4_2$He	$^{20}_{10}$Ne	$^{40}_{20}$Ca	$^{60}_{28}$Ni	$^{238}_{92}$U
Binding energy (MeV)	28.3	160.6	342.1	526.8	1802.0

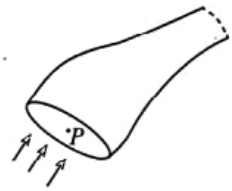
Which one of the above nuclei is the most stable nucleus?

(1) $^4_2$He (2) $^{20}_{10}$Ne (3) $^{40}_{20}$Ca (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 v_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 following 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 (α) of a wheel of a motor vehicle starting from rest with time (t) is shown in figure (a). Variation of the angular velocity (ω) of the wheel with time (t) is best represented by

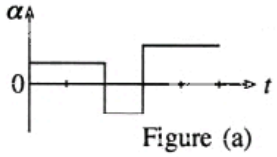
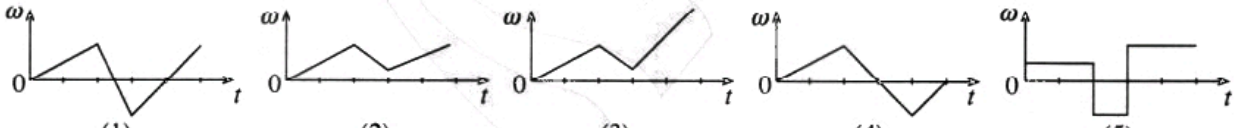
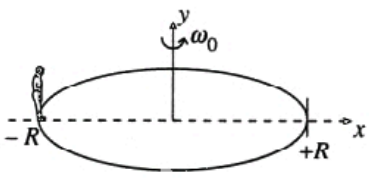
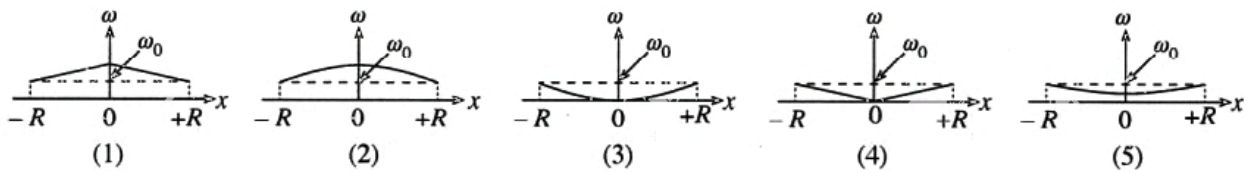


Figure (a)

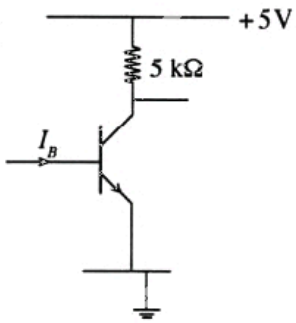


35. A child is standing at $x = -R$ of a horizontal merry-go-round of radius R in a carnival as shown in the figure. x–y is a coordinate system fixed to the merry-go-round with its y-axis along the axis of rotation. Using a driving motor, the merry-go-round is set in rotational motion with constant angular velocity ω_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 (ω) of the merry-go-round with position (x) of the child is best represented by



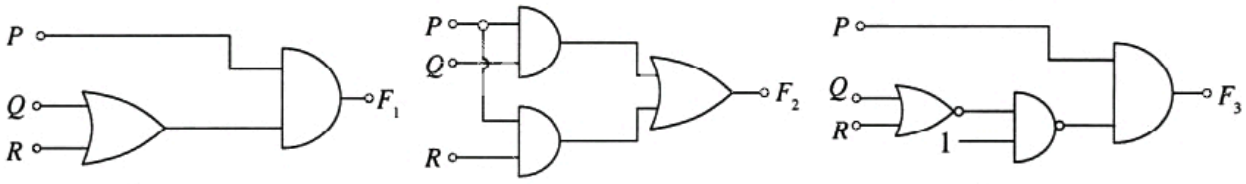


36. In the circuit shown, the current gain of the transistor is 100. When different I_B values are applied to the base, which of the following is true regarding the mode of operation of the transistor?



	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).

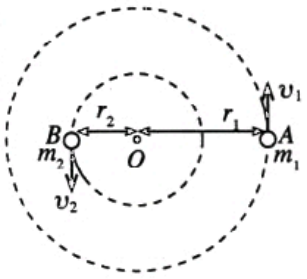


(A) (B) (C)

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 B and 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.

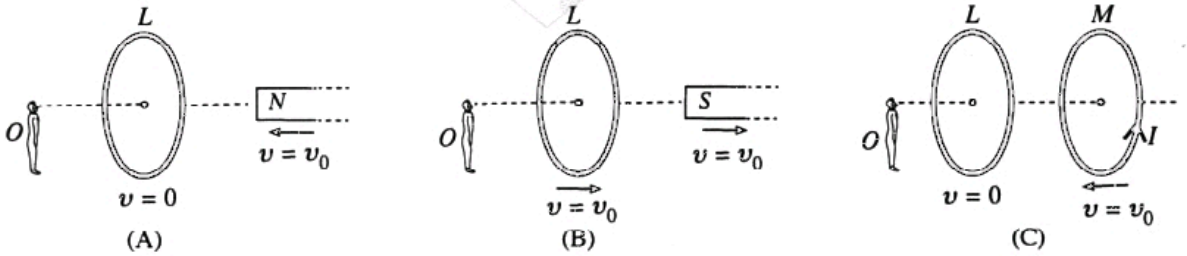
38. Two stars A and B of masses m_1 and m_2 respectively are in circular motions due to their mutual gravitational attraction, about the point O for which $m_1r_1 = m_2r_2$ so that AOB is always co-linear as shown in the figure. If the speeds of m_1 and m_2 are v_1 and v_2 respectively, the ratio $\frac{v_1}{v_2}$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



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

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

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



(A) (B) (C)

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?

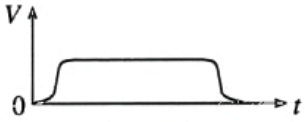


Figure (a)

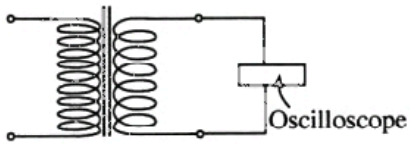
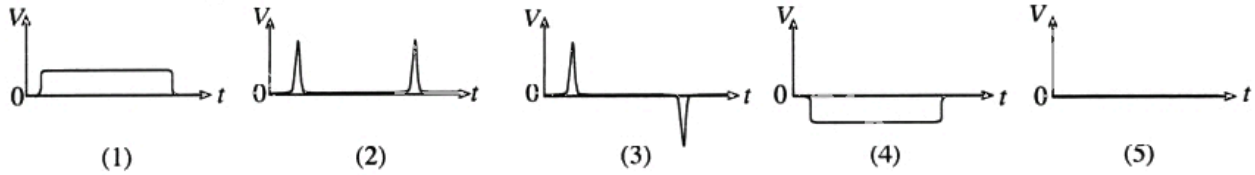


Figure (b)



(1) (2) (3) (4) (5)

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

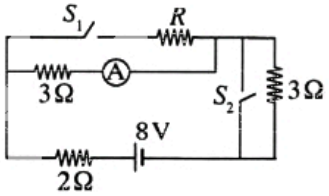
(1) $u_A u_B \sqrt{\dfrac{V_A + V_B}{V_A u_A^2 + V_B u_B^2}}$ (2) $u_A u_B \sqrt{\dfrac{V_A + V_B}{V_A u_B^2 + V_B u_A^2}}$ (3) $\sqrt{\dfrac{V_A u_A^2 + V_B u_B^2}{V_A + V_B}}$

(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 5 s^{-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

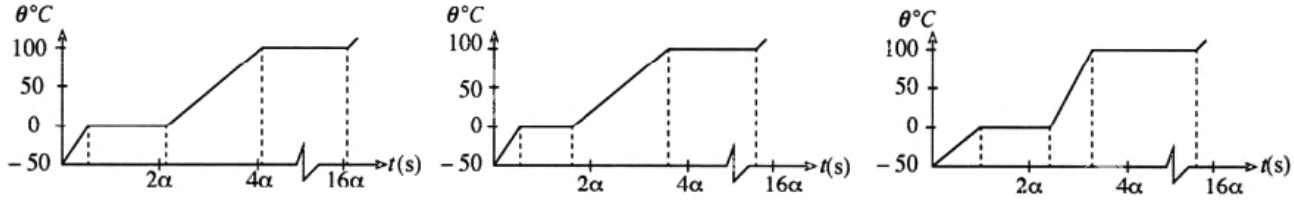


(1) 1 Ω (2) 2 Ω (3) 3 Ω
(4) 4 Ω (5) 6 Ω

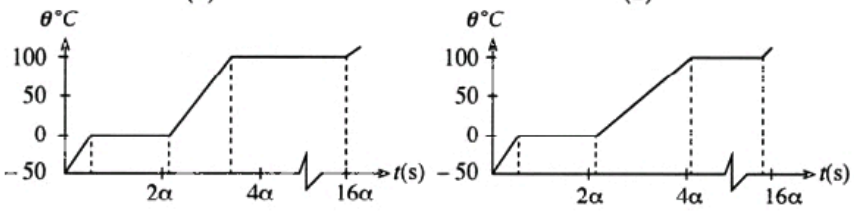
44. A piece of ice of mass 0.1 kg at –50 °C is heated uniformly by providing heat energy at a constant rate of 10 W. If the specific heat capacity of ice is α, in SI units, the values of the other relevant quantities in terms of α can be given approximately as follows.

Specific heat capacity of water = 2α
Latent heat of fusion of ice = 160α
Latent heat of vaporization of water = $1\,200\alpha$

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

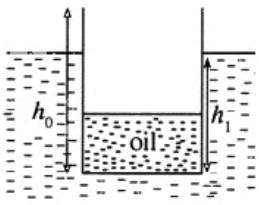


(1) (2) (3)



(4) (5)

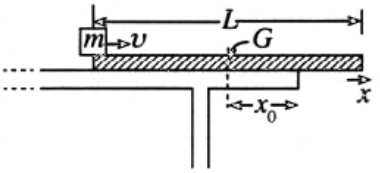
45. A vessel of uniform rectangular cross-section with height h_0 and mass M contains a certain amount of oil having mass m and density ρ_{oil} as shown in the figure. The vessel floats vertically in water of density ρ_ω ($> \rho_{oil}$) with height h_1 under water. A certain volume of oil is now replaced 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) $\frac{(h_0 - h_1)(M + m)\rho_{oil}}{h_1 m(\rho_\omega - \rho_{oil})}$ (2) $\frac{h_0(M - m)\rho_{oil}}{h_1 m(\rho_\omega - \rho_{oil})}$ (3) $\frac{h_1}{h_o} \cdot \frac{\rho_\omega}{\rho_{oil}}$

(4) $\frac{(h_0 - h_1)(M - m)\rho_{oil}}{h_0 m(\rho_\omega + \rho_{oil})}$ (5) $\frac{h_0(M + m)\rho_{oil}}{M(h_0 + h_1)(\rho_\omega + \rho_{oil})}$

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 v is given to it along the strip in the x direction. If the coefficient of kinetic friction between the strip and the block is μ, the minimum speed that can be given to the block to topple the strip is



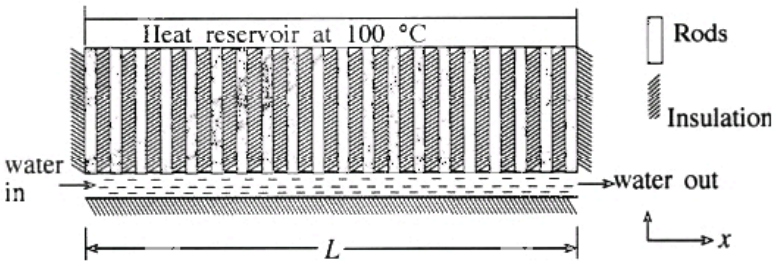
(1) $\sqrt{2\mu g\left(x_0 + \frac{L}{2} + \frac{Mx_0}{m}\right)}$ (2) $\sqrt{\mu g\left(\frac{L}{4} + \frac{Mx_0}{m}\right)}$

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

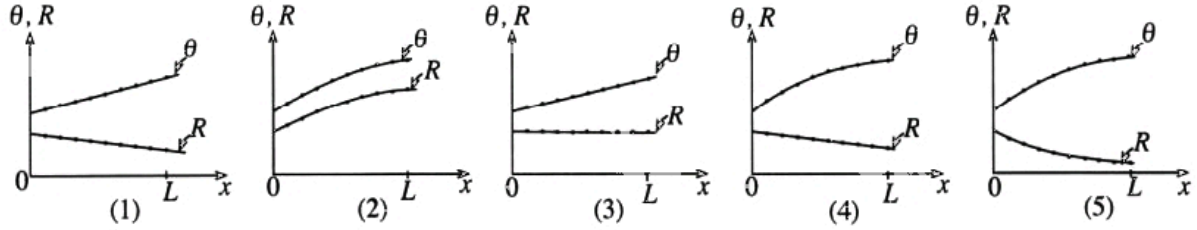
47. During a Tsunami warning, a stationary siren emits sound waves of frequency 1 600 Hz while a wind is blowing at a uniform speed of 60 m s^{-1} from the shore towards the land. A person hearing the sound of the siren is driving his car away from the shore towards the land at 30 m s^{-1}. If the wind 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) 1 400 Hz (2) 1 480 Hz (3) 1 600 Hz (4) 1 740 Hz (5) 1 880 Hz

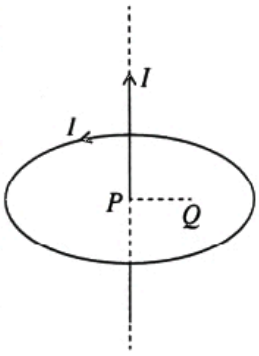
48. Water flows at a uniform rate through a tube of length L, which is made of an insulating material. A large number of identical, uniform and insulated metal rods which are equally spaced as shown in the figure is connected between the tube and a large heat reservoir maintained at 100 °C to transfer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

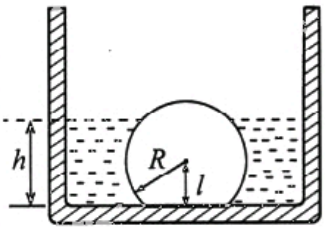
(B) When the current carrying straight wire is moved to point Q parallel to the axis of the loop, there is a net torque on the loop due to the current carrying straight wire.

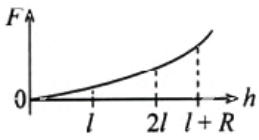
(C) When the current carrying straight wire is moved to point Q parallel to the axis of the loop, the net force on the loop due to the current carrying straight wire is not zero.

Of the above statements,

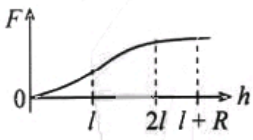
(1) only A is true.
(2) only B is true.
(3) only C is true.
(4) only A and B are true.
(5) all A, B and C are true.

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

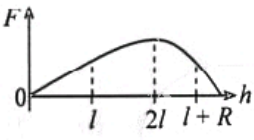




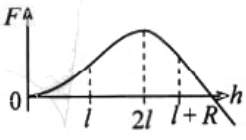
(1)



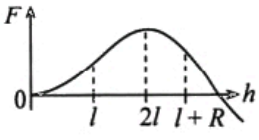
(2)



(3)



(4)



(5)