

# SOLUTIONS To AIEEE, 2008

## PART C – PHYSICS

71. A body of mass  $m = 3.513 \text{ kg}$  is moving along the  $x$ -axis with a speed of  $5.00 \text{ ms}^{-1}$ . The magnitude of its momentum is record as

- (1)  $17.565 \text{ kg ms}^{-1}$       (2)  $17.56 \text{ kg ms}^{-1}$   
 (3)  $17.57 \text{ kg ms}^{-1}$       (4)  $17.6 \text{ kg ms}^{-1}$

71. (4)

Significant figure in answer should be 3.

72. Consider a uniform square plate of side ‘ $a$ ’ and mass ‘ $m$ ’. The moment of inertia of this plate about an axis perpendicular to its plane and passing through one of its corners is

- (1)  $\frac{1}{12} ma^2$       (2)  $\frac{7}{12} ma^2$   
 (3)  $\frac{2}{3} ma^2$       (4)  $\frac{5}{6} ma^2$

72. (3)

$$I_g = 1/6 ma^2$$

From parallel axis theorem

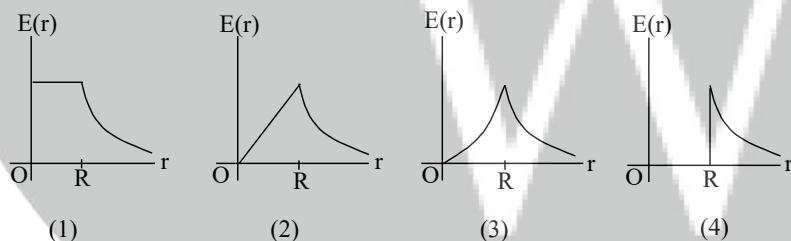
$$I = I_g + Md^2 = \frac{1}{6} Ma^2 + M\left(\frac{a\sqrt{2}}{2}\right)^2 = \left(\frac{1}{6} + \frac{1}{2}\right)ma^2 = \frac{2}{3}ma^2$$

73. The speed of sound in oxygen ( $O_2$ ) at a certain temperature is  $460 \text{ ms}^{-1}$ . The speed of sound in helium ( $He$ ) at the same temperature will be (assume both gases to be ideal)

- (1)  $500 \text{ ms}^{-1}$       (2)  $650 \text{ ms}^{-1}$   
 (3)  $330 \text{ ms}^{-1}$       (4)  $460 \text{ ms}^{-1}$

73. No option is correct. Answer must be 1421 meter per second.

74. A thin spherical shell of radius  $R$  has charge  $Q$  spread uniformly over its surface. Which of the following graphs most closely represents the electric field  $E(r)$  produced by the shell in the range  $0 \leq r < \infty$ , where  $r$  is the distance from the centre of shell?



74. (4)

$$\begin{aligned} E &= 0 & (0 \leq r < R) \\ E &= \frac{kQ}{r^2} & (R \leq r) \end{aligned}$$

75. Relative permitivity and permeability of a material are  $\epsilon_r$  and  $\mu_r$ , respectively. Which of the following values of these quantities are allowed for a diamagnetic material?

- (1)  $\epsilon_r = 1.5, \mu_r = 0.5$       (2)  $\epsilon_r = 0.5, \mu_r = 0.5$   
 (3)  $\epsilon_r = 1.5, \mu_r = 1.5$       (4)  $\epsilon_r = 0.5, \mu_r = 1.5$

75. (1)

76. Suppose an electron is attracted towards the origin by a force  $\frac{k}{r}$  where ‘ $k$ ’ is a constant and ‘ $r$ ’ is the distance of the electron from the origin. By applying Bohr model to this system, the radius of

the  $n$ th orbital of the electron is found to be ' $r_n$ ' and the kinetic energy of the electron to be ' $T_n$ '. Then which of the following is true?

- (1)  $T_n$  independent of  $n$ ,  $r_n \propto n$       (2)  $T_n \propto \frac{1}{n}$ ,  $r_n \propto n$   
 (3)  $T_n \propto \frac{1}{n}$ ,  $r_n \propto n^2$       (4)  $T_n \propto \frac{1}{n^2}$ ,  $r_n \propto n^2$

76. (1)

By Bohr's Postulate

$$\frac{mv^2}{r} = \frac{k}{r} \quad (1)$$

$$mvr = \frac{nh}{2\pi} \quad (2)$$

77. A block of mass 0.50 kg is moving with a speed of  $2.00 \text{ ms}^{-1}$  on a smooth surface. It strikes another mass of 1.00 kg and then they move together as a single body. The energy loss during the collision is

- (1) 1.00 J      (2) 0.67 J  
 (3) 0.34 J      (4) 0.16 J

77. (2)

$$\text{Loss in K.E.} = \frac{1}{2} \left( \frac{m_1 \times m_2}{m_1 + m_2} \right) (V_1 - V_2)^2 = \frac{1}{2} \times \frac{0.5 \times 1}{(1.5)} (2 - 0)^2 = 0.67 \text{ Joule}$$

78. A wave travelling along the  $x$ -axis is described by the equation  $y(x, t) = 0.005 \cos(\alpha x - \beta t)$ . If the wavelength and the time period of the wave are 0.08 m and 2.0 s, respectively, then  $\alpha$  and  $\beta$  in appropriate units are

- (1)  $\alpha = \frac{0.08}{\pi}$ ,  $\beta = \frac{2.0}{\pi}$       (2)  $\alpha = \frac{0.04}{\pi}$ ,  $\beta = \frac{1.0}{\pi}$   
 (3)  $\alpha = 12.50 \pi$ ,  $\beta = \frac{\pi}{2.0}$       (4)  $\alpha = 25.00 \pi$ ,  $\beta = \pi$

78. (4)

Standard Equation :

$$y = A \cos(kx - \omega t)$$

Comparing gives the required result.

79. A working transistor with its three legs marked P, Q and R is tested using a multimeter. No conduction is found between P and Q. By connecting the common (negative) terminal of the multimeter of R and the other (positive) terminal to P or Q, some resistance is seen on the multimeter. Which of the following is true for the transistor?

- (1) It is a pnp transistor with R as collector      (2) It is a pnp transistor with R as emitter  
 (3) It is an npn transistor with R as collector      (4) It is an npn transistor with R as base

79. (2)

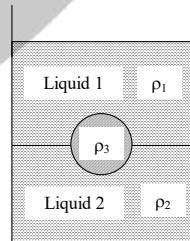
80. A jar is filled with two non-mixing liquids 1 and 2 having densities  $\rho_1$  and  $\rho_2$ , respectively. A solid ball, made of a material of density  $\rho_3$ , is dropped in the jar. It comes to equilibrium in the position shown in the figure.

Which of the following is true for  $\rho_1$ ,  $\rho_2$  and  $\rho_3$ ?

- (1)  $\rho_1 > \rho_3 > \rho_2$       (2)  $\rho_1 < \rho_2 < \rho_3$   
 (3)  $\rho_1 < \rho_3 < \rho_2$       (4)  $\rho_3 < \rho_1 < \rho_2$

80. (3)

$$V \times \rho_3 \times g = V/2 \times \rho_1 \times g + V/2 \times \rho_2 \times g$$



$$\Rightarrow \rho_3 = \frac{\rho_1 + \rho_2}{2}$$

$\rho_2 > \rho_1$  since liquid (2) is below liquid (1)

81. An athlete in the olympic games covers distance of 100 m in 10s. His kinetic energy can be estimated to be in range

- (1)  $2 \times 10^5 \text{ J} — 3 \times 10^5 \text{ J}$  (2)  $20,000 \text{ J} — 50,000 \text{ J}$   
 (3)  $2,000 \text{ J} — 5,000 \text{ J}$  (4)  $200 \text{ J} — 500 \text{ J}$

81. (3)

82. A parallel plate capacitor with air between the plates has a capacitance of 9 pF. The separation between its plates is ‘d’. The space between the plates is now filled with two dielectrics. One of the dielectrics has dielectric constant  $\kappa_1 = 3$  and thickness  $\frac{d}{3}$  while the other one has dielectric constant

$\kappa_2 = 6$  and thickness  $\frac{2d}{3}$ . Capacitance of the capacitor is now

- (1) 45 pF (2) 40.5 pF  
 (3) 20.25 pF (4) 1.8 pF

82. (2)

$$C_0 = \frac{A\epsilon_0}{d} = 9 \text{ pF}$$

$$C_1 = \frac{A\epsilon_0 \times \kappa_1}{d/3} = \frac{A\epsilon_0}{d} \times 9 = 81 \text{ pF}$$

$$C_2 = \frac{A\epsilon_0 \times \kappa_2}{2d/3} = \frac{A\epsilon_0}{d} \times 9 = 81 \text{ pF}$$

Since  $C_1$  and  $C_2$  are in series

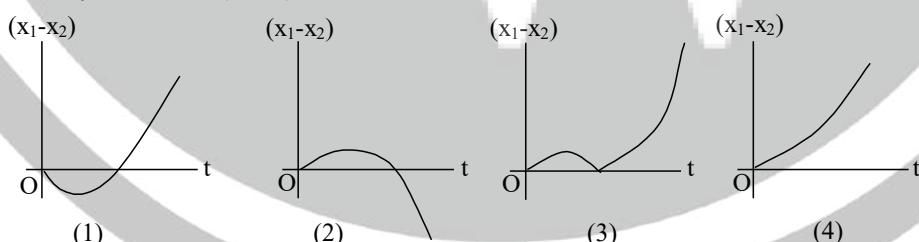
$$C_{eq} = \frac{C_1 \times C_2}{C_1 + C_2} = 40.5 \text{ pF}$$

83. The dimension of magnetic field in M, L, T and C (Coulomb) is given as

- (1)  $MT^2C^{-2}$  (2)  $MT^{-1}C^{-1}$   
 (3)  $MT^{-2}C^{-1}$  (4)  $MLT^{-1}C^{-1}$

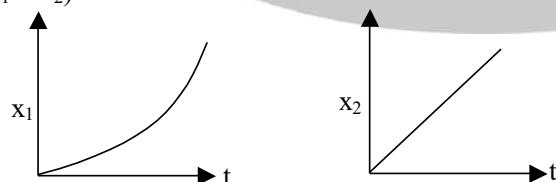
83. (2)

84. A body is at rest at  $x = 0$ . At  $t=0$ , it starts moving in the positive x-direction with a constant acceleration. At the same instant another body passes through  $x = 0$  moving in the positive x-direction with a constant speed. The position of the first body is given by  $x_1(t)$  after time ‘t’ and that of the second body by  $x_2(t)$  after the same time interval. Which of the following graphs correctly describes  $(x_1 - x_2)$  as a function of time ‘t’?

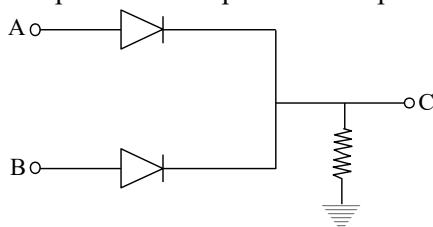


84. (1)

$$(x_1 - x_2) = \frac{1}{2}at^2 - v \times t$$



- 85.** In the circuit below, A and B represent two inputs and C represents the output.



The circuit represents



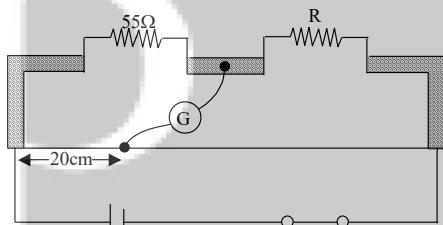
85.

86. While measuring the speed of sound by performing a resonance column experiment, a student gets the first resonance condition at a column length of 18 cm during winter. Repeating the same experiment during summer, she measures the column length to be  $x$  cm for the second resonance. Then

- (1)  $x > 54$       (2)  $54 < x > 36$   
 (3)  $36 > x > 18$       (4)  $18 > x$

86.

87. Shown in the figure below is a meter-bridge set up with null deflection in the galvanometer.



The value of the unknown resistor R is

- The value of the unknown resistor  $R$  is  
 (1)  $220\ \Omega$       (2)  $110\ \Omega$   
 (3)  $55\ \Omega$       (4)  $13.75\ \Omega$

- 87

(1) In balance condition

$$\frac{55}{20} = \frac{R}{80}$$

$$\Rightarrow R = 220 \Omega$$

- 88.** A spherical solid ball of volume  $V$  is made of a material of density  $\rho_1$ . It is falling through a liquid of density  $\rho_2$  ( $\rho_2 < \rho_1$ ). Assume that the liquid applies a viscous force on the ball that is proportional to the square of its speed  $v$ , i.e.,  $F_{\text{viscous}} = -kv^2$  ( $k > 0$ ). The terminal speed of the ball is

- |   |  |
|---|--|
| $(1) \quad \frac{Vg\rho_1}{k}$            | $(2) \quad \sqrt{\frac{Vg\rho_1}{k}}$            |
| $(3) \quad \frac{Vg(\rho_1 - \rho_2)}{k}$ | $(4) \quad \sqrt{\frac{Vg(\rho_1 - \rho_2)}{k}}$ |

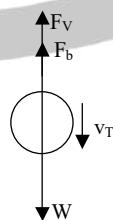
88.

(4) At terminal velocity

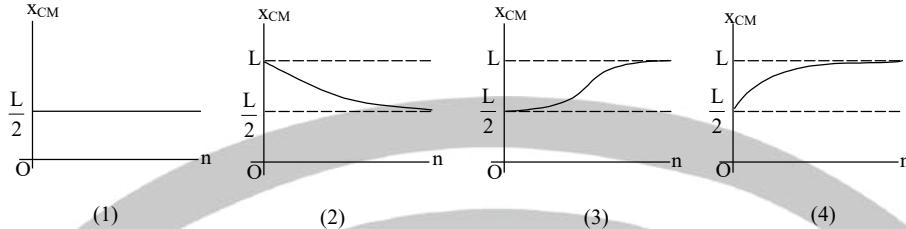
$$W \equiv F_V + F_b$$

$$V \times \rho_1 \times g = V \times \rho_2 g + k V^2_T$$

$$\Rightarrow V_T = \sqrt{\frac{Vg(\rho_1 - \rho_2)}{k}}$$



89. A thin rod of length 'L' is lying along the x-axis with its ends at  $x = 0$  and  $x = L$ . Its linear density (mass/length) varies with  $x$  as  $k\left(\frac{x}{L}\right)^n$ , where  $n$  can be zero or any positive number. If the position  $x_{CM}$  of the centre of mass of the rod is plotted against 'n', which of the following graphs best approximates the dependence of  $x_{CM}$  on  $n$ ?



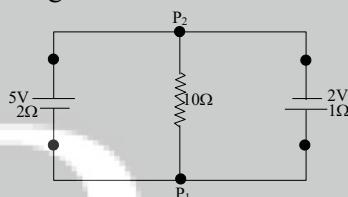
- (1) (4)  
 90. (2) A planet in a distant solar system is 10 times more massive than the earth and its radius is 10 times smaller. Given that the escape velocity from the earth is  $11 \text{ km s}^{-1}$ , the escape velocity from the surface of the planet would be  
 (1)  $11 \text{ km s}^{-1}$  (2)  $110 \text{ km s}^{-1}$   
 (3)  $0.11 \text{ km s}^{-1}$  (4)  $1.1 \text{ km s}^{-1}$
90. (2)  
 91. (4) An insulate container gas has two chambers separated by an insulating partition. One of the chambers has volume  $V_1$  and contains ideal gas at pressure  $P_1$  and temperature  $T_1$ . The other chamber has volume  $V_2$  and contains ideal gas at pressure  $P_2$  and temperature  $T_2$ . If the partition is removed without doing any work on the gas, the final equilibrium temperature of the gas in the container will be  
 (1)  $\frac{P_1 V_1 T_1 + P_2 V_2 T_2}{P_1 V_1 + P_2 V_2}$  (2)  $\frac{P_1 V_1 T_2 + P_2 V_2 T_1}{P_1 V_1 + P_2 V_2}$   
 (3)  $\frac{P_1 T_2 (P_1 V_1 + P_2 V_2)}{P_1 V_1 T_1 + P_2 V_2 T_2}$  (4)  $\frac{T_1 T_2 (P_1 V_1 + P_2 V_2)}{P_1 V_1 T_2 + P_2 V_2 T_1}$
91. (4)  

$$n_1 + n_2 = n_T \quad (1)$$

$$\frac{P_1 V_1}{R T_1} + \frac{P_2 V_2}{R T_2} = n_T$$
 From conservation of energy
 
$$f \times \left( \frac{1}{2} k T_1 \right) \times n_1 \times N_0 + f \times \frac{1}{2} k T_2 \times n_2 \times N_0 = \frac{1}{2} k \times T n_T \times N_0$$

$$\Rightarrow T = \frac{T_1 T_2 (P_1 V_1 + P_2 V_2)}{(P_1 V_1 T_2 + P_2 V_2 T_1)}$$
92. Two full turns of the circular scale of a screw gauge cover a distance of 1 mm on its main scale. The total number of divisions on the circular scale is 50. Further, its is found that the screw gauge has a zero error of  $-0.03 \text{ mm}$ . While measuring the diameter of a thin wire, a student notes the main scale reading of 3 mm and the number of circular scale divisions in line with the main scale as 35. The diameter of the wire is  
 (1)  $3.73 \text{ mm}$  (2)  $3.67 \text{ mm}$   
 (3)  $3.38 \text{ mm}$  (4)  $3.32 \text{ mm}$
92. (3)

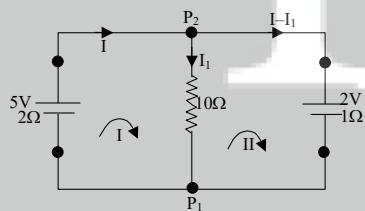
93. A horizontal overhead powerline is at a height of 4 m from the ground and carries a current of 100 A from east to west. The magnetic field directly below it on the ground is ( $\mu_0 = 4\pi \times 10^{-7} \text{ T m A}^{-1}$ )  
 (1)  $5 \times 10^{-6} \text{ T}$  northward      (2)  $5 \times 10^{-6} \text{ T}$  southward  
 (3)  $2.5 \times 10^{-7} \text{ T}$  northward      (4)  $2.5 \times 10^{-7} \text{ T}$  southward
93. (2)
94. An experiment is performed to find the refractive index of glass using a travelling microscope. In this experiment distances are measured by  
 (1) a standard laboratory scale  
 (2) a meter scale provided on the microscope  
 (3) a screw gauge provided on the microscope  
 (4) a vernier scale provided on the microscope
94. (4)
95. A 5V battery with internal resistance  $2\Omega$  and a 2V batter with internal resistance  $1\Omega$  are connected to a  $10\Omega$  resistor as shown in the figure



The current in the  $10\Omega$  resistor is

- (1) 0.03 A P<sub>1</sub> to P<sub>2</sub>      (2) 0.03 A P<sub>2</sub> to P<sub>1</sub>  
 (3) 0.27 A P<sub>1</sub> to P<sub>2</sub>      (4) 0.27 A P<sub>2</sub> to P<sub>1</sub>

95. (2)



For loop I ↗

$$-10I_1 - 2I + 5 = 0$$

For loop II ↗

$$+2 - (I - I_1) \times 1 + 10 \times I_1 = 0$$

After solving (I) and (II) we get

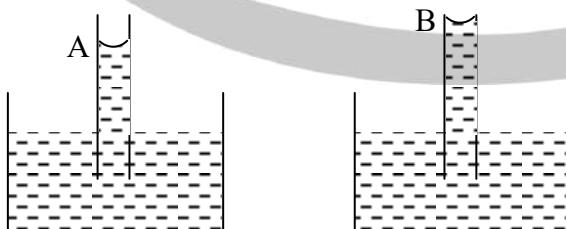
$$I_1 = 0.03 \text{ A } P_2 \text{ to } P_1$$

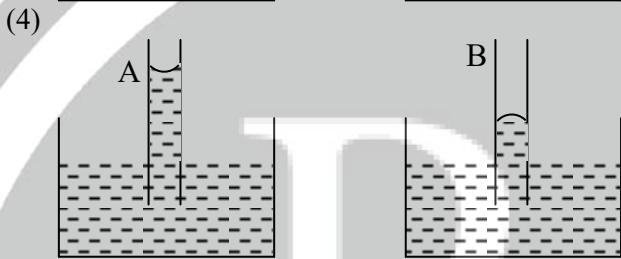
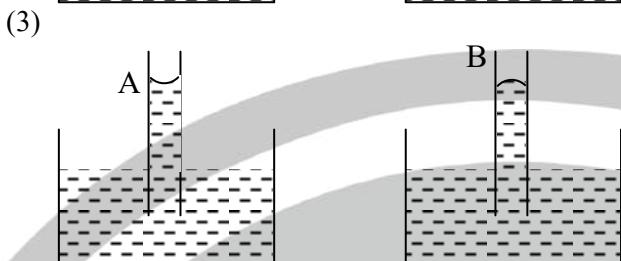
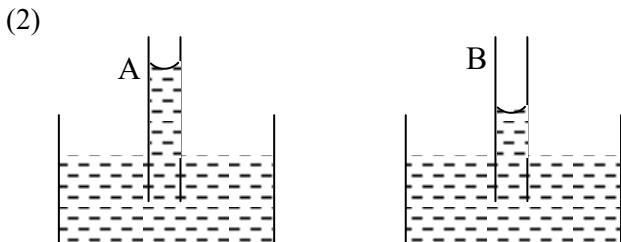
(I)

(II)

96. A capillary tube (A) is dipped in water. Another identical tube (B) is dipped in a soap-water solution. Which of the following shows the relative nature of the liquid columns in the two tubes

- (1)





96.

(2)

For soap water surface tension is less, hence rise of liquid in tube will be less with respect to the water.

97.

Two coaxial solenoid are made by winding thin insulated wire over a pipe of cross-sectional area  $A = 10 \text{ cm}^2$  and length = 20 cm. If one of the solenoids has 300 turns and the other 400 turns, their mutual inductance is

$$(\mu_0 = 4\pi \times 10^{-7} \text{ T mA}^{-1})$$

(1)  $4.8\pi \times 10^{-7} \text{ H}$

(3)  $2.4\pi \times 10^{-4} \text{ H}$

(2)  $4.8\pi \times 10^{-5} \text{ H}$

(4)  $2.4\pi \times 10^{-5} \text{ H}$

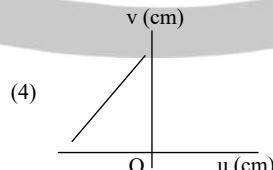
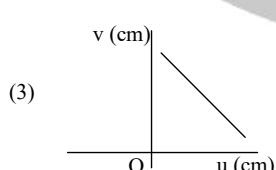
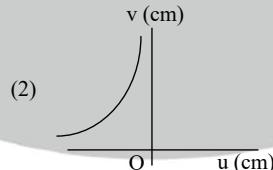
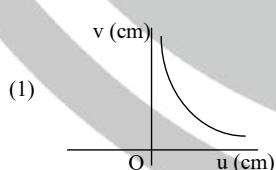
97.

(3)

$$M = \frac{\mu_0 N_1 N_2 A}{L}$$

98.

A student measures the focal length of a convex lens by putting an object pin at a distance 'u' from the lens and measuring the distance 'v' of the image pin. The graph between 'u' and 'v' plotted by the student should look like



98.

(2)

99. This question contains Statement – 1 and Statement 2. Of the four choices given after the statements, choose the one that best describes the two statements.

Statement – 1 :

For a mass  $M$  kept at the centre of a cube of side ‘ $a$ ’ the flux of gravitational field passing through its sides of  $4\pi GM$ .

Statement – 2 :

If the direction of a field due to a point source is radial and its dependence on the distance ‘ $r$ ’ from the source is given as  $\frac{1}{r^2}$ , its flux through a closed surface depends only on the strength of the source enclosed by the surface and not on the size or shape of the surface.

- (1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
- (2) Statement-1 is True, Statement-2 is True; Statement-2 is **not** a correct explanation for Statement-1
- (3) Statement-1 is True, Statement-2 is False
- (4) Statement-1 is False, Statement-2 is True

99.

**(4)** Statement I is wrong since  $4\pi GM$  is total flux through the surface not through the sides

100. This question contains Statement – 1 and Statement 2. Of the four choices given after the statements, choose the one that best describes the two statements.

Statement – 1 :

Energy is released when heavy nuclei undergo fission or light nuclei undergo fusion.  
and

Statement – 2 :

For heavy nuclei, binding energy per nucleon increases with increasing  $Z$  while for light nuclei it decreases with increasing  $Z$ .

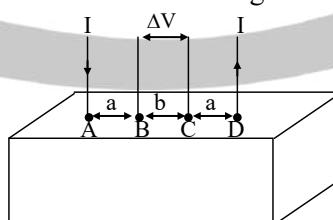
- (1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
- (2) Statement-1 is True, Statement-2 is True; Statement-2 is **not** a correct explanation for Statement-1
- (3) Statement-1 is True, Statement-2 is False
- (4) Statement-1 is False, Statement-2 is True

100. **(3)**

**Direction:** Question No. 101 and 102 are based on the following paragraph.

Consider a block conducting material of resistivity ‘ $\rho$ ’ shown in the figure. Current ‘ $I$ ’ enters at A and leaves from D. We apply superposition principle to find voltage  $\Delta V$  developed between B and C. The calculation is done in the following steps:

- (i) Take current ‘ $I$ ’ entering from A and assume it to spread over a hemispherical surface in the block
- (ii) Calculate field  $E(r)$  at distance  $r$  from A by using Ohm’s law  $E = \rho j$ , where  $j$  is the current per unit area at r.
- (iii) From the  $r$  dependence of  $E(r)$ , obtain the potential  $V(r)$  at r.
- (iv) Repeat (i), (ii) and (iii) for current ‘ $I$ ’ leaving D and superpose results for A and D.



101. For current entering at A, the electric field at a distance r from A is

(1)  $\frac{\rho I}{r^2}$

(2)  $\frac{\rho I}{2\pi r^2}$

(3)  $\frac{\rho I}{4\pi r^2}$

(4)  $\frac{\rho I}{8\pi r^2}$

101. (2)

$$j = \frac{I}{2\pi r^2}$$

$$E = \rho \times j = \frac{\rho I}{2\pi r^2}$$

102.  $\Delta V$  measured between B and C is

(1)  $\frac{\rho I}{a} - \frac{\rho I}{(a+b)}$

(2)  $\frac{\rho I}{2\pi a} - \frac{\rho I}{2\pi(a+b)}$

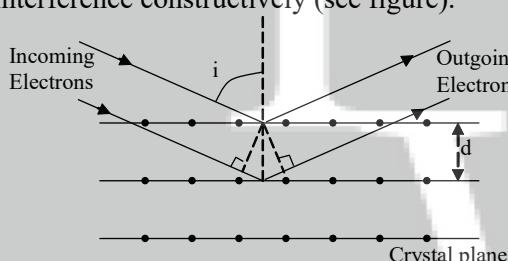
(3)  $\frac{\rho I}{2\pi(a-b)}$

(4)  $\frac{\rho I}{\pi a} - \frac{\rho I}{\pi(a+b)}$

102. (2)

**Direction:** Question No. 103 and 104 are based on the following paragraph.

Wave property of electrons implies that they will show diffraction effect. Davisson and Germer demonstrated this by diffraction from a crystals. The law governing the diffraction from a crystal is obtained by requiring that electron waves reflected from the planes of atoms in a crystal interfere constructively (see figure).



103. If a strong diffraction peak is observed when electrons are incident at an angle 'i' from the normal to the crystal planes with distance 'd' between them (see figure), de Broglie wavelength  $\lambda_{dB}$  of electrons can be calculated by the relationship (n is an integer)

(1)  $2d \cos i = n \lambda_{dB}$

(2)  $2d \sin i = n \lambda_{dB}$

(3)  $d \cos i = n \lambda_{dB}$

(4)  $n \lambda_{dB}$

103. (1)

104. Electrons accelerated by potential V are diffracted from a crystal. If  $d = 1 \text{ \AA}$  and  $i = 30^\circ$ , V should be about ( $h = 6.6 \times 10^{-34} \text{ Js}$ ,  $m_e = 9.1 \times 10^{-31} \text{ kg}$ ,  $e = 1.6 \times 10^{-19} \text{ C}$ )

(1) 50 V

(2) 500 V

(3) 1000 V

(4) 2000 V

104. (1)

$$eV = \text{K.E.} = \frac{P^2}{2m}$$

$$\Rightarrow P = \sqrt{2meV} = \frac{h}{\lambda}$$

$$\Rightarrow \lambda = \frac{h}{\sqrt{2meV}} \quad (1)$$

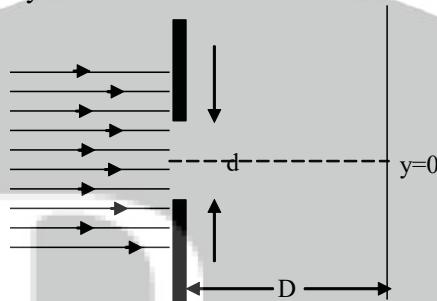
$$2d \cos i = n \lambda_{dB}$$

$$2d \cos i = n \times \frac{h}{\sqrt{2meV}}$$

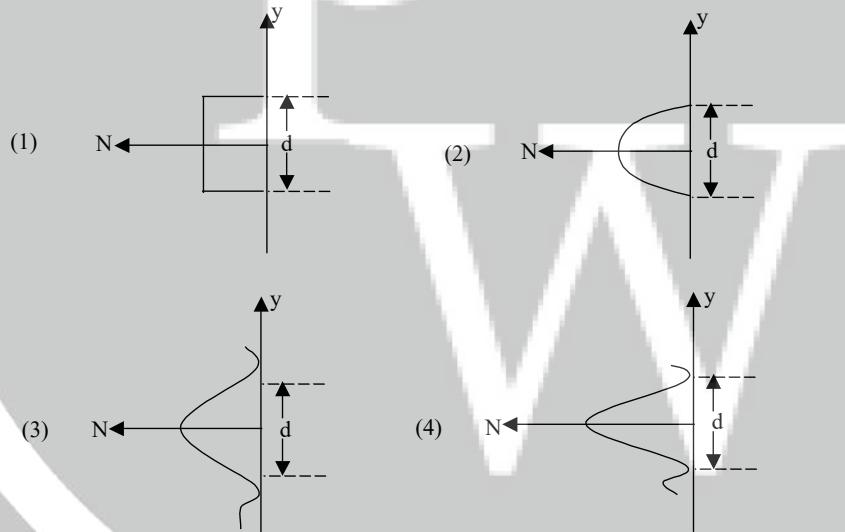
$$\Rightarrow 2 \times 10^{-10} \times \cos 30^{\circ} = \frac{n \times 6.62 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-19} \times V}}$$

$$V = 50 \text{ volt}$$

105. In an experiment, electrons are made to pass through a narrow slit of width 'd' comparable to their de Broglie wavelength. They are detected on a screen at a distance 'D' from the slit (see figure).



Which of the following graphs can be expected to represent the number of electrons 'N' detected as a function of the detector position 'y' ( $y=0$  corresponds to the middle of the slit)?



105. (3)