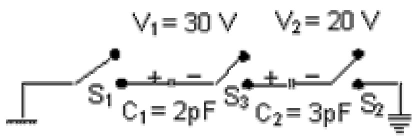
## PART III: PHYSICS

### SECTION – I

**Single Correct Choice Type**

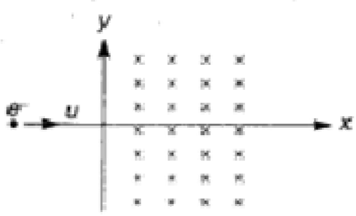
This section contains 8 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4) for its answer, out of which **ONLY ONE** is correct.

41. Which of the following statements is true for the circuit shown?




(1) With $S_1$ closed, $V_1 = 15$ V, $V_2 = 20$V
(2) With $S_3$ closed, $V_1 = V_2 = 25$V
(3) With $S_1$ and $S_2$ closed, $V_1 = V_2 = 0$
(4) With $S_3$ closed, $V_1 = 30$V, $V_2 = 20$V

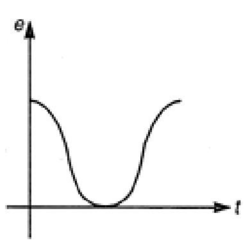
42. An electron moving with a speed u along the positive x-axis at y = 0, enters a region of uniform magnetic field $\vec{B} = -B_0\hat{K}$ existing to the right of y-axis. The electron exits from the region after sometime with the speed v at coordinate y, then



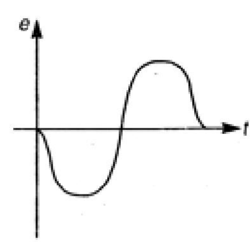

(1) v > u, y < 0
(2) v = u, y > 0
(3) v > y, y > 0
(4) v = u, y < 0

43. The variation of induced emf (e) with time (t) in a coil, if a short bar magnet is moved along its axis with a constant velocity, is best represented by

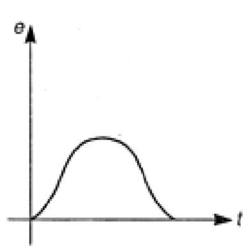
(1)



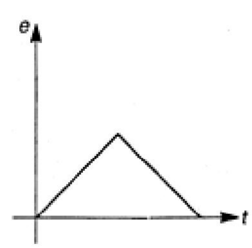

(2)




(3)



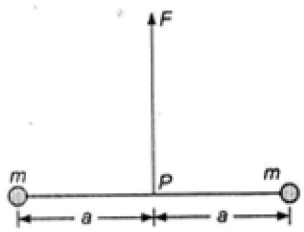

(4)



44. A small block slides without friction, down an inclined plane starting from rest. Let $s_n$ be the distance travelled from t = n – 1 to t = n. Then $\frac{s_n}{s_n + 1}$ is

(1) $\frac{2n-1}{2n}$ (2) $\frac{2n+1}{2n-1}$ (3) $\frac{2n-1}{2n+1}$ (4) $\frac{2n}{2n+1}$

45. Two particles of mass m each, are tied at the ends of a light string of length 2a. The whole system is kept on a frictionless horizontal surface with the string held tight so that each mass is at a distance a from the center P (as shown in the figure)

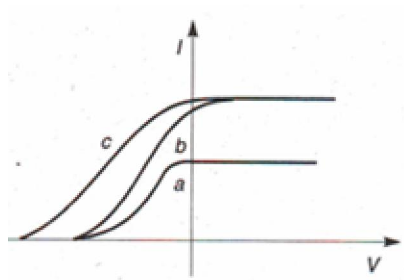



Now, the mid-point of the string is pulled vertically upwards with a small but constant force F. As a result, the particles move towards each other on the surface. The magnitude of acceleration, when the separation between them becomes 2x, is

(1) $\frac{F}{2m}\frac{a}{\sqrt{a^2-x^2}}$ (2) $\frac{F}{2m}\frac{x}{\sqrt{a^2-x^2}}$

(3) $\frac{F}{2m}\frac{x}{a}$ (4) $\frac{F}{2m}\frac{\sqrt{a^2-x^2}}{x}$

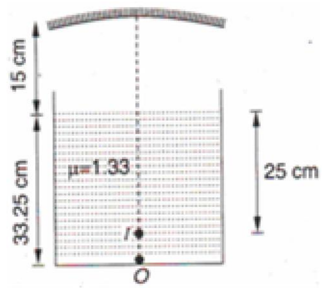
46. The figure shows the variation of photocurrent with anode potential of a photosensitive surface for three different radiations. Let $I_a$, $I_b$ and $I_c$ be the intensities and $f_a$, $f_b$ and $f_c$ be the frequencies for the curves a, b and c respectively. Then,




(1) $f_a = f_b$ and $I_a \neq I_b$ (2) $f_a = f_c$ and $I_a = I_c$

(3) $f_a = f_b$ and $I_a = I_b$ (4) $f_b = f_c$ and $I_b = I_c$

47. A container is filled with water ($\mu$ = 1.33) upto a height of 33.25 cm. A concave mirror is placed 15 cm above the water level and the image of an object placed at the bottom is formed 25 cm below the water level. The approximate focal length of the mirror is




(1) 10 cm (2) 15 cm (3) 19 cm (4) 25 cm

48. An ideal gas is expanding such that $pT^2$ = constant. The coefficient of volume expansion of the gas is:

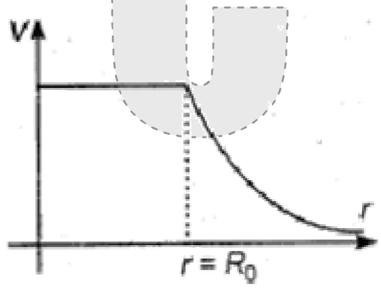
(1) $\frac{1}{T}$ (2) $\frac{2}{T}$ (3) $\frac{3}{T}$ (4) $\frac{4}{T}$

**SECTION – II**

**Multiple Correct Choice Type**

This section contains 4 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4) for its answer, out of which **ONE OR MORE** is/are correct.

49. For spherical symmetrical charge distribution, variation of electric potential with distance from the centre is given in the diagram.




V = $\frac{q}{4\pi\varepsilon_0 R_0}$ for $r \le R_0$

and V = $\frac{q}{4\pi\varepsilon_0 r}$ for $r \ge R_0$

Which option(s) is/are correct?

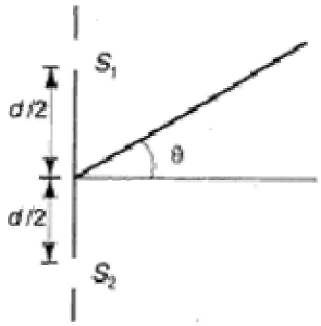
(1) Total charge within $2R_0$ is q

(2) Total electrostatic energy for $r \le R_0$ is zero

(3) At r = $R_0$ electric field is discontinuous

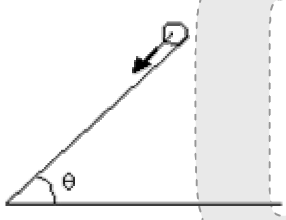
(4) There will be no charge anywhere except at r = $R_0$

50. In an interference arrangement similar to Young's double-slit experiment, the slits $S_1$ and $S_2$ are illuminated with coherent microwave sources, each of frequency $10^6$ Hz. The sources are synchronized to have zero phase difference. The slits are separated by a distance d = 150.0 m. The intensity I ($\theta$) is measured as a function of $\theta$, where $\theta$ is defined as shown. If $I_0$ is the maximum intensity, then I($\theta$) for $0 \leq \theta \leq 90^o$ is given by




(1) I ($\theta$) = $I_0$ / 2 for $\theta$ = $30^o$
(2) I ($\theta$) = $I_0$ / 4 for $\theta$ = $90^o$
(3) I ($\theta$) = $I_0$ for $\theta$ = $0^o$
(4) I ($\theta$) is constant for all values of $\theta$

51. A solid sphere is in pure rolling motion on an inclined surface having inclination $\theta$. `Which of these statement(s) is/are correct?




(1) Frictional force acting on sphere is f = $\mu$ mg cos $\theta$.
(2) f is a dissipative force.
(3) Friction will increase its angular velocity and decrease its linear velocity.
(4) If $\theta$ decreases, friction will decrease

52. When a monochromatic point source of light is at a distance of 0.2 m from a photoelectric cell, the cut-off voltage and the saturation current are respectively 0.6 Vand 18.0 mA. If the same source is placed 0.6 m away from the photoelectric cell, then
(1) the stopping potential will be 0.2 V
(2) the stopping potential will be 0.6 V
(3) the saturation current will be 6.0 mA
(4) the saturation current will be 2.0 mA

## SECTION – III

### Comprehension Type

This section contains 2 groups of questions. Each group has 3 multiple choice questions based on a paragraph. Each question has 4 choices (1), (2), (3) and (4) for its answer, out of which **ONLY ONE** is correct.

**Paragraph for Question Nos. 53 – 55:**

A typical billiard ball has a mass m = 0.5 kg and radius r = 50 mm. A cue would typically deliver an impulse of I, for a very short duration (in the range of 10 milliseconds). After leaving the tip of the cue, friction (f) is the only force acting on the ball. However, it should be noted that the ball doesn't start a purely rolling motion immediately after it is struck. It slides for a short duration before it sets into a pure rolling motion. Use coefficient of kinetic friction = $\mu$ to solve the problems stated below if the cue strikes along the centre of mass horizontally.

53. After what duration, on being struck, does the ball fall into a purely rolling motion?

(1) $\frac{2}{7}\frac{I}{f}$ (2) $\frac{5}{2}\frac{I\mu}{f}$ (3) $\frac{2}{5}\frac{I}{f}$ (4) $\frac{2}{7}\frac{I}{mg}$

54. What distance does the ball cover before it sets into pure rolling?

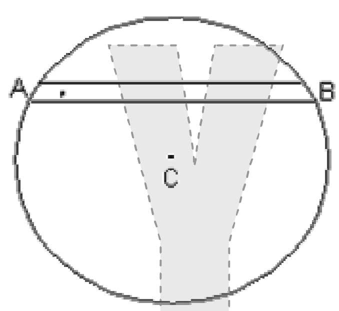
(1) $\frac{12}{49}\frac{I^2}{mf}$ (2) $\frac{2}{7}\frac{I^2}{mf}$ (3) $\frac{2}{7}\sqrt{\frac{Ir}{Mf}}$ (4) $\frac{5}{2}\frac{Mfr^2}{I^2}$

55. At what height above the centre of mass should the cue strike horizontally so that the ball is immediately set into pure rolling motion?

(1) $\frac{1}{7}r$ (2) $\frac{2}{5}r$ (3) $\frac{2}{7}r$ (4) $\frac{5}{2}r$

**Paragraph for Question Nos. 56 – 58:**

A tunnel is dug across the earth as shown and a train of mass 'm' moves on frictionless rails of length l, from A to B, solely driven by gravity. Assume that the density of earth is $\rho$




56. What time will the train take to reach B from A?

(1) $\pi\sqrt{\frac{R}{g}}$ (2) $\pi\sqrt{\frac{g}{R}}$ (3) $\frac{4}{3}\pi\sqrt{\frac{g}{R}}$ (4) $\sqrt{\frac{\pi R}{g}}$

57. What is the velocity of the train at the middle of the track?

(1) $\frac{\ell}{2}\sqrt{\frac{g}{R}}$ (2) $\frac{\ell}{4}\sqrt{\frac{g}{R}}$ (3) $\ell\sqrt{\frac{g}{R}}$ (4) $\sqrt{\frac{g\ell}{2}}$

58. What is the accelerating force acting on the train at the middle of the track?

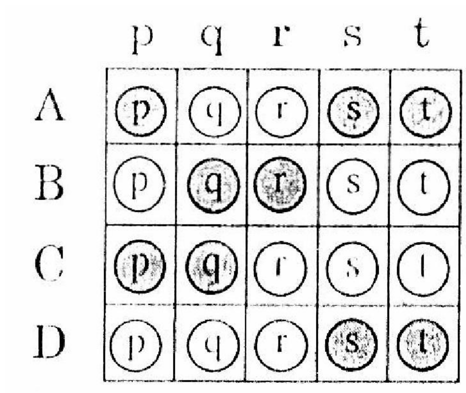
(1) $\frac{4}{3}\pi G\rho mr$ (2) $\frac{4}{3}\pi\frac{G\rho M}{R}$ (3) $\frac{4}{3}\pi G\rho m\theta$ (4) 0

**SECTION – IV**

**Matrix – Match Type**

This section contains 2 questions. Each question contains statements given in two columns, which have to be matched. The statements in **Column I** are labeled A, B, C and D, while the statements in **Column II** are labeled p, q, r, s and t. Any given statement in **Column I** can have correct matching with **ONE OR MORE** statement(s) in **Column II**. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following example:

If the correct matches are A – p, s and t; B – q and r; C – p and q; and D – s and t; then the correct darkening of bubbles will look like the following:




59.

| Column I | Column II |
|---|---|
| (A) Nuclear fusion | (p) Converts some matter into energy |
| (B) Nuclear fission | (q) Generally possible for nuclei with low atomic number |
| (C) $\beta$ -decay | (r) Generally possible for nuclei with high atomic number |
| (D) Exothermic nuclear reaction | (s) Essentially proceeds by weak nuclear forces |

60.

| Column I | Column II |
|---|---|
| (A) Dielectric ring uniformly charged | (p) Time independent electrostatic field out of system |
| (B) Dielectric ring uniformly charged rotating with angular velocity $\omega$ | (q) Magnetic field |
| (C) Constant current in ring $i_0$ | (r) Induced electric field |
| (D) $i = i_0 \cos \omega t$ | (s) Magnetic moment |

**ANSWERS KEY**

| | | | | |
|---|---|---|---|---|
| 1. (1) | 2. (3) | 3. (4) | 4. (2) | 5. (3) |
| 6. (3) | 7. (1) | 8. (3) | 9. (1), (4) | 10. (2), (4) |
| 11. (1), (2), (4) | 12. (2), (3) | 13. (4) | 14. (2) | 15. (4) |
| 16. (3) | 17. (2) | 18. (2) | 19. (1) | 20. (1) |
| 21. (1) | 22. (1) | 23. (4) | 24. (1) | 25. (4) |
| 26. (1) | 27. (3) | 28. (2) | 29. (2) | 30. (1), (4) |
| 31. (3), (4) | 32. (1), (3) | 33. (1) | 34. (4) | 35. (2) |
| 36. (3) | 37. (2) | 38. (2) | 39. (1) | 40. (4) |
| 41. (4) | 42. (4) | 43. (2) | 44. (3) | 45. (2) |
| 46. (1) | 47. (3) | 48. (3) | 49. (1), (2), (3), (4) | 50. (1), (3) |
| 51. (3), (4) | 52. (2), (4) | 53. (1) | 54. (1) | 55. (2) |
| 56. (1) | 57. (1) | 58. (4) | 59. (1) | 60. (1) |