

Topics : Rotation, Capacitor, Center of Mass, Gravitation, Current Electricity, Electrostatics

Type of Questions

Single choice Objective ('-1' negative marking) Q.1 to Q.2

(3 marks, 3 min.)

M.M., Min.

[6, 6]

Multiple choice objective ('-1' negative marking) Q.3

(4 marks, 4 min.)

[4, 4]

Subjective Questions ('-1' negative marking) Q.4 to Q.5

(4 marks, 5 min.)

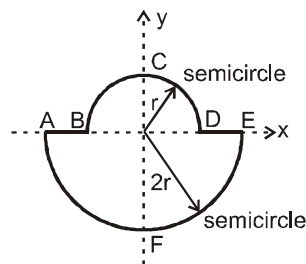
[8, 10]

Comprehension ('-1' negative marking) Q.6 to Q.8

(3 marks, 3 min.)

[9, 9]

1. A uniform thin rod is bent in the form of a closed loop ABCDEFA as shown in the figure.



(A) > 1

(B) < 1

(C) $= 1$

(D) $= 1/2$

2. An uncharged parallel plate capacitor is connected to a battery. The electric field between the plates is 10V/m . Now a dielectric of dielectric constant 2 is inserted between the plates filling the entire space. The electric field between the plates now is

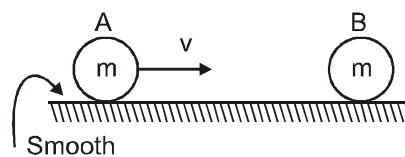
(A) 5 V/m

(B) 20 V/m

(C) 10 V/m

(D) none of these

3. In the figure shown, coefficient of restitution between A and B is $e = \frac{1}{2}$, then :



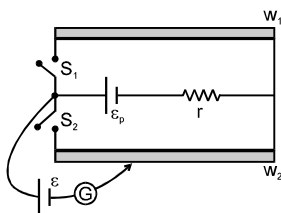
(A) velocity of B after collision is $\frac{v}{2}$

(B) impulse on one of the balls during collision is $\frac{3}{4}mv$

(C) loss of kinetic energy in the collision is $\frac{3}{16}mv^2$

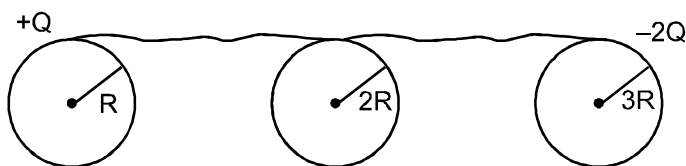
(D) loss of kinetic energy in the collision is $\frac{1}{4}mv^2$

4. A spherical planet has uniform density $\frac{\pi}{2} \times 10^4 \text{ kg/m}^3$. Find out the minimum period for a satellite in a circular orbit around it in seconds. (Use $G = \frac{20}{3} \times 10^{-11} \frac{\text{N-m}^2}{\text{kg}^2}$).
5. Two potentiometer wires w_1 and w_2 of equal length ℓ connected to a battery of emf ε_p and internal resistance 'r' through two switches s_1 and s_2 . A battery of emf ε is balanced on these potentiometer wires. If potentiometer wire w_1 is of resistance $2r$ and balancing length on w_1 is $\ell/2$ when only s_1 is closed and s_2 is open. On closing s_2 and opening s_1 the balancing length on w_2 is found to be $\left(\frac{2\ell}{3}\right)$, then find the resistance of potentiometer wire w_2 .



COMPREHENSION

Two conducting spheres of radius R and $3R$ carry charges Q and $-2Q$. Between these spheres a neutral conducting sphere of radius $2R$ is connected. The separation between the sphere is considerably large. Charge flows through conducting wire due to potential difference.



6. The final charge on initially neutral conducting sphere is :
- (A) $-\frac{Q}{6}$ (B) $-\frac{Q}{3}$ (C) $\frac{Q}{3}$ (D) $-\frac{Q}{2}$
7. The decrease in electric potential energy of sphere of radius R is :
- (A) $\frac{KQ^2}{4R}$ (B) $\frac{35KQ^2}{72R}$ (C) $\frac{KQ^2}{72R}$ (D) none
8. The final electric potential of sphere of radius $3R$ will be :
- (A) $-\frac{KQ}{6R}$ (B) $-\frac{KQ}{2R}$ (C) $-\frac{2KQ}{3R}$ (D) $-\frac{3KQ}{R}$

Answers Key

1. (B) 2. (C) 3. (B) (C) 4. 3000
5. $R = r$ 6. (B) 7. (B) 8. (A)

Hints & Solutions

1. Moment of inertia of semicircular portions about x and y axes are same. But moment of inertia of straight portions about x-axis is zero.

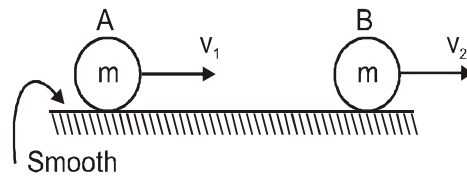
$$\therefore I_x < I_y \quad \text{or} \quad \frac{I_x}{I_y} < 1$$

2. As voltage applied across capacitor is same i.e. 10V in both case. Therefore in both case

$$Ed = 10 \Rightarrow E = \frac{10}{d}, \text{ as } d \text{ is constant. Therefore}$$

electric field remains the same as 10 V/m

3. after collision



By momentum conservation in horizontal direction

$$V = V_1 + V_2 \quad \dots\dots\dots(i)$$

and

$$e = \frac{V_2 - V_1}{V} = \frac{1}{2} \quad \dots\dots\dots(ii)$$

By (i) and (ii) $V_2 = \frac{3V}{4}$

So impulse on B

$$= m \left(\frac{3V}{4} \right)$$

and loss in K.E.

$$= \frac{3}{16} mV^2$$

4. **Ans.** 3000

Time period is minimum for the satellites with minimum radius of the orbit i.e. equal to the radius of the planet. Therefore.

$$\frac{GMm}{R^2} = \frac{mv^2}{R}$$

$$\Rightarrow V = \sqrt{\frac{GM}{R}}$$

$$T_{\min} = \frac{2\pi R}{\sqrt{\frac{GM}{R}}}$$

$$= \frac{2\pi R \sqrt{R}}{\sqrt{GM}}$$

$$\text{using } M = \frac{4}{3} \pi R^3 \cdot \rho$$

$$T_{\min} = \sqrt{\frac{3\pi}{G\rho}}$$

Using values $T_{\min} = 3000 \text{ s}$

5. When S_1 is closed

$$i = \frac{\varepsilon_p}{2r+r} = \frac{\varepsilon_p}{3r}$$

$$\therefore \varepsilon = \frac{\varepsilon_p}{3r} \cdot r = \frac{\varepsilon_p}{3} \quad \dots\dots\dots (1)$$

when S_2 is closed (Let resistance of w_2 be R)

$$i = \frac{\varepsilon_p}{R+r}$$

$$\varepsilon = \frac{\varepsilon_p}{R+r} \cdot \left(R \cdot \frac{2}{3}\right) \quad \dots\dots\dots (2)$$

From (1) & (2) $R = r$. Ans.

Alternate Solution :

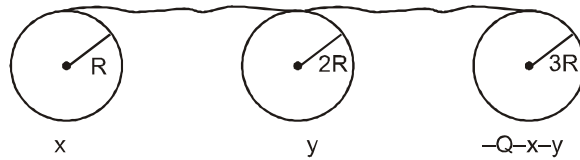
If in second case both S_1 & S_2 are closed,

$$\varepsilon = \frac{\varepsilon_p}{r+2r} \cdot \frac{2r}{\ell} \cdot \frac{\ell}{2} = \frac{\varepsilon_p}{3}$$

$$\varepsilon = \frac{\varepsilon_p}{r + \frac{2rx}{2r+x}} \cdot \frac{2rx}{2r+x} \cdot \frac{2}{3}$$

$$\Rightarrow \frac{\varepsilon_p}{3} = \frac{4\varepsilon_p x}{2r+x+2x}$$

Sol.(57 to 59)



Final potential of spheres will be same

$$\text{So, } K \frac{x}{R} = \frac{Ky}{2R} = \frac{K(-Q-x-y)}{3R}$$

$$y = 2x \quad \text{and} \quad 3x = -Q - x - y$$

$$\therefore 6x = -Q$$

$$x = -\frac{Q}{6} \quad y = -\frac{Q}{3}$$

Charge on sphere of radius 3R is $-\frac{Q}{2}$

Change in potential energy of sphere of radius 'R' is

$$\Delta U = \frac{KQ^2}{2R} - \frac{K(-Q/6)^2}{2R}$$

$$\Delta U = \frac{35KQ^2}{72R}$$