PHYSICS

DPP

DAILY PRACTICE PROBLEMS

DPP No. 17

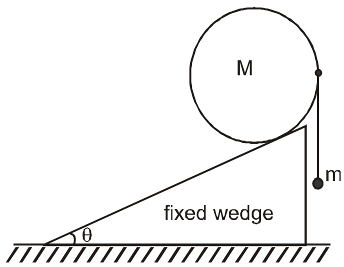
Total Marks : 39

Max. Time : 43 min.

Topic : Rigid Body Dynamics, String Wave, Kinetic Throry of Gases, Thermal Expansion, Simple Harmonic Motion, Electrostatics

Type of Questions		M.M., Min.
Single choice Objective ('–1' negative marking) Q.1 to Q.2	(3 marks, 3 min.)	[6, 6]
Multiple choice objective ('–1' negative marking) Q.3 to Q.4	(4 marks, 4 min.)	[8, 8]
Subjective Questions ('–1' negative marking) Q.5 to Q.6	(4 marks, 5 min.)	[8, 10]
Comprehension ('–1' negative marking) Q.7 to Q.9	(3 marks, 3 min.)	[9, 9]
Match the Following (no negative marking) (2 × 4)Q.10	(8 marks, 10 min.)	[8, 10]

1. A uniform cylinder of mass M lies on a fixed plane inclined at an angle θ with horizontal. A light string is tied to the cylinder's right most point, and a mass m hangs from the string, as shown. Assume that the coefficient of friction between the cylinder and the plane is sufficiently large to prevent slipping. For the cylinder to remain static, the value of mass m is-



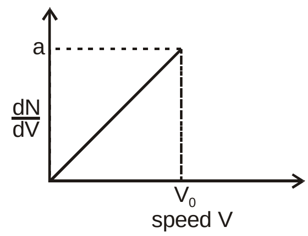
(A) $\frac{M\cos\theta}{1+\sin\theta}$ (B) $M\frac{\sin\theta}{1+\sin\theta}$

(C) $M\frac{\cos\theta}{1-\sin\theta}$ (D) $M\frac{\sin\theta}{1-\sin\theta}$

2. At t = 0, a transverse wave pulse travelling in the positive x direction with a speed of 2 m/s in a long wire is described by the function $y = \frac{6}{x^2}$, given that $x \neq 0$. Transverse velocity of a particle at x = 2m and t = 2 seconds is :

(A) 3 m/s (B) – 3 m/s (C) 8 m/s (D) – 8 m/s

3. Graph shows a hypothetical speed distribution for a sample of N gas particle (for $V > V_0$; $\frac{dN}{dV} = 0$, $\frac{dN}{dV}$ is rate of change of number of particles with change veloicty)



(A) The value of aV_0 is 2N.

(B) The ratio V_{avg}/V_0 is equal to 2/3.

(C) The ratio V_{rms}/V_0 is equal to $1/\sqrt{2}$.

(D) Three fourth of the total particle has a speed between 0.5 V_0 and V_0.

4. A vessel is partly filled with liquid. When the vessel is cooled to a lower temperature, the space in the vessel, unoccupied by the liquid remains constant. Then the volume of the liquid (V_L), volume of the vessel (V_v), the coefficients of cubical expansion of the material of the vessel (γ_v) and of the liquid (γ_L) are related as

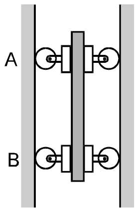
(A) $\gamma_L > \gamma_v$ (B) $\gamma_L < \gamma_v$ (C) $\gamma_v/\gamma_L = V_v/V_L$ (D) $\gamma_v/\gamma_L = V_L/V_v$

5. Two particles perform SHM with the same amplitude and same frequency about the same mean position and along the same line. If the maximum distance between them during the motion is A (A is the amplitude of either) then the phase difference between their SHM is _______.

6. Calculate the magnitude of electrostatic force on a charge placed at a vertex of a triangular pyramid (4 vertices, 4 faces), if 4 equal point charges are placed at all four vertices of pyramid of side 'a'.

COMPREHENSION

A bar of mass m is held as shown between 4 uniform discs each of mass m′ and radius r = 75 mm. The bar has been released from rest, knowing that the normal forces exerted on the discs by vertical walls are sufficient to prevent any slipping. Answer the following questions assuming attachments are massless and fixed to the bar. (Acceleration due to gravity is g)



7. If m = 5 kg and m′ = 2 kg, then acceleration of the bar is

(A) g (B) 13g/7 (C) 13g/17 (D) $\frac{g}{17}$

8. If the mass m′ of the discs is negligible, then acceleration of the bar is

(A) g (B) 2g/3 (C) 13g/17 (D) $\frac{g}{17}$

9. If the mass m of the bar is negligible, then acceleration of the bar is

(A) g (B) 2g/3 (C) 13g/17 (D) $\frac{g}{17}$

10. Assume only electrostatic interaction forces :

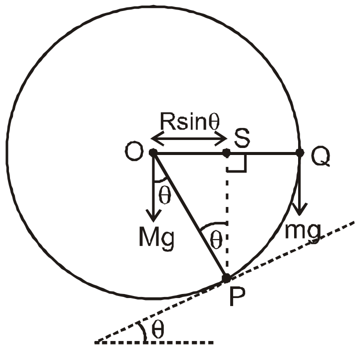
Column – I	Column – II
(A) Three charges are kept along a straight line	(p) The system may be in equilibrium with proper choice of the value of charges.
(B) Three charges are kept at the vertices of an equilateral triangle	(q) The system will be in equilibrium for any value of the charges.
(C) Three charges are kept at the three vertices of a square, and a fourth charge is kept at the point of intersection of the diagonals.	(r) The system will not be in equilibrium for any choice of the value of charges.
(D) Three charges are kept at the vertices of an equilateral triangle with the fourth charge at the centroid.	(s) The equilibrium is unstable.

Answers Key

1. (D)	**2.** (B)	**3.** (A), (B), (C), (D)			
4. (A), (D)		**5.** $\phi = \pi/3$			
6. $\dfrac{\sqrt{6}\,q^2}{4\pi \in_0 a^2}$		**7.** (C)	**8.** (A)		
9. (B)	**10.** (A) p, s ; (B)r ; (C) r ; (D) p, s				

Hints & Solutions

1.



Let the radius of cylinder be R
For the cylinder to remain static, net torque on cylinder about point P (point of contact with inclined surface) should be zero.

$\therefore$ Mg (OS) = mg (SQ)

or Mg R sinq = mg R (1 – sinq)

or $m = \dfrac{M\sin\theta}{1-\sin\theta}$

2. (B) $y(x, t = 0) = \dfrac{6}{x^2}$ then $y(x,t)$

$= \dfrac{6}{(x-2t)^2}$

$\Rightarrow \dfrac{\partial y}{\partial t} = \dfrac{24}{(x-2t)^3}$

at $x = 2,\ t = 2$

$V_y = \dfrac{24}{(-2)^3} = -3$ m/s.

3. Area under the curve is equal to number of molecules of the gas sample. Hence

$$N = \frac{1}{2} . a . V_0 \Rightarrow aV0 = 2N$$

$$V_{avg} = \frac{1}{N} \int_0^{\infty} v\, N(V) dV$$

$$= \frac{1}{N} \int_0^{V_0} C . \left(\frac{a}{v_0} . V \right) dV = \frac{2}{3} V_0 \qquad \Rightarrow \frac{V_{avg}}{V_0} = \frac{2}{3}$$

$$v_{rms}^2 = \frac{1}{N} \int_0^{\infty} V^2 N(V) dV$$

$$= \frac{1}{N} \int_0^{v_0} V^2 \left(\frac{a}{V_0} . V \right) dV = \frac{V_0^2}{2} \qquad \Rightarrow \frac{V_{rms}}{V_0} = \frac{1}{\sqrt{2}}$$

Area under the curve from 0.5 V_0 to V_0 is $\frac{3}{4}$ of total area.

4. $\Delta V_L = \Delta V_V$

$\Rightarrow \; Y_L V_L = Y_V V_V$

or $\frac{Y_L}{Y_V} = \frac{V_V}{V_L}$

but $V_V > V_L$

$\Rightarrow \; Y_L > Y_V$

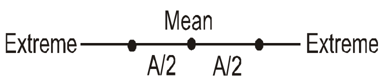
5. $Y_1 = A \sin \omega t$

$Y_2 = A \sin(\omega t + \phi) \qquad \phi = 2\pi/3$

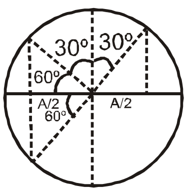
As, $Y_2 + Y_1 = A$

Now, solve and use the condition of maxima.

Alternate : by symmetry both should be on opposite side of mean position at equal distance from mean (for max. seperation)

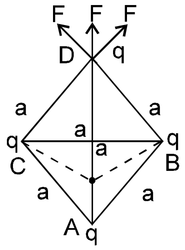


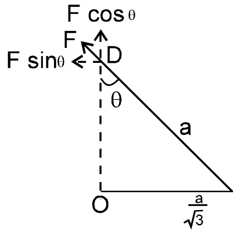
As projection of SHM on circular path

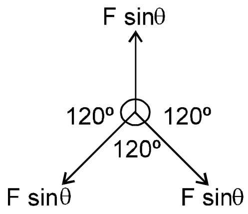


The phase difference from figure is $\frac{\pi}{6} + \frac{\pi}{6} = \frac{\pi}{3}$

6.







$\cos\theta = \sqrt{\frac{2}{3}}$

$\therefore\ F_{net} = 3F\cos\theta = 3\frac{Kq^2}{a^2}\sqrt{\frac{2}{3}}$

$= \frac{\sqrt{6}\,q^2}{4\pi\epsilon_0 a^2}$

[Ans. $\frac{\sqrt{6}\,q^2}{4\pi\epsilon_0 a^2}$ **]**

Sol. 7 to 9

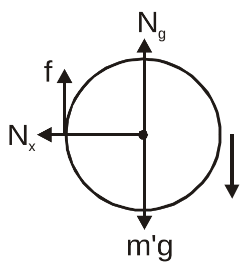
7. F.B.D. of disc

$\Rightarrow$ In horizontal direction $N = N_x$ .....(1)

In vertical direction $m'g - f - N_y = m'a$.....(2)

Torque due to friction ;

$fR = \frac{m'R^2}{2}\propto$



As $a = R\alpha$

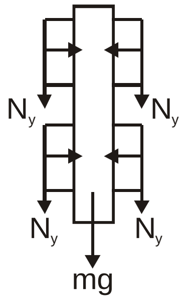
$\therefore\ fR = \frac{m'R^2}{2}\frac{a}{R}$

$\Rightarrow\ f = \frac{m'a}{2}$ put in (2)

$\therefore\ m'g - N_y = \frac{3m'a}{2}$

$N_y = m'g - \frac{3m'a}{2}$ .....(3)

Now, F.B.D. of bar ;



$4N_y + mg = ma$

Put N_y from (3)

$4m'g - 6m'a + mg = ma$ ..... (4)

As $m' = 2kg$ & $m = 5$ kg

$\therefore$ $8g - 12a + 5g = 5a$

$a = \dfrac{13g}{17} \downarrow$

8. From equation (4) (neglecting m') $a = g \downarrow$

9. From equation (4) (neglecting m) $a = \dfrac{2g}{3} \downarrow$

10. (A) $\rightarrow$ p, s ; (B) $\rightarrow$ r ; (C) $\rightarrow$ r ; (D) $\rightarrow$ p, s