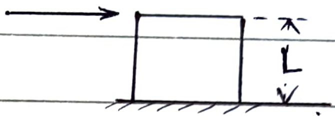
Rotational Dynamics

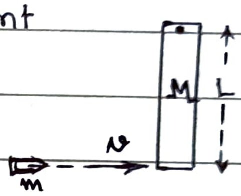
Worksheet (Dose-II)

1. A cubical block of side L rest on a rough horizontal surface with coefficient of friction μ. A horizonal force F is applied on the block. If the coefficient of friction is sufficiently high so that the block does not slide before toppling, what is the minimum force required to topple the block?



Ans: $Mg/2$

2. A rod of length L and mass M is hinged at point 'O'. A small bullet of mass m hits the rod with velocity v. The bullet gets embedded in the rod. Find the angular velocity of the system just after the impact.

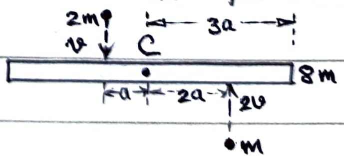


Ans: $\frac{3mv}{(M+3m)L}$

3. Two point masses of 0.3 kg and 0.7 kg are fixed at the ends of a rod of length 1.4 m and of negligible mass. The rod is set rotating about an axis passing perpendicular to its length with a uniform angular speed. The point on the rod through which the axis should pass in order that the workdone required for rotation of the rod is minimum is locat x distance from 0.3 kg mass. Find x.

Ans: $x = 0.98$ m

4. A uniform bar of length 6a and mass 8m lies on a smooth horizontal table. Two point masses m and 2m moving in the same horizontal plane with speed 2v and v respectively, strike the bar and stick to the bar after collision. then we have after the collision



a) $v_c = 0$ b) $\omega = \frac{3v}{5a}$ c) $\omega = \frac{v}{5a}$ d) $E = \frac{3mv^2}{5}$

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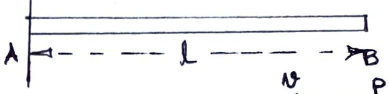
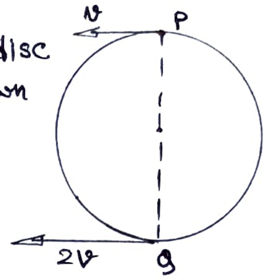
5. Linear mass density of a rod depends on the distance from one end as $\lambda_x = (\alpha x + \beta)$. Here α, β are constants. Find the moment of inertia of this rod about an axis passing through A and perpendicular to the rod. Length of the rod is l.



Ans: $\frac{\alpha l^4}{4} + \frac{\beta l^3}{3}$

6. Two points P and Q, diametrically opposite on a disc of radius R have linear velocities v and $2v$ as shown in figure. Find the angular speed



7. A uniform disc of mass m and radius R is rotated about an axis passing through its centre and perpendicular to its plane with an angular velocity ω_0. It is placed on a rough horizontal plane with the axis of the disc keeping vertical. Coefficient of friction between the disc and the surface is μ. Find:

a) the time when disc stops rotating

b) the angle rotated by the disc before stopping.

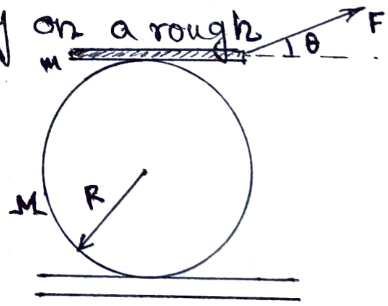
Ans: $t = \frac{3\omega_0 R}{4\mu g}$

$\theta = \frac{3\omega_0^2 R}{8\mu g}$

8. A uniform disc of mass 20 kg and radius 0.5 m can turn about a smooth axis through its centre and perpendicular to the disc. A const torque is applied to the disc for 3 s from rest and the angular velocity at the end of that time is $\frac{240}{\pi}$ rev/min. Find the magnitude of the torque. If the torque is then removed and the disc is brought to rest in t seconds by a constant force of 10 N applied tangentially at a point on the rim of the disc, find t.

Ans: $\frac{20}{3}$ N-m, 4 s

9. Consider a cylinder of mass M and radius R lying on a rough horizontal plane. It has a plank lying on its top. A force F is applied on the plank such that the plank moves and causes the cylinder to roll. The plank always remains horizontal. There is no slipping at any point of contact. Calculate the acceleration of the cylinder and the frictional forces at the two contact.



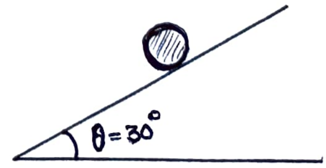
Ans: $f_1 = \frac{3MF\cos\theta}{3M+8m}$; $f_2 = \frac{MF\cos\theta}{3M+8m}$

10. In the fig. shown a solid sphere of mass 4 kg and radius 0.25 m is placed on a rough surface. Find:

a) minimum coefficient of friction for pure rolling

b) If $\mu > \mu_{min}$, find linear acceleration of sphere

c) If $\mu = \frac{\mu_{min}}{2}$, find linear acceleration of cylinder.



$\mu_{min} = 2/7\sqrt{3}$

Ans: $a = \frac{25}{7}$ m/s²

$a = \frac{30}{7}$ m/s²