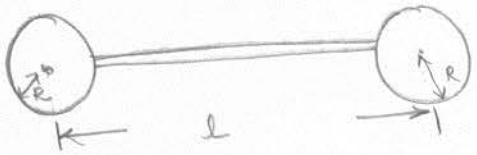
Homework 4.

INSTRUCTOR: ARIJIT BOSE.

DUE DATE: THURSDAY, JUNE 16, 2011 (In lecture)

(1) An airplane propeller consists of three radial blades, each of length 1.8 m and mass 20 kg. What is the kinetic energy of this propeller when rotating at 2500 rev/min? Assume that each blade is (approximately) a uniform rod.

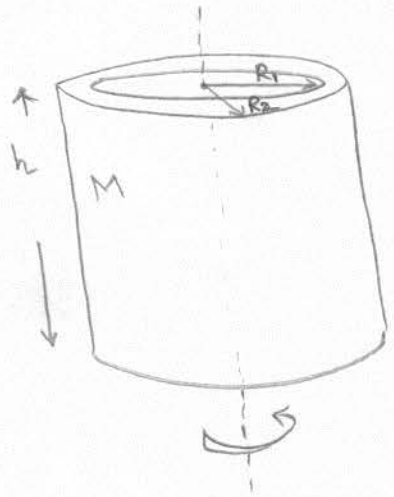
2)a) A dumbbell consists of two uniform spheres of mass M and radius R joined by a thin rod of mass m and length l



What is the moment of inertia of this device about an axis through the center of the rod perpendicular to the rod? About an axis along the rod?

b) A piece of steel pipe (in figure) has an inner radius R_1 and an outer radius R_2 and a mass M. Find the moment of inertia about the axis of the pipe.

[Hint: Break the system up into thin cylinders of radius r & mass dm, use calculus to find I from dI for each of these]

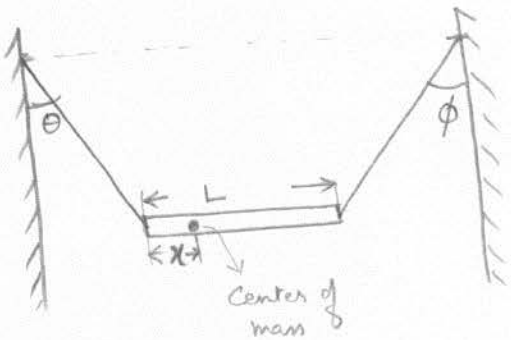


(3) A horizontal aluminium rod 4.8 cm diameter projects 5.3 cm from a wall. A 1200 kg object is suspended from the end of the rod. The shear modulus of aluminium is 3.0×10^{10} N/m^2. Neglecting the rod's mass, find

(a) the shear stress of the rod and

(b) the vertical deflection of the end of the rod

(4) A non-uniform rod is suspended at rest in a horizontal position by two massless cords, as shown in the figure. One cord makes an angle θ with the vertical; the other makes an angle ϕ with the vertical. If L is the length of the bar, find the distance x from the left end of the bar to its center of mass.



put $\theta = 36.9°$; $\phi = 53.1°$ and $L = 6.10$ m and find x.

(5) A uniform plank of length L and mass M rests on the ground and against a frictionless roller at the top of a wall of height h. The plank remains in equilibrium for any value of $\theta \geq \theta_{min}$ but slips for $\theta < \theta_{min}$. Find the coefficient of static friction between the plank and the ground.

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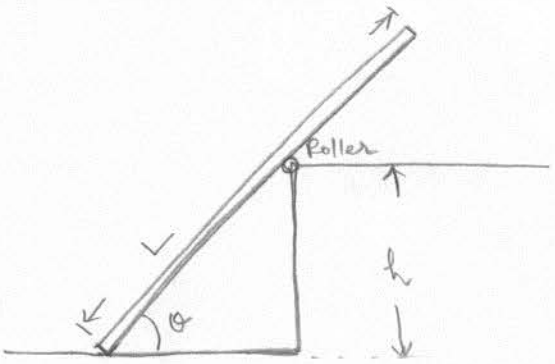


Put $L = 6.10\ m$

$Mg = 445$

$h = 3.05\ m$

$\theta_{min} = 70°$

and find a value for μ_s between the plank and the ground.

(6) Consider a tire of diameter 66cm on a car travelling at 80 km/hr on a level road in the positive direction of an x-axis. Relative to a woman in the car, what are (a) the linear velocity $\vec{v}$ and (b) the magnitude a of the linear acceleration of the center of the wheel? What are (c) $\vec{v}$ and (d) a for a point at the top of the tire? What are (e) $\vec{v}$ and (f) a for a point at the bottom of the tire?

Now repeat the questions relative to a hitchhiker sitting near the road: What are (g) $\vec{v}$ at the wheel's center, (h) a at the wheel's center, (i) $\vec{v}$ at the tire top (j) a at the tire top, (k) $\vec{v}$ at the tire bottom (l) a at the tire bottom?

(7) A body of radius R and mass m is rolling smoothly with speed v on a horizontal surface. It then rolls up a hill to a maximum height h. (a) If $h = \frac{3v^2}{4g}$, what is the body's rotational inertia about the rotational axis through its center of mass?

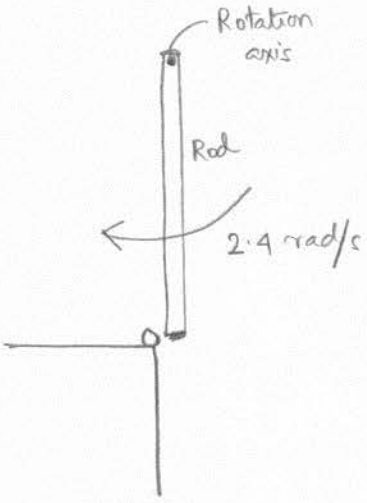
(b) What might the body be?

(8) A uniform disk of mass 10 m and radius 3.0 r can rotate freely about its fixed center like a merry-go-round. A smaller uniform disk of mass m and radius r lies on top of the larger disk, concentric with it. Initially the two disks rotate together with an angular velocity of 20 rad/sec. Then a slight disturbance causes the smaller disk to slide outwards across the larger disk, until the outer edge of the smaller disk catches on the outer edge of the larger disk. Afterward, the two disks again rotate together (without further sliding)

(a) What then is their angular velocity about the center of the larger disk?

(b) What is the ratio K/Ko of the new kinetic energy of the two disk system to the system's initial kinetic energy?

(9)



A uniform rod of length 0.60 m and mass 1 kg rotates about an axis through one end. As the rod swings through its lowest position, the end of the rod collides with a small 0.20 kg putty wad that sticks to the end of the rod. If the angular speed of the rod just before the collision is 2.4 rad/sec, what is the angular velocity of the rod-putty system immediately after the collision?

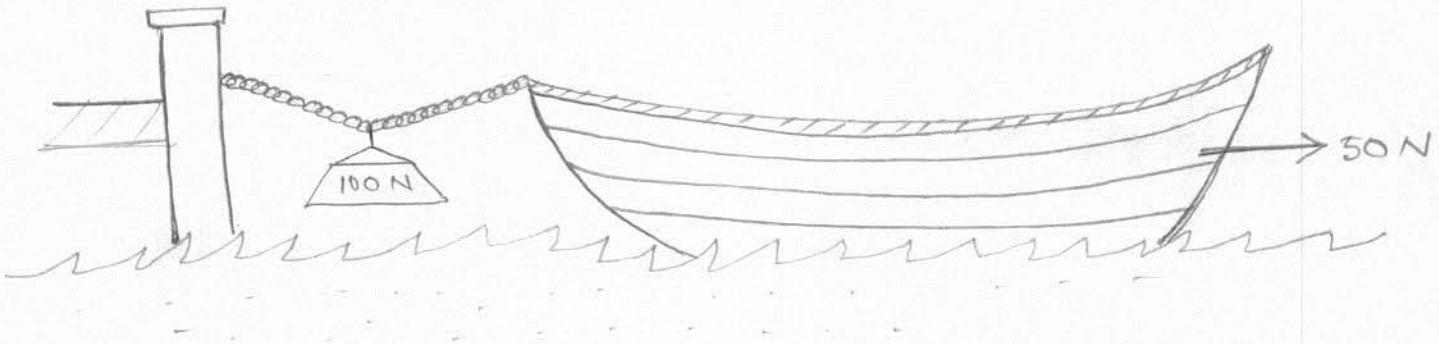
(10) A boat is moored at the end of a dock in a rapidly flowing river by a chain 5 m long, as in figure. To give the chain some flexibility, a 100 N weight is attached to the center of the chain, to allow for variations in force pulling the boat away from the dock.

(a) If the drag force on the boat is 50 N, what is the tension in the chain?

(b) How far will the chain sag? Ignore the weight of the chain itself.

(c) How far is the boat from the dock?

(d) If the maximum tension that the chain can support is 500 N, what is the maximum value of the force that the river can exert on the boat?



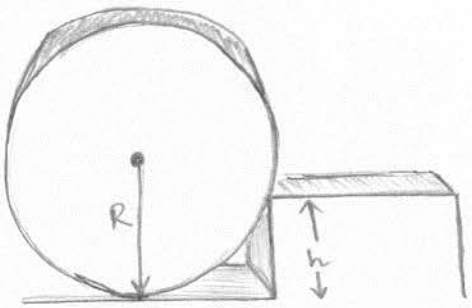
(11) A cylinder of mass M and radius R rolls against a step of height h as in figure. When a horizontal force $\vec{F}$ is applied to the top of the cylinder, the cylinder remains at rest

(a) What is the normal force exerted by the floor on the cylinder

(b) What is the horizontal force exerted by the edge of the step on the cylinder?

(PTO)

(c) What is the vertical component exerted by the edge of the step on the cylinder ?



$R > h$

(12) A uniform log with a mass 100 kg, a length 4 m, and a radius of 12 cm is held in an inclined position, as in figure. The coefficient of static friction between the log and the horizontal surface is 0.6. The log is on the verge of slipping to the right. Find the tension in the support wire and the angle the wire makes with the vertical wall.