Week 11- Problems

11-1 What is a rigid body?

11-2 What is the difference between force and torque?

11-3 Four particles of equal masses $M$ are connected by thin (massless) rods. Calculate the moment of inertia (i) about the y-axis, (ii) about the dashed line ($45^o$ to x-axis).
11-4 For a rigid body, in translation the linear momentum \( P = MV \) and the kinetic energy is \( K = \frac{P^2}{2M} \). Show that in rotation about a fixed axis, the kinetic energy is \( K = \frac{L^2}{2I} \), the angular momentum is \( L = I\omega \) where \( I \) is the moment of Inertia.

11-5 What is the kinetic energy of the Earth due to its daily rotation? Assume that the moment of Inertia is \( I = \frac{1}{3} M_B R_E^2 \).

11-6 For a disk rotating on an axis perpendicular to its center \( I = \frac{Mr^2}{2} \). The disk shown has \( M = 5\text{kg} \) and \( r = 0.5\text{m} \). For the forces indicated (i) what is the total torque in the disk? (ii) What is the angular acceleration of the disk?
11-7 A disk of radius 20cm and mass 0.05kg is rotating about the z-axis with angular velocity \( \omega = -2 \text{rad/s} \). If you wish to stop it in 5 secs, what force must be applied on the rim?

11-8 In the loop-the-loop of problem 10-8 suppose the object is a sphere of radius \( r \) which rolls without slipping as it goes around the track. What is the minimum value of \( h \) necessary so it can go completely around the loop? \( (I = \frac{2}{5} Mr^2) \).

11-9 A ladder of mass \( M \) and length \( L \) is leaning against a smooth vertical wall. The floor is rough, the coefficient of static friction being \( \mu_s \). Explain why it is essential that to prevent slipping you must not make the angle \( \theta \) too small.
11-10 A 4kg cylinder is mounted so it can rotate freely about its horizontal (z) axis. A string is wound around the cylinder and has a 1 kg mass hanging. If you release the 1 kg mass, how far will it drop in 2 secs? Why?

![Diagram of a cylinder with a string winding around it and a 1 kg mass hanging from it.]

11-11 On an inclined plane you release (i) a ring and (ii) a sphere. Which will reach the bottom first if there is no slip in either case? Why?

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I_{\text{ring}} = Mr^2, \quad I_{\text{sphere}} = \frac{2}{5}Mr^2
\]
11-12 In the Atwood machine [Prob 4-14] the pulley has a mass $M_p$. Show that the magnitude of the accelerations of $M_1, M_2$ is

$$a = \frac{(M_1 - M_2)g}{M_1 + M_2 + \frac{M_p}{2}}$$

if the string does not slip on the pulley.

11-13 Calculate the pressure increase in the fluid in a syringe if the nurse applies a force of 42 N to the syringe’s piston of diameter 0.5 m.

11-14 The pressure at the center of a tornado is 0.1 atm. What is the net force on a window pane of dimension 1.4m x 1.4m? Assume that the house is airtight and the pressure inside is 1 atm.