Laws of Rotational Motion

Pre-Class Questions

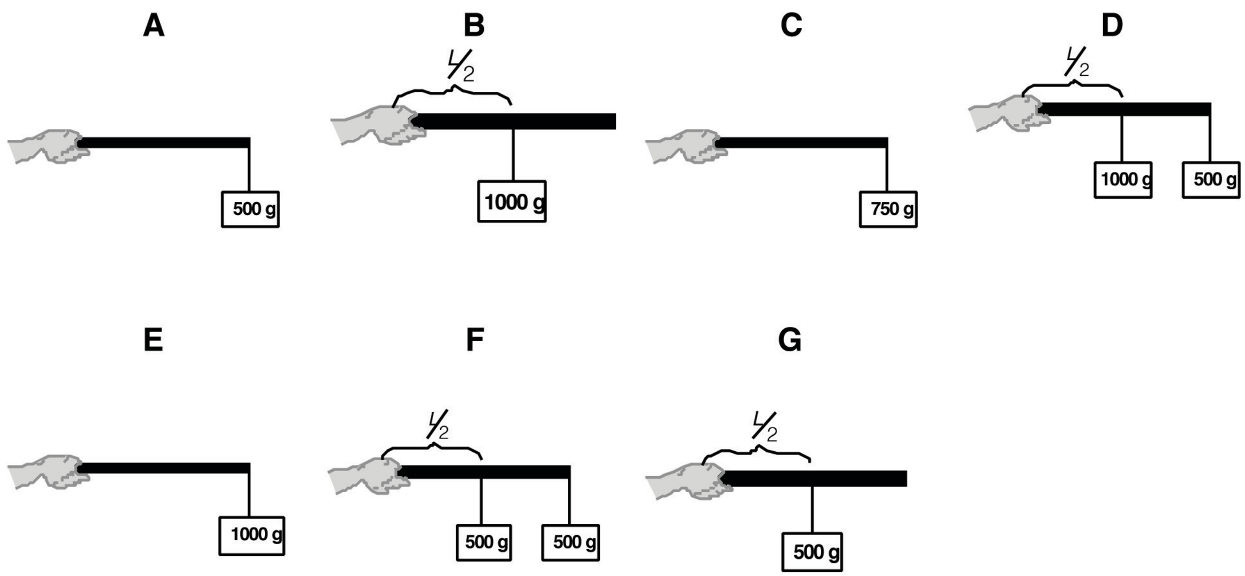
Problem Set (due next time)
Ch 10 - 4, 7, 9, 11

Lecture Outline

1. The First Law of Rotation
2. The Second Law of Rotation

Shown below are seven situations where a student is holding a meter stick at the left end at various angles. A 1000 g mass is hung on the meter sticks at different locations. All of the meter sticks are identical, but the distance along the meter stick at which the 1000 g mass is hung and the angles at which the student holds the meter stick vary. Specific values are given in each figure. (Ignore the mass of the meter stick.)

Rank these situations, from greatest to least, on the basis of the size of the torque exerted by the mass about the hand. That is, put first the situation where the torque would be largest and put last the situation where the torque would be smallest.



Hardest 1______ 2_______ 3_______ 4_______ 5_______ 6______ 7______ Easiest

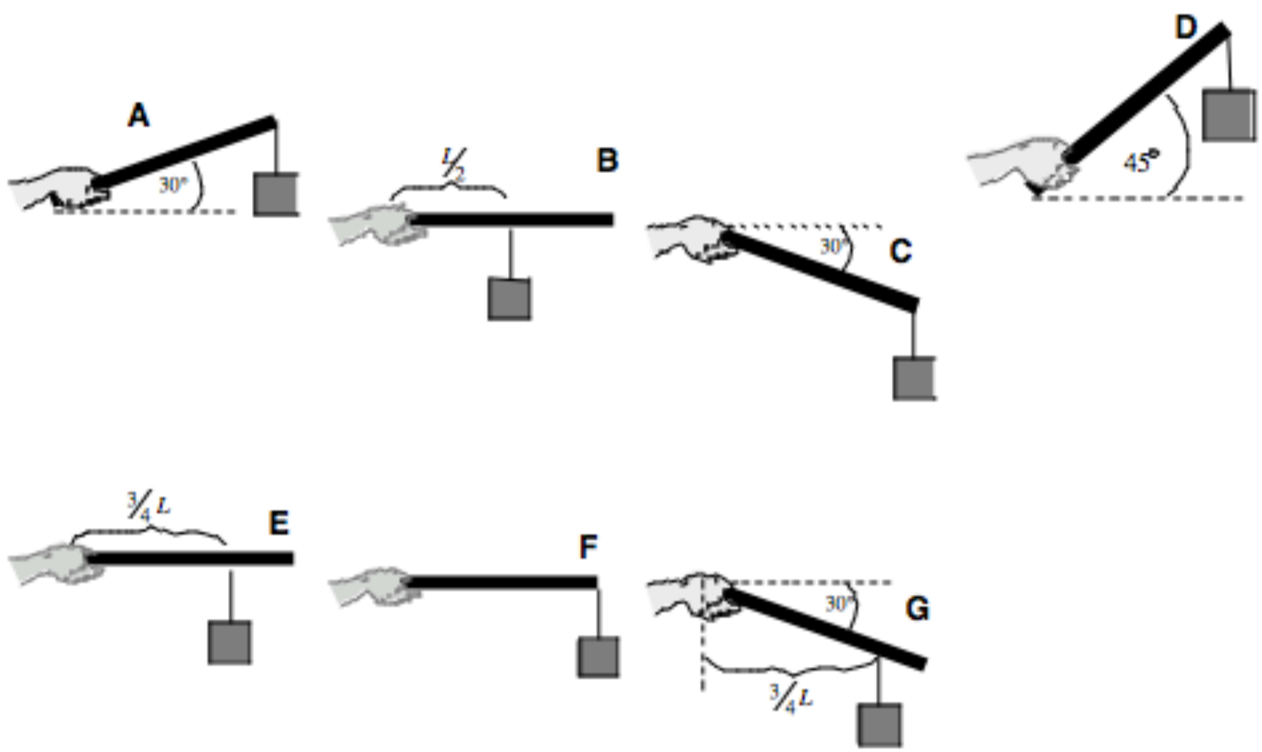
Or, it would be equally difficult to hold all seven of these meter sticks as shown. ________

Please carefully explain your reasoning.

Example 1: To open a paint can, a force of 100N is exerted downward on a 25.0cm long screwdriver. Find (a)the torque produced and (b)the force needed if it is exerted at an angle of 30.0° to the vertical.

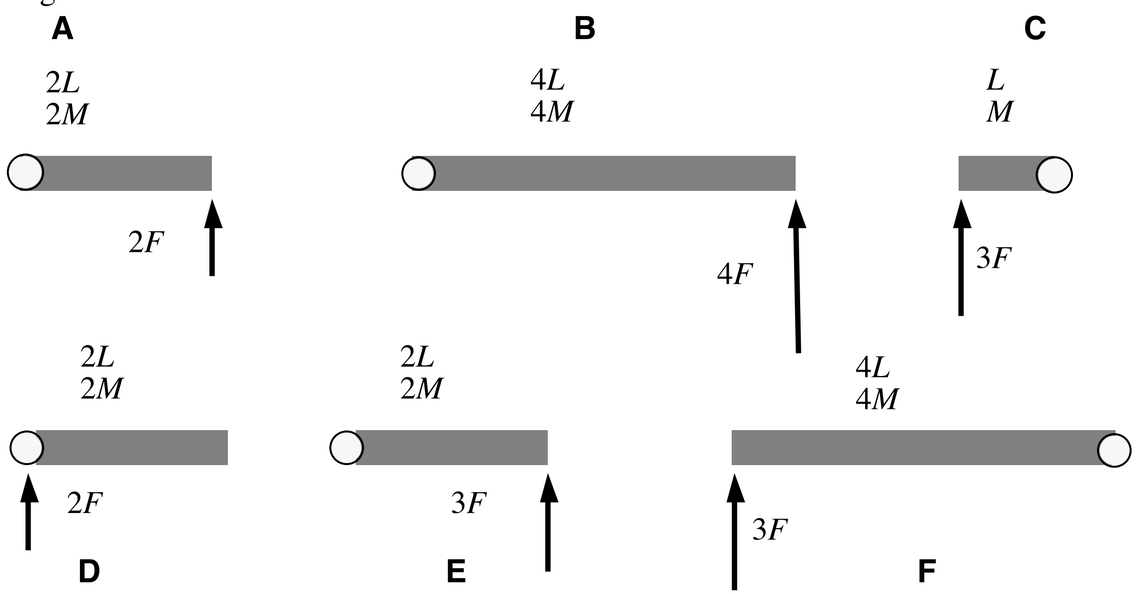
Shown below are seven situations where a student is holding a meter stick at the left end at various angles. A 1000 g mass is hung on the meter sticks at different locations. All of the meter sticks are identical, but the distance along the meter stick at which the 1000 g mass is hung and the angles at which the student holds the meter stick vary. Specific values are given in each figure. (Ignore the mass of the meter stick.)

Rank these situations, from greatest to least, on the basis of how difficult it would be for the student to hold the meter stick from the left end in the position shown. That is, put first the situation where it would be hardest to hold the meter stick at the angle shown and put last the situation where it would be easiest to hold it at the angle shown.



Shown below in a top view are six uniform rods that vary in mass (M) and length (L). Also shown are circles representing a vertical axis around which the rods are going to be rotated in a horizontal plane and arrows representing forces acting to rotate the rods. The forces change direction in order to always act perpendicular to the rods. Specific values for the lengths and masses of the rods and the magnitudes of the forces are given in each figure.

Rank these rods, from greatest to least, on the basis of the magnitude of their angular acceleration. That is, put first the rod that has the largest angular acceleration and put last the one that will have the smallest angular acceleration.



Greatest 1________ 2________ 3________ 4________ 5________ 6_______ Least

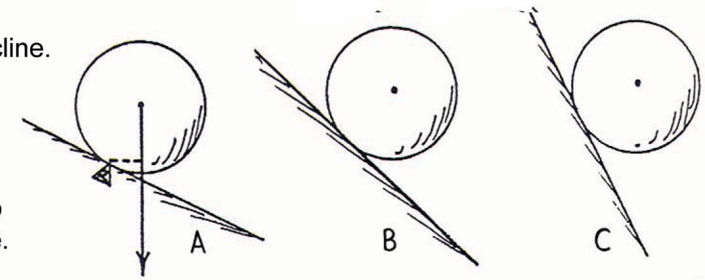
Or, all six of these rods will have the same magnitude angular acceleration. _________

Please carefully explain your reasoning.

Example 2: A dumb bell consisting of two 10.0kg masses 50.0cm apart is rotating about its center of mass. Find the torque required to slow it uniformly from 5.00rpm to rest in 3.00s.

CONCEPTUAL Physics PRACTICE PAGE

2. We all know that a ball rolls down an incline. But only a few people know that the reason a ball picks up rotational speed is because of a torque. In sketch A, we see a torque acting on a ball. Note the force due to gravity and the lever arm to the point where surface contact is made.



a. Construct the lever arms for positions B and C.

b. As the incline becomes steeper, the torque [increases] [decreases] [remains the same].

Lecture 24 - Summary

Definition of Torque $\tau = F_{\perp} r$

The size of the torque depends upon:

- The size of the force
- The distance from the pivot
- The component of the force perpendicular to the distance from the pivot.

Newton's First Law of Rotation
"Every object will move with a constant angular velocity unless a torque acts on it."

Newton's Second Law of Rotation
"Angular Acceleration of an object is directly proportional to the net torque acting on it and inversely proportional to its rotational inertia."

Newton's Second Law for Rotation $\Sigma\tau = I\alpha$