TORQUE WITH MOTION EQUATIONS

● Similar to Force problems, some Torque problems will require both _______________ AND rotational motion equations.

- Remember: The variable that connects *Newton's 2nd Law* & *Motion Equations* is ____________________ (____).

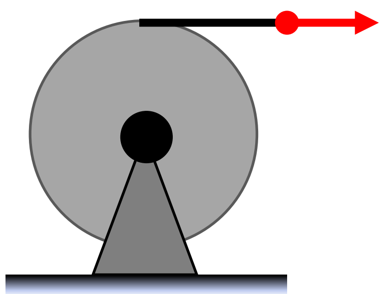
EXAMPLE: A solid sphere, 200 kg in mass and 6 m in diameter, spins about an axis through its center with 180 RPM clockwise. How much torque is needed to stop it in just 10 s?

UAM EQUATIONS
(1) $w = w_o + \alpha t$
(2) $w^2 = w_o^2 + 2 \alpha \Delta\Theta$
(3) $\Delta\Theta = w_o t + \frac{1}{2} \alpha t^2$
*(4) $\Delta\Theta = \frac{1}{2} (w_o + w) t$

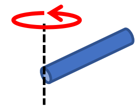
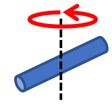
PRACTICE: TORQUE WITH MOTION / ROPE ON DISC

UAM EQUATIONS
(1) $w = w_o + \alpha t$
(2) $w^2 = w_o^2 + 2 \alpha \Delta\Theta$
(3) $\Delta\Theta = w_o t + ½ \alpha t^2$
*(4) $\Delta\Theta = ½ (w_o + w) t$

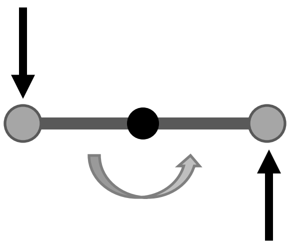
PRACTICE**:** A light, long rope is wrapped around a solid disc, in such a way that pulling the rope causes the disc to spin about a fixed axis perpendicular to itself and through its center. The disc has mass 40 kg, radius 2 m, and is initially at rest, and the rope unwinds without slipping. You pull on the rope with a constant 200 N. Use the rotational version of Newton's Second Law to calculate how fast (in rad/s) the disc be spinning after you pull 50 m of rope**.**



PRACTICE: TORQUE WITH MOTION / TWO FORCES ON A SYSTEM

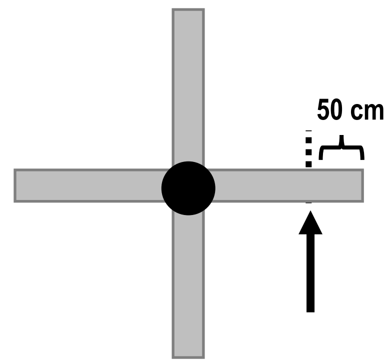
Common Moments of Inertia	
End of Rod 	$I = \frac{1}{3}mL^2$
Center of Rod 	$I = \frac{1}{12}mL^2$

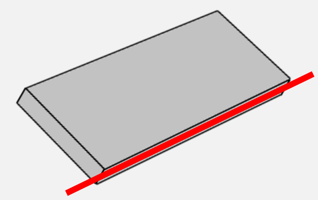
PRACTICE**:** A system is made of two small, 3 kg masses attached to the ends of a 5 kg, 4 m long, thin rod, as shown. The system is free to rotate about an axis perpendicular to the rod and through its center. Two forces, both of magnitude F and perpendicular to the rod, are applied as shown below. What must the value of F be to the system from rest to 10 rad/s in exactly 8 complete revolutions?



PRACTICE: TORQUE WITH MOTION / ROTATING DOORS

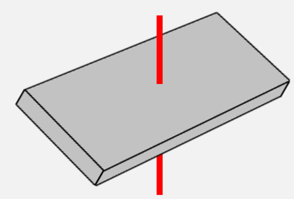
PRACTICE**:** Two rotating doors, each 6.0 m long, are fixed to the same central axis of rotation, as shown (top view). When you push on one door with a constant 100 N, directed perpendicular from the face of the door and 50 cm from its outer edge, the rotating door system takes 8 s to complete a full revolution from rest. The doors can be modeled as thin rectangles (moments of inertia for thin rectangles, around two different axes, are shown for reference). Calculate the mass of the system**.**





$I = 1/3\ m\ A^2$

A = side that extends away from axis

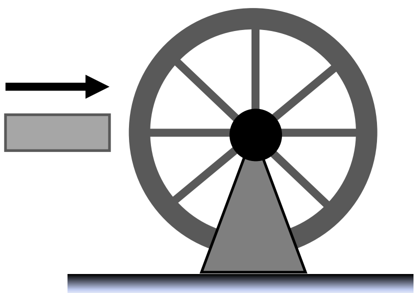


$I = 1/12\ m\ (A^2 + B^2)$

A and B = sides on face of rectangle

EXAMPLE: TORQUE WITH MOTION / STOPPING WITH FRICTION

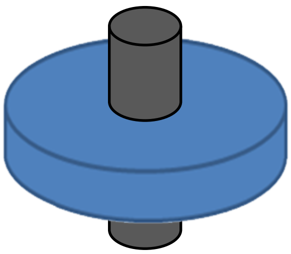
EXAMPLE**:** A flywheel is a rotating disc that is used to store energy. Suppose a flywheel has 8×10^4 kg in mass, 5.0 m in diameter, and is setup vertically, as shown below, free to spin around a fixed, frictionless, perpendicular axis through its center. To slow down the flywheel, you push a block against its outer rim. If the coefficients of friction between the block and the flywheel's rim are 0.6 and 0.8, how hard would you have to push against the flywheel so that it comes to a complete stop, from 300 RPM, in just 30 s**?** You may assume that the wheel's entire mass is concentrated on its outer rim**.**

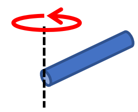
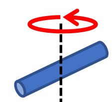
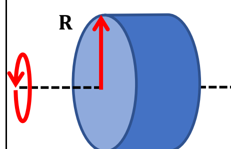
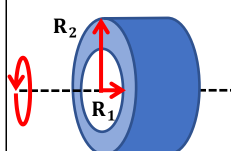


PRACTICE: TORQUE WITH MOTION / STOPPING WITH FRICTION

PRACTICE**:** A 1,000 kg disc that has a 5 m outer radius is mounted on a vertical, inner axle 80 kg in mass and 1 m in radius**.** A motor acts on the axle to speed up or slow down the system**.** Suppose the motor stops functioning when the system is spinning at 70 rad/s**.** To bring it to a complete stop, you apply a constant 200 N friction to the surface of the axle. How many revolutions will the system take to stop**?**

(Note there are two objects (two I's) and that the larger disc is NOT a solid cylinder)



Common Moments of Inertia	
End of Rod 	$I = \frac{1}{3}mL^2$
Center of Rod 	$I = \frac{1}{12}mL^2$
Solid Cylinder 	$I = \frac{1}{2}MR^2$
Thick-Walled Cylinder 	$I = \frac{1}{2}M(R_1^2 + R_2^2)$