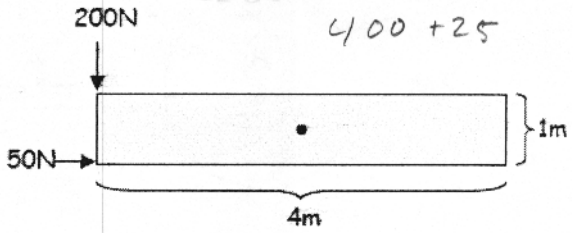
Rotational Motion Review KEY

$\Sigma\tau = 200N \cdot 2m + 50N \cdot 0.5m$

$400 + 25$

1. Calculate the net torque acting on the 5kg object, about an axis perpendicular to the page passing through its center.



a. 200Nm **b.** 300Nm **c.** 350Nm **d.** 375Nm **e.** 425Nm

2. A 5m-radius disk starts from rest at t=0s and begins to rotate about its central axis with a rotational acceleration of 5rad/s2. How many radians has it passed through by the time t=4s?

a. 10 **b.** 20 **c.** 40 **d.** 80 **e.** 160

$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

3. For the situation described in #2, what is the linear velocity, in meters per second, of a point on the disk's edge at time t=4s?

a. 4 **b.** 20 **c.** 25 **d.** 50 **e.** 100

$\omega = \omega_0 + \alpha t$

$V = r\omega$

4. A circular hoop of mass M and radius R rolls down an incline without slipping, from an initial height H. Its translational kinetic energy at the bottom of the incline is which one of the following?

a. MgH **b.** greater than MgH **c.** less than MgH **d.** ½MR² **e.** ¼MR²

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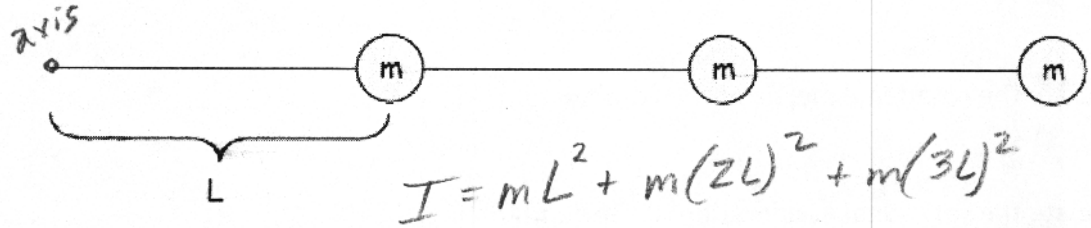


$I = mL^2 + m(2L)^2 + m(3L)^2$

5. Three equal masses are connected at equal distances along a rod of length 3L and negligible mass. What is the moment of inertia about the left end of the rod?

a. $3mL^2$ **b.** $9mL^2$ **c.** $14mL^2$ **d.** $17mL^2$ **e.** $27mL^2$

$mL^2 + 4mL^2 + 9mL^2$

$14mL^2$

6. The rotational acceleration of an object as a function of time is given by $3t_2$. Calculate the rotational speed, in rad/s, of the object at time t=4 seconds.

a. 12 **b.** 24 **c.** 40 **d.** 48 **e.** 64

$\alpha = 3t^2$

$\omega = 6t$

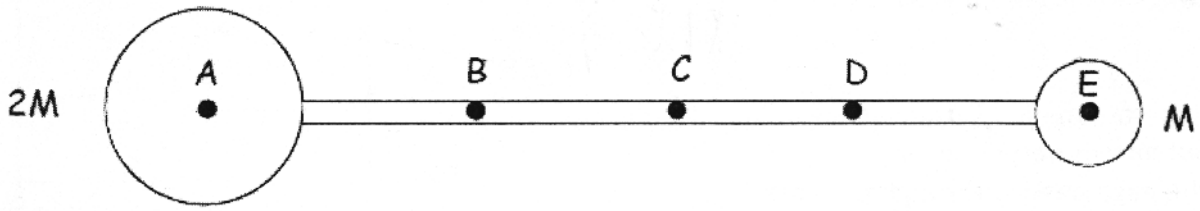
7. A 1kg hoop of radius 2m is rotating about its center with an angular speed of 3rad/s. What is the rotational kinetic energy of the hoop?

a. 4J **b.** 6J **c.** 12J **d.** 18J **e.** 20J

$K = \frac{1}{2}I\omega^2$

$\frac{1}{2}mr^2\omega^2$

$\frac{4 \times 9}{2}$



8. A sphere of mass M is connected to a sphere of mass 2M by a rigid rod of negligible mass, as shown in the above diagram. Which of the five lettered points is the best location for a perpendicular axis that will lead to the lowest rotational inertia, and therefore allow for the easiest rotation?

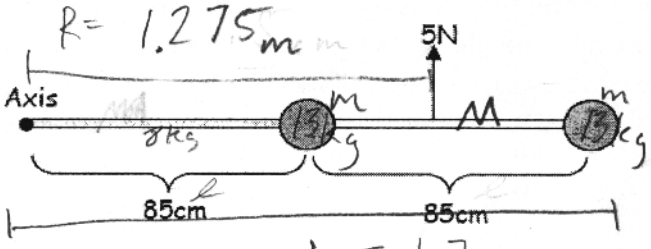
a. A **b.** B **c.** C **d.** D **e.** E

Problem

9. Two masses on a frictionless horizontal plane, each with mass of 13kg, are attached to each other and to a rotation axis, by two 85cm-long thin rods of mass 8kg. The combination starts from rest, and is acted on by a 5N force that pulls perpendicularly to the length of the rods, at a location halfway between the two masses. (The force remains perpendicular to the rods even when they begin to rotate.)

$M = 16kg$ rod

$R = 1.275m$



$L = 1.7m$

a. Calculate the rotational inertia of the combination.

$I = \frac{1}{3}ML^2 + m\ell^2 + mL^2 = 15.4 + 9.39 + 37.57 = \boxed{62.36\ kg\cdot m^2}$

b. Calculate the rotational acceleration of the combination.

$\tau = I\alpha \qquad \alpha = \frac{\tau}{I} = \frac{6.375}{62.36} = \boxed{0.1\ rad/s^2} \qquad \tau = 5N \cdot 1.275m$

c. Calculate the rotational kinetic energy of the combination, 3 seconds after the 5N force begins acting.

$\omega = \alpha t = .3\ rad/s \qquad K = \frac{1}{2}I\omega^2 = \boxed{2.8J}$

10. A 3kg box is tied to a string that is wound tightly around the outside of a 2kg disk of radius 15cm. The disk is mounted on a fixed axis through its center (to behave like a pulley), and the box is released from rest to fall and unwind the disk. If there is no friction at the disk's axis, and if the string does not slip along the edge of the disk, find the speed of the box after it has fallen 92cm.

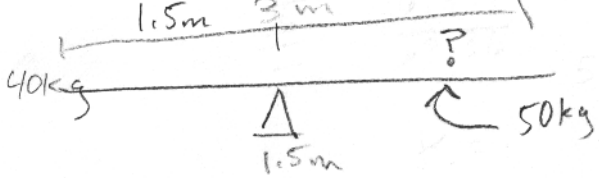
$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 \qquad gh = \frac{3}{4}v^2$

$mgh = \frac{1}{2}mv^2 + \frac{1}{4}mv^2$

$\sqrt{\frac{4gh}{3}} = v = \boxed{3.47\ m/s}$

14. Two children balance on a 3m-long teeter-totter with the pivot point directly under the center of the teeter-totter. The child on the left end has a mass of 40kg and sits on the edge of her seat. The child on the right has a mass of 50kg and must scoot in some from the edge in order to balance. How far from the pivot point does the child on the right sit?

$\Sigma\tau = 0$



$40kg \cdot 1.5m = 50kg \cdot X$

$\boxed{1.2m}$