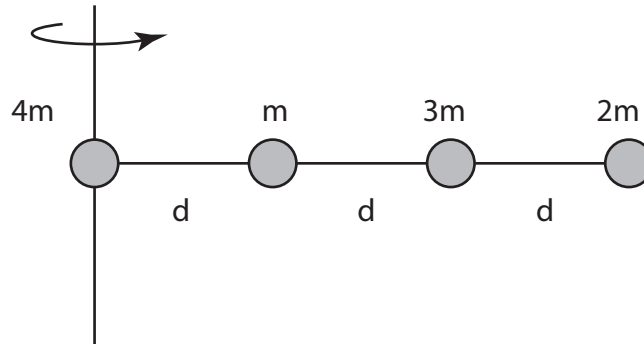
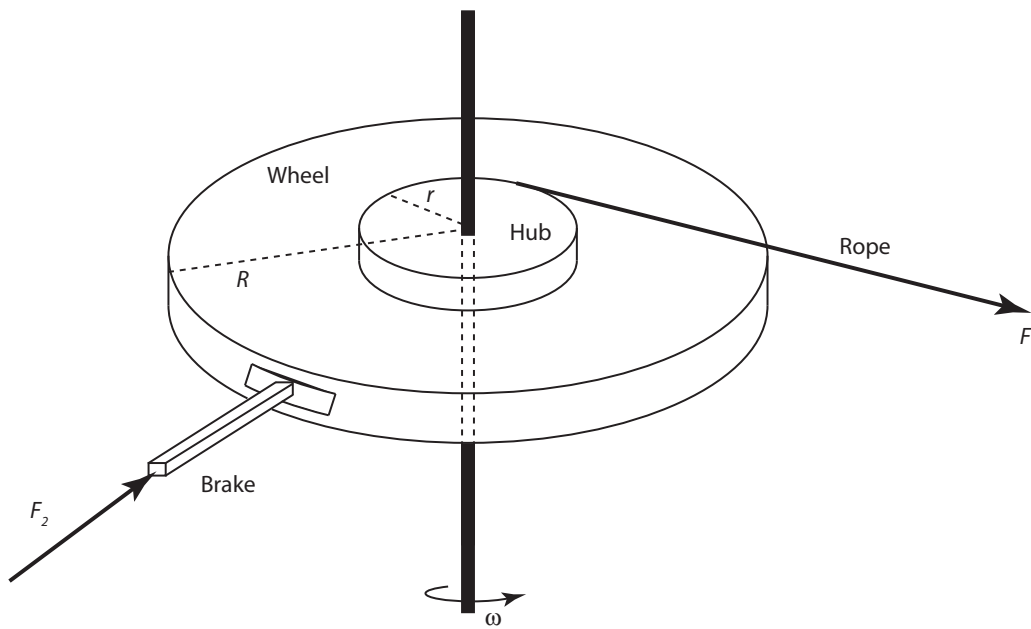


Rotational Dynamics of Rigid Objects

1. Four small masses are connected by a very light rod and allowed to rotate about an axis through the mass on the extreme left. Calculate the moment of inertia of the system as shown above, and repeat the calculation for similar axes passing through each of the other masses in turn.



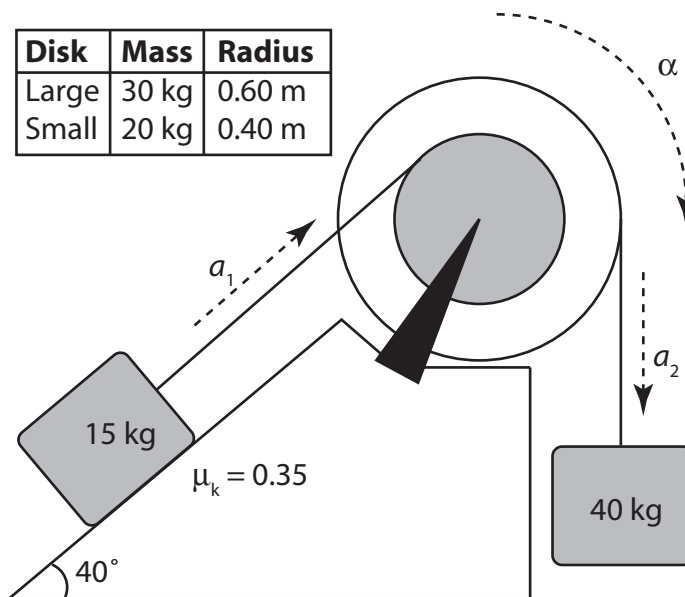
2. A solid circular flywheel ($R = 0.75$ m and $M = 40$ kg) has a thin rope wrapped around an inner hub ($r = 0.25$ m). The rope is pulled with a steady force (F_1) until the wheel is rotating at an angular velocity of 8.0 rad/s after 5 m of string has been unwound. The rope is then released and the wheel is slowed down to 3.0 rad/s in a further time of 2.0 s by means of a 75 N force (F_2) applied radially to a friction brake.
- Find the angular acceleration of the wheel during the first phase, the time taken to reach maximum velocity, and the magnitude of the force F_1 .
 - Find the number of revolutions the wheel makes during the braking period and the friction coefficient for the brake.



3. The radius of a roll of paper shown is 7.6 cm and its moment of inertia is $I = 2.9 \times 10^{-3} \text{ kg m}^2$. A force of 3.2 N is exerted on the end of the roll for 1.3 s, but the paper does not tear so it begins to unroll. A constant friction torque of magnitude 0.11 Nm is exerted on the roll which gradually brings it to a stop. Assuming that the paper's thickness is negligible, calculate the length of paper that unrolls during the time that the force is applied (1.3 s).



4. Two disks are glued together to form a composite pulley. Then strings are wrapped around them and attached to the 15 kg and 40 kg objects as shown, and the system is released from rest.



- Write down the 3 dynamics equations for the system;
- express a_1 and a_2 in terms of α ;
- solve for the values of a_1 , a_2 , α , and the tensions in the two strings.

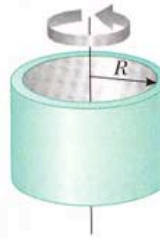
Answers

1. $31md^2, 15md^2, 19 md^2, 43md^2$
2. a) $\alpha = 1.6 \text{ rad/s}^2, t = 5 \text{ s}, F_1 = 72 \text{ N}$, b) $\Delta\theta = 1.75 \text{ rev}, \mu_k = 0.50$
3. $L = 2.95 \text{ m}$
4. $a_1 = 3.05 \text{ m/s}^2 \quad a_2 = 4.58 \text{ m/s}^2 \quad \alpha = 7.63 \text{ rad/s}^2 \quad T_1 = 179.7 \text{ N} \quad T_2 = 208.8 \text{ N}$

Table 10.2

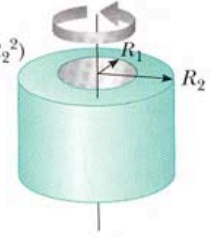
Moments of Inertia of Homogeneous Rigid Objects with Different Geometries

Hoop or thin cylindrical shell
 $I_{CM} = MR^2$

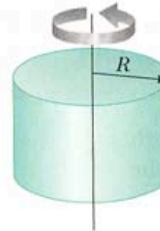


Hollow cylinder

$$I_{CM} = \frac{1}{2} M(R_1^2 + R_2^2)$$

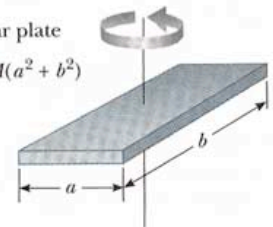


Solid cylinder or disk
 $I_{CM} = \frac{1}{2} MR^2$



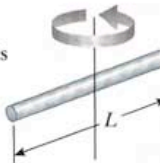
Rectangular plate

$$I_{CM} = \frac{1}{12} M(a^2 + b^2)$$



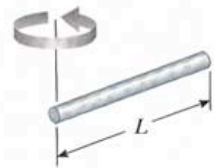
Long thin rod with rotation axis through center

$$I_{CM} = \frac{1}{12} ML^2$$

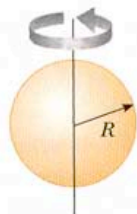


Long thin rod with rotation axis through end

$$I = \frac{1}{3} ML^2$$



Solid sphere
 $I_{CM} = \frac{2}{5} MR^2$



Thin spherical shell

$$I_{CM} = \frac{2}{3} MR^2$$

