Practice Problem Set 9 Solutions

1 Ch.10 Q.48

A pulley 12 cm in diameter is free to rotate about a horizontal axle. A 200-g mass and a 470-g mass are tied to either end of a massless string, and the string is hung over the pulley. Assuming the string doesn't slip, what torque must be applied to keep the pulley from rotating?

$\tau = rF\sin\theta$. In this case, r is the radius of the pulley. F is the tention of the string. θ is 90 degrees because the force vector and r are perpendicular to each other. The tension of the string equals the difference of the gravitational forces of the two masses. $F = (0.47\text{kg} - 0.2\text{kg}) \cdot 9.8\text{N/kg} = 2.65\text{N}$. $\tau = rF = 0.12\text{m} \cdot 2.65\text{N} = 0.32\text{N} \cdot \text{m}$

2 Ch.10 Q.59

A potter's wheel is a stone disk 90 cm in diameter with mass 120 kg. If the potter's foot pushes at the outer edge of the initially stationary wheel with a 75-N force for one eighth of a revolution, what will be the final speed?

The rotational inertia of the wheel $I = \frac{1}{2}MR^2 = 0.5 \cdot 120\text{kg} \cdot (0.45\text{m})^2 = 12.15\text{kg} \cdot \text{m}^2$. The torque $\tau = RF = 0.45\text{m} \cdot 75\text{N} = 33.75\text{N} \cdot \text{m}$. The work is the product of the torque and the angular displacement $W = 33.75\text{N} \cdot \text{m} \cdot \frac{2\pi}{8}\text{rad} = 26.5\text{J}$. The wheel is initially stationary, so the final rotational energy is 26.5 J. $K_{rot} = \frac{1}{2}I\omega^2$. $\omega = \sqrt{\frac{2 \cdot 26.5\text{J}}{12.15\text{kg} \cdot \text{m}^2}} = 2.1\text{rad/s}$

3 Ch.10 Q.62

A hollow ball rolls along a horizontal surface at 3.7 m/s when it encounters an upward incline. If it rolls without slipping up the incline, what maximum height will it reach?

When the ball rolls without slipping, it has both translational and rotational kinetic energies. $E_{tot} = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$. The rotational inertia of a hollow spherical shell about diameter $I = \frac{2}{3}mR^2$. And for the case of rolling without slipping, the angular velocity about the center of the ball $\omega = \frac{v}{R}$.

$$E_{tot} = \frac{1}{2}mv^2 + \frac{1}{2}\frac{2}{3}mR^2 \cdot (\frac{v}{R})^2 = \frac{5}{6}mv^2$$

At the highest point, both translational and rotational kinetic energies are converted into gravitational potential.

$$E_{tot} = mgh = \frac{5}{6}mv^2$$

$$h = \frac{5}{6}v^2/g = 1.2\text{m}$$