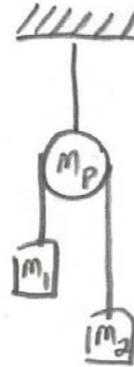


~~**Problem 6: escape speed of moon**~~

~~Find the escape speed of a rocket from the moon. Ignore the rotational motion of the moon. The mass of the moon is $m = 7.36 \times 10^{22} \text{ kg}$. The radius of the moon is $R = 1.74 \times 10^6 \text{ m}$.~~

Problem 7: (Torque and angular acceleration)

A pulley of mass m_p , radius R , and moment of inertia $I_{cm} = (1/2)m_p R^2$ about the center of mass is hung from a ceiling with a massless string. A massless inextensible rope is wrapped around the pulley and attached on one side to an object of mass m_1 and on the other side to an object mass $m_2 > m_1$. At time $t = 0$, the objects are released from rest.



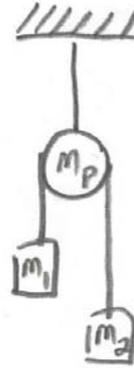
- Draw the free body diagram on the pulley and the two objects.
- Write down Newton's Second Law for the pulley and the two objects.
- Write down the rotational equation of motion for the pulley.
- Find the direction and magnitude of the translational acceleration of the two objects.
- How long does it take for the object of mass m_2 to fall a distance d ?
- What is the tension on the two sides of the rope?

~~**Problem 8: Projectile Motion**~~

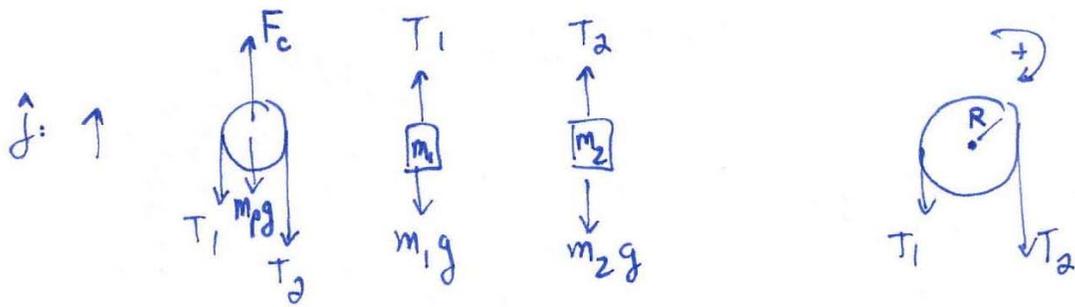
~~A bat hits a baseball into the air with an initial speed, $v_0 = 5.0 \times 10^1 \text{ m/s}$, and makes an angle $\theta = 3.0 \times 10^1$ deg with respect to the horizontal. How high does it go from the point where it was hit? How far does the ball travel if it is caught at exactly the same height that it is hit from? When the ball is in flight, ignore all forces acting on the ball except for gravitation.~~

Problem 7: (Torque and angular acceleration)

A pulley of mass m_p , radius R , and moment of inertia $I_{cm} = (1/2)m_p R^2$ about the center of mass is hung from a ceiling with a massless string. A massless inextensible rope is wrapped around the pulley and attached on one side to an object of mass m_1 and on the other side to an object mass $m_2 > m_1$. At time $t = 0$, the objects are released from rest.



- Draw the free body diagram on the pulley and the two objects.
- Write down Newton's Second Law for the pulley and the two objects.
- Write down the rotational equation of motion for the pulley.
- Find the direction and magnitude of the translational acceleration of the two objects.
- How long does it take for the object of mass m_2 to fall a distance d ?
- What is the tension on the two sides of the rope?



pulley: $F_c - T_1 - T_2 - m_p g = 0$

mass m_1 : $T_1 - m_1 g = m_1 a_1$

mass m_2 : $T_2 - m_2 g = m_2 a_2$

constraint condition: $a \equiv a_1 = -a_2 > 0$

torque equation: $T_2 R - T_1 R = I_{cm} \alpha$

rope not slipping: $a = R \alpha > 0$ since $m_2 > m_1$

$$(T_2 - T_1) R = \frac{I_{cm} a}{R}$$

Solve for acceleration:
$$\left. \begin{aligned} T_1 - m_1 g &= +m_1 a \\ T_2 - m_2 g &= -m_2 a \end{aligned} \right\} \text{subtract}$$

$$(T_2 - T_1) - (m_2 - m_1)g = -(m_2 + m_1)a$$

moment of inertia of:

$$I_{cm} = \frac{1}{2} m_p R^2$$

$$\Rightarrow (T_2 - T_1) R = \frac{1}{2} m_p R^2 \frac{a}{R} = \frac{1}{2} m_p a R$$

$$\Rightarrow (T_2 - T_1) = \frac{1}{2} m_p a$$

$$(T_2 - T_1) - (m_2 - m_1)g = -(m_1 + m_2)a$$

$$\frac{1}{2}m_p a - (m_2 - m_1)g = -(m_1 + m_2)a$$

$$a = \frac{(m_2 - m_1)g}{\left(\frac{1}{2}m_p + (m_1 + m_2)\right)} = a_1 = -a_2$$

$$d = \frac{1}{2}at^2 \Rightarrow t = \left(\frac{2d}{a}\right)^{1/2}$$

$$t = \left(\frac{2d}{(m_2 - m_1)g} \left(\frac{1}{2}m_p + (m_1 + m_2)\right)\right)^{1/2}$$

$$T_1 = m_1 a + m_1 g$$

$$T_1 = \left(\frac{m_1(m_2 - m_1)}{\frac{1}{2}m_p + (m_1 + m_2)} + m_1\right)g$$

$$T_1 = \frac{\left(\frac{1}{2}m_p m_1 + 2m_1 m_2\right)g}{\frac{1}{2}m_p + (m_1 + m_2)}$$

$$T_2 = -m_2 a + m_2 g = \left(m_2 - \frac{m_2(m_2 - m_1)}{\frac{1}{2}m_p + (m_1 + m_2)}\right)g$$

$$T_2 = \left(\frac{\frac{1}{2}m_p m_2 + 2m_1 m_2}{\frac{1}{2}m_p + (m_1 + m_2)}\right)g$$