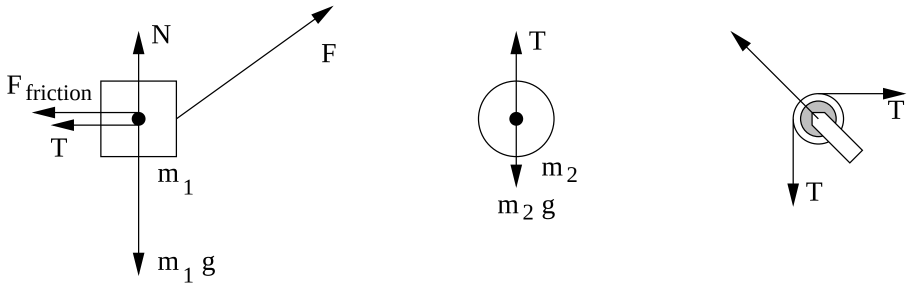
Problem 1 Solution:

(a)



(b) The block m_1 moves in x-direction:

$$m_1 a = F\cos\theta - T - N\mu, \qquad N = m_1 g - F\sin\theta$$

The block m_2 moves in y-direction:

$$m_2 a = T - m_2 g$$

Put in the values of m_1, m_2, F, and μ, we obtain

$$\begin{aligned} 3Ma =& 4Mg\frac{4}{5} - T - \frac{1}{3}(3Mg - \frac{12Mg}{5}) \\ Ma =& T - Mg \end{aligned}$$

Add the above two equation together

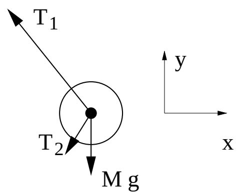
$$4Ma = 2Mg$$

We find $a = \frac{1}{2}g$.
For block m_1: $\vec{a}$ points to the right and $|\vec{a}| = a$
For block m_2: $\vec{a}$ points up and $|\vec{a}| = a$

(c) $T = Ma + Mg = Mg\frac{3}{2}$

Problem 2 Solution:

(a)



(b) Distance between the ball and the rod $r = \sqrt{5^2 - 4^2}L = 3L$.
Speed of the ball $v = \frac{2\pi r}{T} = \frac{6\pi L}{T}$.

(c) The acceleration $\vec{a}$ points to the left.
Its magnitude is $|\vec{a}| = \frac{v^2}{r} = \frac{12\pi^2 L}{T^2}$.

(d) The the x- and y-components of the force on the ball from the upper string: $\vec{F}_1 = (-T_1\frac{3}{5}, T_1\frac{4}{5})$
The the x- and y-components of the force on the ball from the lower string: $\vec{F}_1 = (-T_2\frac{3}{5}, -T_2\frac{4}{5})$
Newtons law for y-direction

$$0 = T_1\frac{4}{5} - T_2\frac{4}{5} - Mg$$

Newtons law for x-direction

$$-M|\vec{a}| = -T_1\frac{3}{5} - T_2\frac{3}{5}$$

We find

$$T_1 - T_2 = Mg\frac{5}{4}$$
$$T_1 + T_2 = M|\vec{a}|\frac{5}{3}$$

or

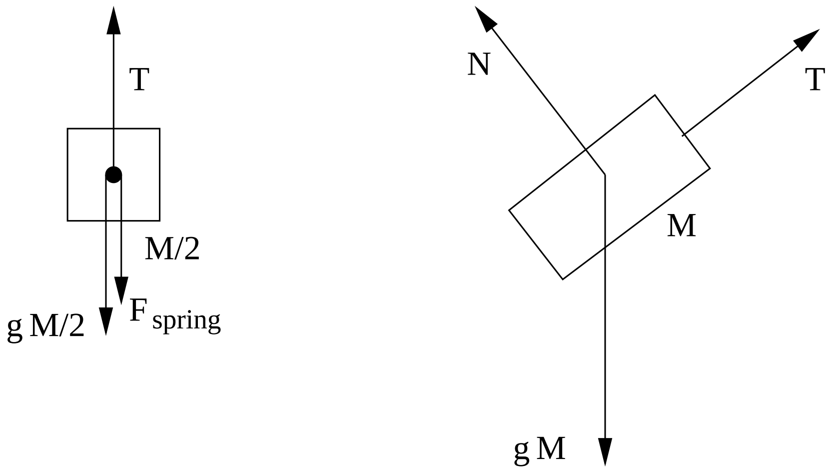
$$T_1 = Mg\frac{5}{8} + M|\vec{a}|\frac{5}{6} = Mg\frac{5}{8} + M\frac{10\pi^2 L}{T^2}$$

(e)

$$T_2 = -Mg\frac{5}{8} + M|\vec{a}|\frac{5}{6} = -Mg\frac{5}{8} + M\frac{10\pi^2 L}{T^2}$$

Problem 3 Solution:

(a)



(b) Assume the potential energy is zero when the string is unstretched. After we pull the M block by a distance L, the potential energy of the M block is lower by $MgL\sin\theta$, the potential energy of the $M/2$ block is increased by $\frac{M}{2}gL$, and the potential energy of the spring is increased by $\frac{1}{2}kL^2$. So the total potential energy of the system is

$$U_1 = -MgL\sin\theta + \frac{M}{2}gL + \frac{1}{2}kL^2 = \frac{1}{2}kL^2$$

When the M block moves to the position where the spring is unstretched, U_1 is converted to the kinetic energy $K = \frac{1}{2}Mv^2 + \frac{1}{2}\frac{M}{2}v^2 = U_1$. We find

$$v = \sqrt{2\frac{U_1}{M+\frac{M}{2}}} = L\sqrt{\frac{2k}{3M}}$$

(c) Let L_2 be the distance by which the M block moves up the plane from the position where the spring is unstretched. The kinetic energy of the block M, $\frac{1}{2}Mv^2$, turns into its potential energy $L_2 = Mg\sin\theta$:

$$MgL\sin\theta = \frac{1}{2}Mv^2 = \frac{1}{2}M\frac{2kL^2}{3M}$$

We find

$$L_2 = \frac{2kL^2}{3Mg}, \qquad \text{or} \quad h = L_2\sin\theta = \frac{kL^2}{3Mg}$$

Problem 4 Solution:

(a) c

(b) a

(c) b

(d) e

(e) c