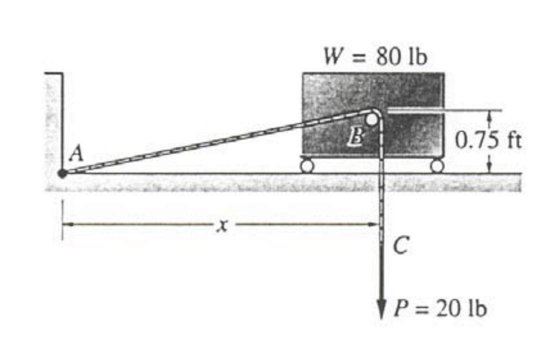
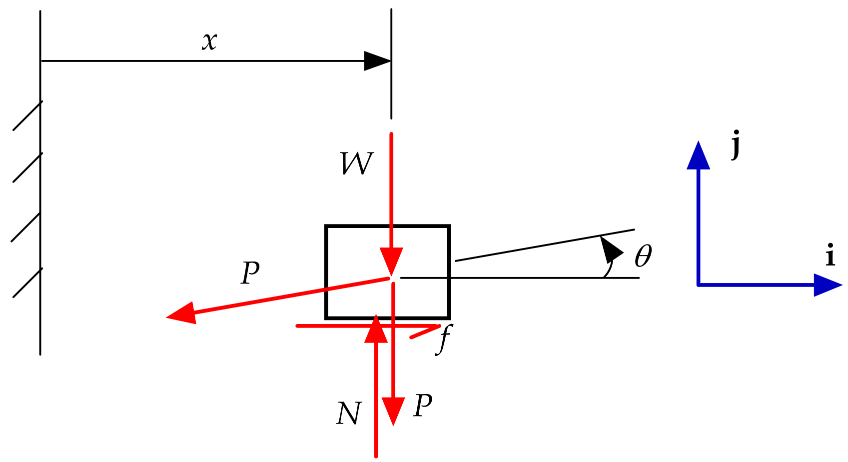
Example 7.3

The rope *ABC* passes over a frictionless peg *B* that is attached to the 80-lb block. A constant vertical force of 20 lb is applied to the end of the rope. The coefficient of kinetic friction between the block and the plane is 0.2. If the block has a velocity of 5 ft/s to the left when x = 6 ft, determine its acceleration in this position.



Solution:

The free-body diagram for the block is shown below. Note that the friction force *f* is shown pointing to the right because the problem states that the block is moving to the left at the specified instant.



Writing dynamic balance equations in the horizontal and vertical directions we obtain:

$$-P\cos\theta + f = m\ddot{x}$$

$$N - W - P - P\sin\theta = 0$$

Since the friction force is given by $f = \mu N$ the first equation can be written as

$$-P\cos\theta + \mu\left(W + P + P\sin\theta\right) = m\ddot{x}$$

The trigonometric quantities can be written in terms of x as

$$\cos\theta = \frac{x}{\sqrt{x^2 + (0.75)^2}}$$

$$\sin\theta = \frac{0.75}{\sqrt{x^2 + (0.75)^2}}$$

Substituting the given values for all the variables we obtain for the acceleration of the block

$$\ddot{x} = \frac{P}{m}\left[\mu\left(1 + \frac{0.75}{\sqrt{x^2 + (0.75)^2}}\right) - \frac{x}{\sqrt{x^2 + (0.75)^2}}\right] + \mu g$$

$$= \frac{20}{80/32.2}\left[0.2\left(1 + \frac{0.75}{\sqrt{(6)^2 + (0.75)^2}}\right) - \frac{6}{\sqrt{(6)^2 + (0.75)^2}}\right] + (0.2)(32.2) = 0.262\ \text{ft/s}^2$$

The positive sign indicates that the block is slowing down at the instant given (since it is moving to the left and x is measured toward the right).