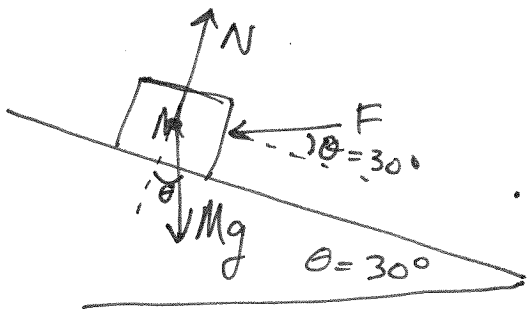
Chapter 5 Problem 90

Given

$M = 5.00\ kg$

$F = 65.0\ N$

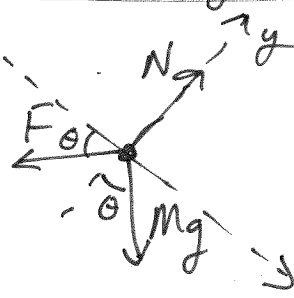
$\theta = 30°$



Find the magnitude of the acceleration of the block

The Free-Body diagram is given to the right. The x-axis is lined up with downslope and the y-axis is lined up with the perpendicular to the ramp.

Free-Body Diagram



Use Newton's 2nd Law

$$\Sigma \vec{F} = m\vec{a}$$

$$\vec{F} + \vec{W} + \vec{N} = m\vec{a}$$

Using the coordinate system

$\vec{F} = -F\cos\theta\,\hat{i} - F\sin\theta\,\hat{j}$

$\vec{W} = Mg\sin\theta\,\hat{i} - Mg\cos\theta\,\hat{j}$

$\vec{N} = N\hat{j}$

$$-F\cos\theta\,\hat{i} - F\sin\theta\,\hat{j} + Mg\sin\theta\,\hat{i} - Mg\cos\theta\,\hat{j} + N\hat{j} = Ma\,\hat{i}$$

x-dir:

$$-F\cos\theta + Mg\sin\theta = Ma \quad (\#1)$$

y-dir:

$$-F\sin\theta\,\hat{j} - Mg\cos\theta + N = 0 \quad (\#2)$$

Since we only want the acceleration, we can use the first equation and solve for a.

$$-\frac{F\cos\theta}{M} + \frac{Mg\sin\theta}{M} = a \rightarrow a = g\sin\theta - \frac{F}{M}\cos\theta$$

The block will accelerate up the ramp.

Substitute in the given values

$$a = \left(9.80\frac{m}{s^2}\right)\sin(30°) - \frac{65.0\,N}{5.00\,kg}\cos(30°)$$

$$= 4.9\ m/s^2 - 11.3\ m/s^2 = \boxed{6.36\ m/s^2}$$