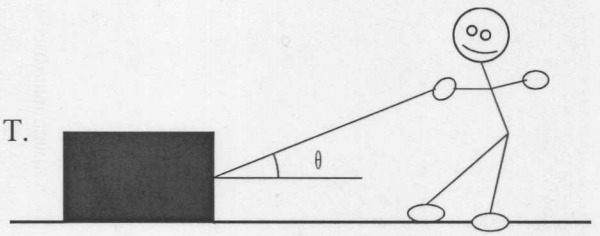
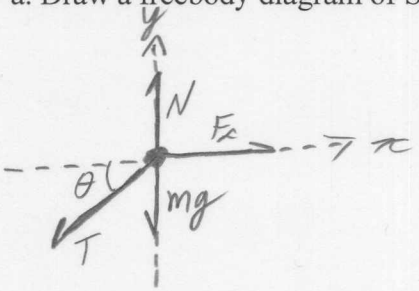
Force Problems

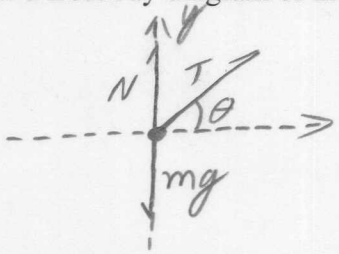
While standing on a rough surface, Stickman is pulling an ice block to the right with a tension T.



a. Draw a freebody diagram of Stickman. (He does not slide)



b. Draw a freebody diagram of the ice block. (It's frictionless)



c. Assume that the Box is frictionless and calculate the velocity of the box after it has traveled a distance d starting from rest. Your velocity should be in terms of m,T, θ, and d.

x: $T\cos\theta = ma_x$

y: $N + T\sin\theta - mg = \cancel{ma_y}^{\,0}$

From x: $a = \dfrac{T\cos\theta}{m}$

to get velocity given an acceleration, we use kinematics:

$$\frac{dv_x}{dt} = a \Rightarrow \int_0^{v_f} dv = \int_0^t a\,dt \Rightarrow v_f = at \Rightarrow \boxed{v_f = \frac{T\cos\theta}{m}t} \quad ①$$

$$\frac{dx}{dt} = v \Rightarrow \int_0^d dx = \int_0^t v\,dt \Rightarrow \boxed{d = \frac{1}{2}\frac{T\cos\theta}{m}t^2} \quad ②$$

continued ↓

Solve ① for t:

$$t = \frac{m v_f}{T \cos\theta}$$

Plug into ②

$$d = \frac{1}{2} \frac{\cancel{T}\cos\theta}{\cancel{m}} \cdot \frac{m^{\cancel{2}} v_f^2}{T^{\cancel{1}} \cos^{\cancel{2}}\theta} = \frac{1}{2} \frac{m v_f^2}{T \cos\theta}$$

and solve for v_f:

$$\boxed{v_f = \left[\frac{2dT\cos\theta}{m}\right]^{1/2}}$$