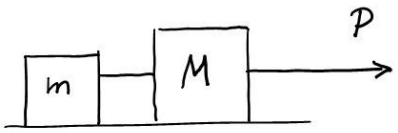
Physics 1145 Homework #7: Newton's 2nd law, friction, interacting objects, circular motion

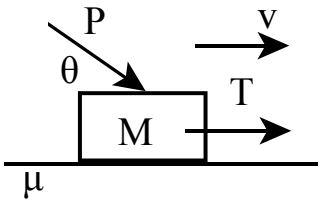
Remember to draw a fully labeled free-body diagram for every object and to begin with Newton's 2nd Law.

1. Two crates with treasure, a small one with mass m=100kg and a large one with mass *M*=300kg are connected by a massless rope and are on a frozen lake which you may assume to be frictionless. A rope is attached to the front of the heavy crate, and a band of dwarves, which stand at the shore and dig their heels into the soil so they do not slip, are pulling with a horizontal force that causes the crates to accelerate with an acceleration of 2 m/s^2.



Determine the magnitude of the pulling force and the tension in the rope that connects the crates.

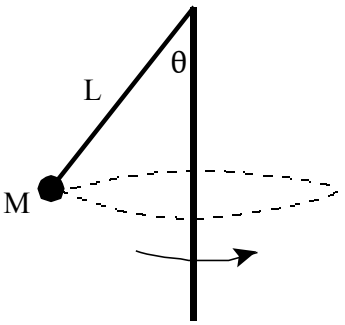
2. Two students are moving a heavy crate of mass *M* across a rough horizontal floor. One student applies a constant force of magnitude *P* that is directed an angle θ down from the horizontal. The other student pulls with a horizontal force of magnitude *T*. The coefficient of kinetic friction between the crate and the floor equals μ. The crate is moving to the right.



Derive expressions for the normal force, the force of kinetic friction, and the crate's acceleration.

3. A toy car of mass 1.2 kg is driving vertical circles inside a hollow cylinder of radius 2.0m. It is moving at a constant speed of 6 m/s.
a) Calculate the magnitude of the normal force acting on the car when it is on the top of the circle and when it is on the bottom of the circle, respectively.
b) What is the minimum speed the car needs to go around the circle without falling off?

4. A tetherball of mass M=1.0kg is hanging from a string of length L=1.0m. The ball is moving in a horizontal circle so that the string makes an angle θ=12° with the vertical.
Calculate the tension in the string and the speed of the ball.



5. A curve of radius R= 100m is banked at an angle θ= 15°. Derive a symbolic answer and calculate a numerical value for the speed at which the car can take this curve **without friction**.