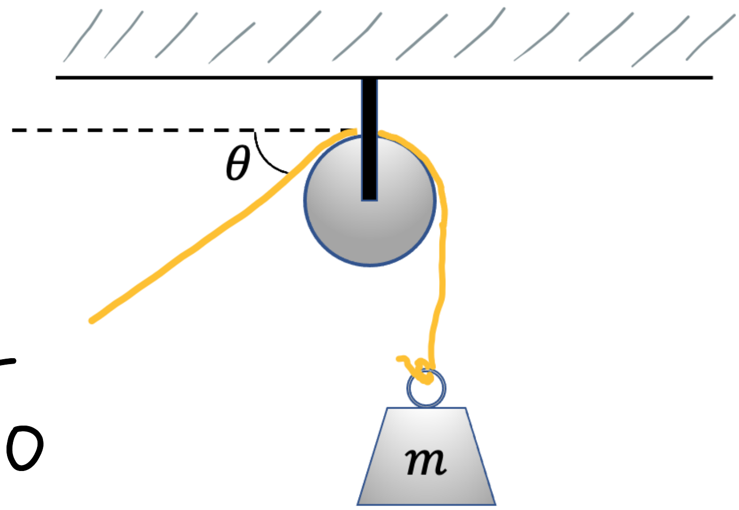
Problem 1

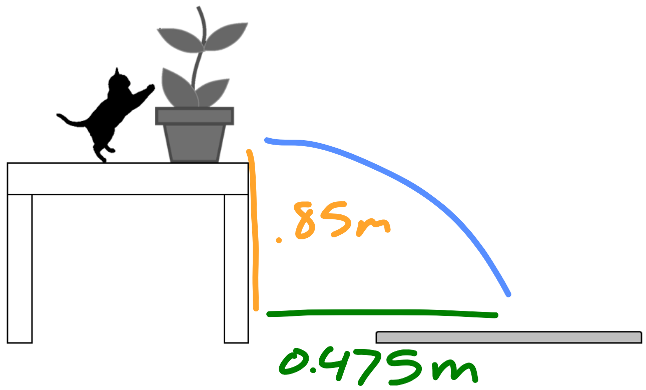
Mass m has been lifted off the ground and is being held stationary by someone who is pulling on the free end of a light rope. The rope wraps around a pulley with negligible mass/friction, making an angle of θ with respect to the horizontal. When $\theta = 0°$, the tension in the rope is measured to be T_0. When $\theta = 45°$, the tension in the rope is measured to be T_{45}. When $\theta = 90°$, the tension in the rope is measured to be T_{90}. Rank these three tensions according to their magnitudes using the symbols $<, >$, and $=$.



$T_{90} > T_{45} > T_0$

Problem 2

The cat shown below pushes a plant with mass $m = 4.50\,\text{kg}$ off the table in order to create a huge mess on the carpet. The plant's vertical displacement as it falls is $\Delta y = -85.0\,\text{cm}$, and the edge of the carpet is located $\Delta x = 47.5\,\text{cm}$ away from the base of the table. For this problem, model the plant as a point particle and assume that its launch velocity is perfectly horizontal.



Δx
Δy
a
V_0

(a) Find a **symbolic** expression for the minimum launch speed the plant must have in order to hit the carpet. Don't plug in any numbers yet – your answer should be stated in terms of the given parameters of the problem ($\Delta x, \Delta y$, etc.).

$$\Delta y = \cancel{V_0 t} + \frac{1}{2}at^2 \rightarrow t = \sqrt{\frac{2\Delta y}{a}}$$ .416

$$\Delta d = \sqrt{\Delta x^2 + \Delta y^2}$$ .974

$$\Delta d = V_0 t + \frac{1}{2}at^2 \rightarrow V_0 t = \Delta d - \frac{1}{2}at^2 \rightarrow V_0 = \frac{\Delta d}{t} - \frac{1}{2}at$$

$$\Delta x = V_0 \sqrt{\frac{2\Delta y}{a}}$$ .303

(b) Perform a units check on the expression you found above. Prove that it has the correct units for speed.

$$\sqrt{\frac{m}{m/s^2}} \rightarrow \sqrt{s^2} \rightarrow \boxed{s}$$

$$\sqrt{m^2 + m^2} \rightarrow \sqrt{m^2} \rightarrow \boxed{m}$$

$$\frac{m}{s} - \left(\frac{m}{s^2}\right)(s) \rightarrow \frac{m}{s} - \frac{m}{s} \rightarrow \boxed{m/s}$$

(c) Perform a limits check on the expression you found above: as the carpet is moved far away from the table ($\Delta x \to \infty$), what value does v_i approach according to your equation?

$$\lim_{\Delta x \to \infty} V_i = \infty$$

(d) Can you make physical sense out of this limiting value for v_i? Explain your thinking.

A greater initial velocity is required to cover a greater distance.

(e) Now that you're reasonably confident that you derived the correct formula, use the values given in the problem statement to calculate the plant's minimum launch speed.

$t = .416\ s$

$\Delta d = .974\ m$

$\boxed{V_i = .303\ m/s}$

(f) Perform one final check on your answer: is the numerical value you obtained in part (e) reasonable? Explain your thinking.

Yes, because there is an added acceleration of gravity on top of the initial velocity that would cause the time to be what it is.