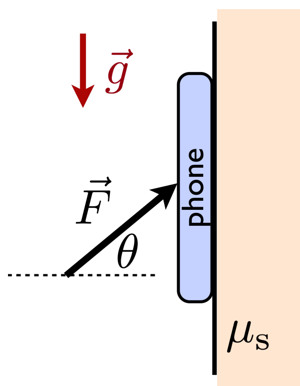
PHY254 Homework Problems #1, Fall 2020

Due Wednesday, October 7th, at midnight, sharp.

Homework Grading Policy. Read the Homework Policy posted on Quercus. Did you read and understand the policy? A "Yes" should be answered truthfully before continuing with these homework problems.

1. **Statics: holding a phone against a rough wall.**.

   A phone of mass m is positioned up against a vertical wall. The coefficient of static friction between the phone and the wall is μ_s. An external force $\vec{F}$ is applied to the phone at an angle $\theta = 45° = \pi/4$ radians.



   (a) Suppose that the magnitude of F is equal to the weight of the phone mg. Find the minimum value of the static friction coefficient μ_s such that the phone does not slide *down* the wall.

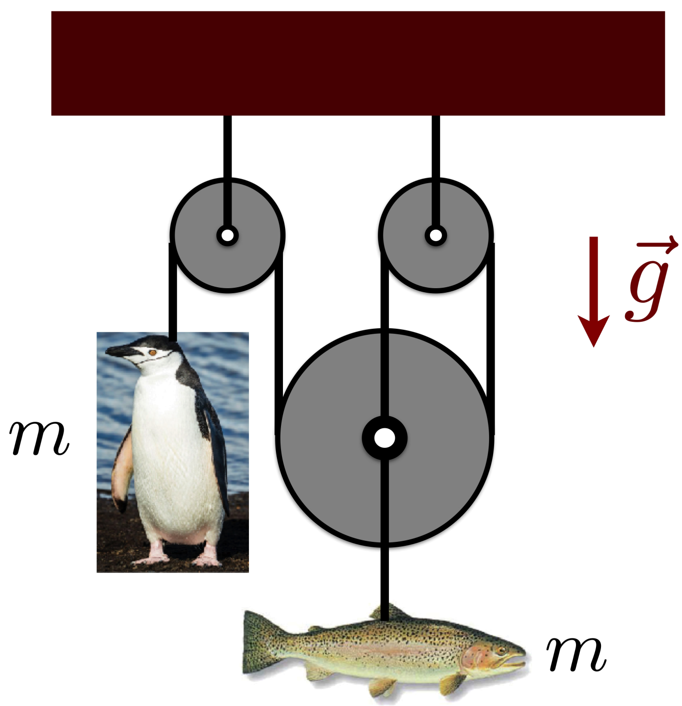
   (b) Now suppose that the magnitude of the applied force is slowly increased from $F = mg$ to $\beta F = \beta mg$, with $\beta > 1$, until the phone is on the threshold of sliding *up* the wall. The angle θ and μ_s are unchanged. Find β.

2. **Thrown brick with linear drag in 2D.** A brick is thrown with an initial velocity of magnitude v_0 at an angle θ_0 with respect to the ground. In addition to gravity downward, it experiences a linear drag force $\vec{F}_\mathrm{d} = -\beta\,\vec{v} = -m\alpha\,\vec{v}$, with $\alpha, \beta > 0$. Notice that $\vec{F}_\mathrm{d}$ is always in the opposite direction to the motion at every instant.

   Find an expression for the complete trajectory $\vec{r}(t) = (x(t), y(t))$, assuming the initial position $\vec{r}(0) = (0, 0)$.

3. **Pulley contraption attached to a penguin and a trout.**

   Consider the pulley contraption shown in the figure. The larger pulley has two ropes attached to its axle, as shown. One rope is attached to a penguin, via the three pulleys, and the other directly to a trout. The penguin and the trout both have mass m. All the pulleys are frictionless and massless. Find the accelerations of the penguin and the trout.



4. $F = ma$ **with a** $-bv^2$ **drag force.**

A particle of mass m is acted upon by a force $F(v) = -bv^2$. The particle moves in one dimension and $b > 0$.

We will do this both analytically and numerically, to compare.

(a) First solve the problem analytically using calculus. Find expressions for the acceleration $a(t)$, the velocity $v(t)$ and the position $x(t)$. Take the initial position $x(0) = x_0 = 0$ and an arbitrary initial velocity $v(0) = v_0$.

(b) Next solve the problem numerically, using a time stepping code. Use $v(0) = 3.0$ m/s and $b = 0.25$ Ns^2/m^2. You can take $m = 1.0$ kg.

Do this by modifying the python code called `bv2_force_plot_template.py` which is posted on Quercus. Fill in the missing information in the python code for both the analytic expressions and the time stepping scheme. Run the code to make plots for small (like 0.01 s) and large (like 0.5 s) values of `dt`. Compare the analytic and numerical plots for various time step sizes.

For this part, make plots with your name and `dt` in the titles of the plots. Just hand in the plots, not the whole code.