NYU General Physics 1—Problem set 4

Problem 1: Look up the definition of the "coefficient of friction" and the difference between "static friction" and "sliding" or "kinetic" friction. Once you have done that, re-do the block on an inclined plane problem but with friction and the following parameters:

(a) The block has mass m. The plane is inclined at an angle $\theta = 35$ deg to the horizontal. The block-plane interface has a frictional force with coefficient of friction $\mu = 0.1$. Draw the free-body diagram. Draw the vector force sum as a vector diagram in two dimensions (as we did in lecture). Compute the magnitude a of the acceleration; give your answer in terms of the magnitude g of the acceleration due to gravity. Compute the magnitude f of the frictional force.

(b) The same again, but now with a coefficient of friction $\mu = 1.0$. Note that this case will be *qualitatively differerent* because the friction will be static.

(c) What happens if you re-do part *(a)* but with $\theta = 5$ deg?

Problem 2: A ball of mass M swings like a pendulum on a light, inextensible string of length L. Imagine that the pendulum is swinging back and forth with a significant amplitude (say an amplitude of $L/4$). Think about the tension in the string. At the lowest point in the swing, is the tension in the string equal to, less than, or greater than $M\,g$? Explain why in words.

Don't *calculate* the tension; we will do that later in the semester.

Problem 3: A solid rubber ball of radius 1.5 cm is dropped from a height of 1 m onto a hard surface. It bounces. The objective of this problem is to figure out the magnitude of the contact force on the ball *during* the bounce.

(a) The contact force pushing the ball upwards will be far larger in magnitude than the gravitational force pushing the ball downwards. Explain why in words.

(b) Estimate the mass m of the ball and also the speed v at which the ball will be traveling just before it hits the floor. Use the internet or the library for the density of rubber.

(c) If the ball is in contact with the floor for about one millisecond, and if it bounces back upwards with about the "equal and opposite" velocity to that it had before the contact, what is the mean acceleration $\vec{a}$ of the ball during the bounce?

(d) What is the implied mean contact force $\vec{N}$ during the bounce?

(e) I said the ball will be in contact with the floor for $\sim 1\,\mathrm{ms}$. How could you estimate this? One option is to consider the time it takes a sound wave to traverse the diameter of the ball. Look up the speed of sound in rubber and estimate this time; is $1\,\mathrm{ms}$ reasonable? Also, can you think of other ways to make an estimate?