NYU Physics I—Problem set 1

Due Thursday 2016 September 15 at the beginning of lecture.

Problem 1: *(a)* What is the maximum amount of cash you can obtain by successfully robbing an armored truck? Assume that it is packed with twenties; that is, estimate an answer by considering the volume of the truck, and (harder to estimate) the volume of a 20-dollar bill. State your assumptions and explain your work, but please don't attempt an experiment. Be sure to explain exactly how you estimated the volume of a 20-dollar bill. *Hint: think of a stack of bills to estimate the volume. Feel free to* check *any part of your answer on the internet, but make sure you actually make a justified, quantitative estimate independently.*

(b) Do you think that many of the armored trucks in Manhattan are fully packed with 20-dollar bills?

(c) Would a similar truck weigh more, less, or about the same if it contained the same amount of money but in the form of gold bars instead of 20-dollar bills?

Problem 2: Imagine you have a mass M, a length h, a velocity v, and an acceleration g. What combinations of these can you make that will have units of *(a)* time, *(b)* force, and *(c)* energy? Don't try to be exhaustive; just try to get two different expressions for each!

Problem 3: A bit on air resistance and terminal velocities. If you want more discussion of these issues, see `http://arxiv.org/abs/0709.0107` (click the PDF link at the right of the page).

(a) Show that the ram-pressure formula $\rho\,A\,v^2$ has the correct units to be a force, when ρ is a mass density, A is a cross-sectional area, and v is a speed. Look up air drag on Wikipedia and see what this formula is missing.

(b) At what downward falling speed v does an object with mass M and cross-sectional area A find that ram pressure balances the gravitational force? Derive an expression. This is the formula (ish) for the terminal velocity!

(c) Two pennies are dropped (carefully) from a tall building, one so that it falls precisely edge-on, and one so that it falls precisely face-on (difficult but not impossible in practice). What (roughly) are the two terminal velocities and what (roughly) is their ratio $v_{\mathrm{edge}}/v_{\mathrm{face}}$?

(d) Roughly how far does a typical American car have to drive to "sweep up" or drive through a column of air that is comparable in weight to the car itself? You will have to estimate the cross-sectional area and weight of a typical car (or look both things up on the web; if you look them up, give the make and model).

Extra Problem (will not be graded for credit): Describe in words the *environmental significance* of the distance you calculated in part *(d)* of the previous problem.