NYU General Physics 1—Problem set 1

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 estimating the likely volume of the inside of the truck, and (harder) 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: *(a)* Power P has dimensions of energy per time. Energy E has dimensions you can infer from the famous formula $E = m\,c^2$. What combination can you make of a speed v (length per time), an area A (length squared), and a density ρ (mass per volume) that has dimensions of power?

(b) Can you think of any environmental or economic or engineering significance of that calculation? *Hint: Imagine that the density is the density of the air, and the area is the cross-sectional area of a car!*

(c) What combination can you make of a speed v, a mass m, and an acceleration g (length per time squared) that has dimensions of power?

(d) Can you think of any biological or physiological significance of that calculation? *Hint: Imagine that the speed is the speed you can sustainably climb stairs, the mass is your mass, and the acceleration is the acceleration due to gravity!*

Problem 3: For very small objects, like cells in a centrifuge, there is a "settling velocity" that depends on a density ρ (actually a density difference, but we will worry about that much later), an acceleration g, a particle size (length or radius) R, and a "dynamic viscosity" μ. The dynamic viscosity has dimensions of mass per length per time (for example, $\mathrm{kg\,m^{-1}\,s^{-1}}$; if that seems odd, look it up). Without worrying about any details—this is only

dimensional analysis—find a combination of these quantities that has the dimensions of velocity (length per time). Compare to what is written in the first couple of paragraphs of the Wikipedia page called "Stokes Law".