NYU Physics I—Problem Set 2

Due Tuesday 2018 September 20 at the beginning of lecture.

Problem 1: *(a)* Look up the masses and sizes of neutral atoms—or a scaling law for the sizes of the outer electron shell for neutral atoms—and compute the densities (in $\mathrm{kg\,m^{-3}}$) of a Hydrogen atom, an Oxygen atom, an Iron atom, and a Uranium atom. Compare the last two to the densities of iron and uranium in metallic form.

(b) Compute (or look up!), using the ideal gas law, the density of diatomic Nitrogen gas at "standard temperature and pressure". How close do you think this estimate will be to the density of air at STP?

Problem 2: Re-do the numerical integration worksheet problem from recitation this week (download it from the course web site if you have forgotten), but this time do it with a computer spreadsheet and use a time resolution (Δt) of 0.01 s. No need to hand in the whole spreadsheet, or the answers to all the questions, but hand in a graph (plotted by your spreadsheet program) of the position as a function of time for the duration $0 < t < 2\,\mathrm{s}$. Make sure your axes are clearly labeled and "calibrated" in units of m and s.

Problem 3 Now do something similar to the above, but analytically. Consider a stone thrown at $t = 0$ precisely upwards (in the y direction, for definiteness) at $1.5\,\mathrm{m\,s^{-1}}$, with an initial position (launch point) at $y = 0$. Ignore air resistance! Make very careful plots of the vertical position y, the vertical velocity v_y, and the vertical acceleration a_y of the stone as a function of time for the duration $0 < t < 0.4\,\mathrm{s}$. Carefully label the time and y-position of the peak of the trajectory (the highest point) in all three curves, and the time at which the trajectory passes back through $y = 0$, if that ever happens. Be very careful to include units with all of your numbers and labels!

Problem 4 When an airplane turns a corner, it banks (tilts). When the plane is flown correctly, the tangent (yes, the trig function "tan") of this tilt angle is set by the ratio of the transverse acceleration (centripetal acceleration) to the acceleration due to gravity.

(a) If you see a commercial jet aircraft tilted at 30 deg because it is turning, about what do you think the radius of the turn is? Clearly state your assumptions! You might have to look up or estimate the speed at which planes fly. Does your answer seem reasonable given what you know about planes and travel?

(b) Draw a free-body diagram for the turning airplane, showing the gravitational force, the lift force from the wings, the thrust force from the engines, and the drag force from air resistance. These are the *only* four forces you need to have to explain the turning airplane.