Reading for Week 2:
Poets: Ch. 3.
IIP: Ch. 2.

Written assignment for Week 2 — due in Friday precept.

1) The vector $\vec{P}$ is 2 units long and points along the $x$-axis. The vector $\vec{Q}$ is $2\sqrt{2}$ units long and points at 45° above the $x$-axis. Both are shown in the figure. Construct each of the following vectors graphically, that is, by drawing $\vec{P}$ and $\vec{Q}$ carefully (use graph paper or draw a grid) in the appropriate arrangement and using the methods shown in lecture to find the desired “resultant” vector.

   a) $\vec{A} = \vec{P} + \vec{Q}$
   b) $\vec{B} = \vec{P} - \vec{Q}$
   c) $\vec{C} = \vec{Q} - \vec{P}$ — do your answers have the appropriate relationship between $\vec{B}$ and $\vec{C}$?
   d) $\vec{D} = \vec{Q} + 2 \times \vec{P}$
   e) Find $\vec{E}$ such that $\vec{P} + \vec{Q} + \vec{E} = 0$

2) Show in a sketch drawn approximately to scale the answer to the following question: If you are in a boat that has a speed (with respect to the water) of 5 km/h and you want to go directly across a river with a current of 1 km/h (that is, you don’t want to drift upstream or downstream at all), in what direction should you point the boat? Make your diagram and its labels as clear as possible — anyone looking at it should see immediately how your diagram is the solution. On this course, will your actual speed with respect to the land be faster, slower, or equal to 5 km/h? **Hint:** what is the relationship between the vectors $\vec{v}_{\text{boat w/rt water}}$, $\vec{v}_{\text{water}}$, and $\vec{v}_{\text{boat w/rt land}}$? (“w/rt” = “with respect to”)

3) In our monkey and hunter demonstration, letting go of the branch as soon as the gun was fired (it was, you will recall, pointed straight at the monkey’s original position), was the worst thing the monkey could have done. If he had done nothing, for example, the ball would have passed underneath him. To hit a smarter monkey that simply does nothing, we would have to aim higher. If we were using a real gun (with fast, small bullets, instead of slow, big softballs), would this correction for gravity (that is, the amount by which we aim above the monkey) be larger, smaller, or the same as for the softballs? **Explain your answer.** A good explanation will be very brief and will use the principles we have developed. Your answer should explicitly state which matter(s): the size, the weight, or the speed of the projectile.
4) An order-of-magnitude estimate to show that molecules are very small and there are lots of them: How many molecules from Galileo’s last breath are in your lungs right now? (Valentine’s Day, by the way, is Galileo’s birthday.) We will assume that the air in the Earth’s atmosphere mixes up entirely every few years. Some useful numbers: treat the atmosphere as uniform in density and 4 km thick. You will need to calculate its volume, so you need the Earth’s radius: $6.4 \times 10^6$ m. Your lungs hold about one liter ($1000$ cm$^3$) and a liter of air at normal temperatures and pressures contains about $3 \times 10^{22}$ molecules. One method of calculating this:

a) What is the volume of the atmosphere? (Note this is not the same as the volume of the Earth + atmosphere!)

b) What fraction of the atmosphere is one breath?

c) How many molecules from one of Galileo’s breaths are in one of yours?

d) What other assumptions (besides mixing of the atmosphere) are we implicitly making?

5) You throw a ball straight up. It leaves your hand with speed $v_i$ at $t = 0$. Call the height of your hand when the ball leaves it $y = 0$. The ball reaches its maximum height $y = y_{\text{max}}$ at a time $t = t_1$. Make sketches of the height $y$, the vertical velocity $v$, and the vertical acceleration $a$, all versus time $t$, from when the ball leaves your hand to when you catch it at $y = 0$. For the sake of consistency, call “up” the positive direction for all three quantities, and indicate $t = t_1$ in all the plots. **Note:** it is not necessary to compute anything in this problem.