Homework 2

Due Tuesday, September 14 at 11:59am

Reading for this week: Read Chap 3 & begin reading Chap 4.

1. **Theory**: In class we constructed part of the following table: (**a**) Without looking at the book,

Constant Acceleration	
Equation	Missing Variable(s)
$v = v_0 + at$	$(x - x_0)$
$x - x_0 = v_0 t + \frac{1}{2}at^2$	v
$v^2 = v_0^2 + 2a(x - x_0)$	t
?	a
?	v_0

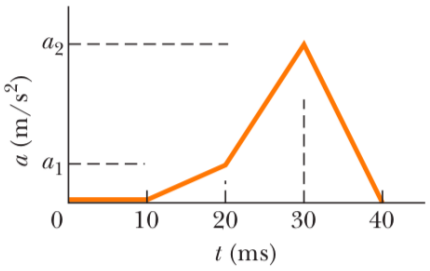
find a way to fill in the two missing entries in this table. Figure out at least two independent checks to confirm that the entries you've constructed are correct and explain how they confirm the validity of your new entries. (Of course, checking against the book does not count.)

(**b**) Once again picking objects or physical processes that are interesting to you, add 3 new distances each separated by at least one order of magnitude and 3 new times each separated by at least one order of magnitude to your distance and time number lines.

(**c**) Create a new velocity number line. Picking physical processes that are interesting to you, draw a velocity line with 5 speeds each separated by at least one order of magnitude. Hold on to your lines so that you can keep adding to them over the course of the semester.

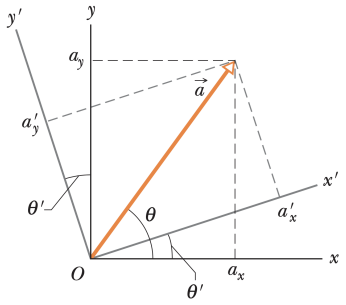
Exercises:

2. A salamander of the genus *Hydromantes* captures prey by launching its tongue as a projectile (checkout from 1 to 2 minutes on this video): The skeletal part of the tongue is shot forward, unfolding the rest of the tongue, until the outer portion lands on the prey, sticking to it. The figure at right shows the acceleration magnitude a versus time t for the acceleration phase of the launch in a typical situation. The indicated accelerations are $a_2 = 400$ m/s^2 and $a_1 = 100$ m/s^2. What is the outward speed of the tongue at the end of the acceleration phase?

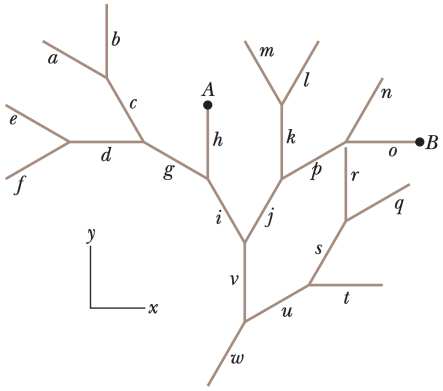


3. For the displacement vectors $\vec{a} = (3\text{ m})\hat{i} + (4\text{ m})\hat{j}$ and $\vec{b} = (5\text{ m})\hat{i} + (-2\text{ m})\hat{j}$, give $\vec{a} + \vec{b}$ in (a) unit-vector notation, and as (b) a magnitude and (c) an angle (relative to $\hat{i}$). Now give $\vec{b} - \vec{a}$ in (d) unit-vector notation, and as (e) a magnitude and (f) an angle.

4. In the Figure at right, a vector $\vec{a}$ with a magnitude of 17 m is directed at angle $\theta = 56°$ counterclockwise from the $+x$ axis. What are the components (a) a_x and (b) a_y of the vector? A second coordinate system is inclined by angle $\theta' = 18°$ with respect to the first. What are the components (c) a'_x and (d) a'_y in this primed coordinate system?

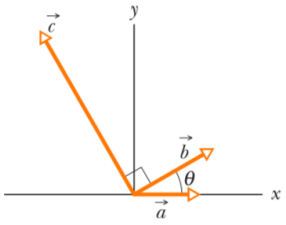


5. Typical backyard ants often create a network of chemical trails for guidance. Extending outward from the nest, a trail branches (bifurcates) repeatedly, with 60° between the branches. If a roaming ant chances upon a trail, it can tell the way to the nest at any branch point: If it is moving away from the nest, it has two choices of path requiring a small turn in its travel direction, either 30° leftward or 30° rightward. If it is moving toward the nest, it has only one such choice. The Figure at right shows a typical ant trail, with lettered straight sections of 2.0 cm length and symmetric bifurcation of 60°. Path v is parallel to the y axis. What are the (a) magnitude and (b) angle (relative to the positive direction of the superimposed x axis) of an ant's displacement from the nest (find it in the figure) if the ant enters the trail at point A? What are the (c) magnitude and (d) angle if it enters at point B?



6. Use the definition of scalar product, $\vec{a} \cdot \vec{b} = ab\cos\theta$, and the fact that $\vec{a} \cdot \vec{b} = a_x b_x + a_y b_y + a_z b_z$ to calculate the angle between the two vectors given by $\vec{a} = 2\hat{i} + 3\hat{j} + 3\hat{k}$ and $\vec{b} = 2\hat{i} + \hat{j} + 3\hat{k}$.

7. The three vectors in the Figure at right have magnitudes $a = 3.00$ m, $b = 4.00$ m, and $c = 10.0$ m and angle $\theta = 30°$. What are (a) the x component and (b) the y component of $\vec{a}$; (c) the x component and (d) the y component of $\vec{b}$; and (e) the x component and (f) the y component of $\vec{c}$? If $\vec{c} = p\vec{a} + q\vec{b}$, what are the values of (g) p and (h) q?



8. The minute hand of a wall clock measures 8 cm from its tip to the axis about which it rotates. The magnitude and angle of the displacement vector of the tip are to be determined for three time intervals. What are the (a) magnitude and (b) angle from a quarter after the hour to half past, the (c) magnitude and (d) angle for the next half hour, and the (e) magnitude and (f) angle for the hour after that?

9. **Problem**: A drowsy cat spots a flowerpot that sails first up and then down past an open window. The pot is in view for a total of half a second. How high above the window top does the flowerpot go? You will need to estimate the top-to-bottom height of the window to find an estimate for how high the pot went.