# Physics 21 Problem Set 2

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**due Monday, January 22, In Class**

**Course Info:** These problems pertain to the second week lectures, and the corresponding reading is pp. 11-18 and 39-45 of K&K.

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1. K&K 1.8
2. K&K 1.11. Add the following:
   (a) Explicitly construct a unit vector called $\hat{\mathbf{b}}$ from the vector $\mathbf{B}$ of the previous problem.
   (b) Use the $\mathbf{A}$ from that problem to explicitly evaluate the vector $\mathbf{V}_1 = (\mathbf{A} \cdot \hat{\mathbf{b}})\hat{\mathbf{b}}$
   (c) Repeat for the vector $\mathbf{V}_2 = (\hat{\mathbf{b}} \times \mathbf{A}) \times \hat{\mathbf{b}}$
   (d) Explicitly add the components to find $\mathbf{V}_1 + \mathbf{V_2}$. Do you get the expected result?
   (e) Explicitly use the components to evaluate $\mathbf{B} \cdot \mathbf{V}_2$. Do you get the expected result?
3. Isaac uses a certain $x$-$y$ coordinate system to describes vectors in a plane, but Albert insists on using a different coordinate system, $x'$-$y'$. Isaac's origin is the same as Albert's, but Albert's system is rotated by $\theta = 30°$ counterclockwise relative to Isaac's.
   (a) Draw a picture of the systems.
   (b) Evaluate $\hat{\mathbf{i}} \cdot \hat{\mathbf{i}}'$
   (c) Evaluate $\hat{\mathbf{i}} \cdot \hat{\mathbf{j}}'$
   (d) Evaluate $\hat{\mathbf{j}} \cdot \hat{\mathbf{i}}'$
   (e) Evaluate $\hat{\mathbf{j}} \cdot \hat{\mathbf{j}}'$
   (f) Express $\hat{\mathbf{i}}$ in terms of $\hat{\mathbf{i}}'$ and $\hat{\mathbf{j}}'$.
   (g) Express $\hat{\mathbf{j}}$ in terms of $\hat{\mathbf{i}}'$ and $\hat{\mathbf{j}}'$.
4. A particle moves in one dimension with a position described by:

$$x(t) = t - \frac{1}{6}t^3 + \frac{1}{120}t^5$$

   where $x$ is in meters and $t$ is in seconds.
   (a) Make a graph of $x(t)$ for $t$ from $-5$ to 5 seconds. Mark points where you surmise $v(t)$ will be zero, and $a(t)$ will be zero.
   (b) Repeat the plot for $v(t)$.
   (c) Repeat the plot for $a(t)$.
   (d) Plot $\sin(t)$ on the same plot that you plotted $x(t)$.

5. A particle moves in an elliptical path, centered on the origin and with semi-major axis $a = 1\,\mathrm{m}$ parallel to $x$, and semi-minor axis $b = 0.2\,\mathrm{m}$ parallel to $y$. Take $x(t) = a\cos(\omega t)$ and $y(t) = b\sin(\omega t)$.

   (a) Evaluate $x(t)$ and $y(t)$ numerically. Plot them, with the same time axis and with a common $t$ axis, for $t$ from 0 to two periods, but with $x$'s origin displaced vertically from that of $y$'s.

   (b) Repeat the last step for $v_x(t)$ and $v_y(t)$.

   (c) Plot the speed as a function of $t$.

   (d) Repeat the step before the last step for the components of acceleration, $a_x(t)$ and $a_y(t)$.

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