In-class problems, Mon Feb 12, 2018 **Due Wed Feb 14, 2018, beginning of class**

1.1-1.5 Newton's laws of motion, review

1. Newton's second law is

$$\sum \vec{F} = m\vec{a}$$

Forces $\vec{F}_1 = 2\hat{x} + 3\hat{z}$ and $\vec{F}_2 = \hat{k} - 9\hat{z}$ affect particle Z.

(a) Calculate the net force on particle Z.
(b) Determine the magnitude of the net force.

2. Particle Q has mass of 5kg and accelerates at $\vec{a} = -6\hat{i} + 4\hat{j}$. Determine the

(a) direction of $\vec{a}$. Give this as an angle with respect to the $+x$ axis.
(b) net force on particle Q.
(c) direction of the net force.

3. The work done by a constant force on an object is given by

$$W = \vec{F} \cdot \Delta\vec{r}$$

The force on object S is $\vec{F}_A = 9\hat{j} + 6\hat{k}$. Its change in position is $\Delta\vec{r} = 2\hat{i} + 5\hat{k}$. Determine the

(a) work done by $\vec{F}_A$.
(b) angle between $\vec{F}_A$ and $\Delta\vec{r}$

Hint: there are two ways to calculate work. Use the easiest way in (a). Use the second way in (b) combined with your result from (a).

4. The torque resulting from a force on an extended object is given by

$$\vec{\tau} = \vec{r} \times \vec{F}$$

A force is $\vec{F}_B = \hat{x} + 3\hat{y}$ is applied at position $\vec{r}_B$. $\vec{r}_B$ has a magnitude of 3m and points at 30° above the +x axis.

(a) Write $\vec{r}$ in terms of the unit vectors $\hat{x}, \hat{y}, \hat{z}$.
(b) Calculate the torque $\vec{\tau}$.

5. A position of a particle moving in a circle is

$$\vec{r}(t) = R\cos(\omega t)\hat{x} + R\sin(\omega t)\hat{y}$$

Calculate

(a) $\vec{v}(t)$
(b) $\vec{a}(t)$

Read 1.6-1.7 Newton's 2nd law in Cartesian and polar coordinates

1. Read 1.6. Write down one main idea in this section. Use 1-2 full sentences. Refer to 1 equation in your description.

2. A skier slides down a straight, frictionless hill, under the force of gravity. Her mass is m. The hill is at angle of θ.

(a) Draw a force diagram (or free body diagram) for the skier. Define $+x$ as going down and parallel to the slope.
(b) Derive the differential equation for the motion of the skier. Start with Newton's second law.
(The answer is $\ddot{x} = g\sin\theta$)
(c) The skier gives herself an given an initial speed of v_0 down the hill. Determine $x(t)$.

3. Read 1.7.
(a) Write down the equations required to transform between Cartesian coordinates and polar coordinates. That is, how do you turn $(x, y) \to (r, \phi)$? How do you turn $(r, \phi) \to (x, y)$?
(b) In Cartesian, $\vec{F} = F_x\hat{x} + F_y\hat{y}$. How do you write $\vec{F}$ in polar?
(c) In Cartesian, Newton's second law is written as $\vec{F} = m\vec{a}$ where $F_x = m\ddot{x}$ and $F_y = m\ddot{y}$. How is Newton's second law written polar?