Physics Unit 4 Study Guide
Vectors & Relative Motion

Essential Questions:

1) **How is the resultant vector of two or more separate vectors determined?**
2) **What affect do the components of a vector have on each other?**

Words to define!

- Vector
- Scalar
- Magnitude
- Direction
- Components
- Upstream & Downstream
- Head wind & Tail wind

Equations to use!

$$\mathbf{v} = \frac{\Delta \mathbf{x}}{\mathbf{t}} \quad \rightarrow \quad \mathbf{x_f} = \mathbf{vt} + \mathbf{x_o}$$ ***Constant Motion***

$$\mathbf{a} = \frac{\Delta \mathbf{v}}{\mathbf{t}} \quad \rightarrow \quad \mathbf{v_f} = \mathbf{at} + \mathbf{v_o}$$ ***Accelerated Motion***

$$\Delta \mathbf{x} = \frac{\mathbf{1}}{\mathbf{2}}\mathbf{at^2} + \mathbf{v_o t}$$

$$\mathbf{v_f}^2 = \mathbf{v_o}^2 + \mathbf{2a\Delta x}$$

$$\mathbf{g} = \mathbf{9.8}\, {}^{\boldsymbol{m}}/_{\boldsymbol{s^2}}$$

Skills to have!

S1 – *Vectors* – understand how to use sine and cosine to break a vector into components and know when to make the component positive or negative.

S2 – *Vector Addition* – know how to add two or more vectors to simplify them into one vector with magnitude and direction. This process is 6 steps: 1) Draw each vector separately, 2) Break each vector into components (don't forget the negatives where appropriate), 3) Add each direction, 4) Draw the new vector using the components, 5) Use Pythagorean Theorem for the magnitude, 6) Use inverse tangent for the direction.

S3 – *Relative Motion* – to change the frame of reference of an object's motion, vectors need to be added.

Concepts to know!

C1 – *Vectors* – know that the components of a vector represent the amount of that vector that is in either the *x*- or *y*-direction and includes positive or negative for those directions.

C2 – *Relative Motion* – Determining the motion relative to a different frame of reference requires adding vectors. For example, suppose that the velocity of a boat is given relative to the water, and the velocity of the water is given relative to the shore. To determine the velocity of the boat relative to the shore, the velocity of the boat needs to be added (as vectors) to the velocity of the water.

C3 – *Relative Motion* – Perpendicular components or perpendicular vectors do not affect each other. For example, the time it takes for a boat to go directly across a river is not affected by the current of the river. Also, the vertical acceleration of a projectile changes because of gravity but not the horizontal component.

Example Problems!

1. A hammer slides down a roof that makes a 32.0° angle with the horizontal. What are the magnitudes of the components of the hammer's velocity at the edge of the roof if it is moving at a speed of 6.25 $^{m}/_{s}$? ($\mathbf{v}_x = \mathbf{5.30}\ ^{\boldsymbol{m}}/_{\boldsymbol{s}}, \mathbf{v}_y = \mathbf{-3.31}\ ^{\boldsymbol{m}}/_{\boldsymbol{s}}$)

2. Sudhir walks 0.40 km in a direction 60.0° west of north, then goes 0.50 km due west. What is his displacement? ($\boldsymbol{0.87\ km\ at\ 77°\ West\ of\ North}$)

3. To get a cart to move, two farmers pull on ropes attached to the cart. One farmer pulls with a force of 50.0 N in a direction 35.0° East of North, while the other exerts a force of 30.0 N in a direction 25.0° West of North. What are the magnitude and the direction of the combined force exerted on the cart? ($\boldsymbol{70.0\ N\ at\ 76.8°\ North\ of\ East}$)

4. The moving sidewalk at an airport has a speed of 0.9 $^{m}/_{s}$ to the East relative to the stationary ground.
   a. A man walking toward the East on the moving sidewalk at a speed of 1.0 $^{m}/_{s}$ relative to the moving sidewalk. What is the velocity of the man relative to a woman standing on the stationary ground? ($\mathbf{v}_{M/W} = \mathbf{1.9}\ ^{\boldsymbol{m}}/_{\boldsymbol{s}}\ \boldsymbol{East}$)
   b. Ahead of the man walking on the moving sidewalk, a child is walking toward him (West) at a speed of 0.4 $^{m}/_{s}$. What is the speed of the child relative to the man? ($\mathbf{v}_{C/M} = \mathbf{1.4}\ ^{\boldsymbol{m}}/_{\boldsymbol{s}}\ \boldsymbol{West}$)
   c. What is the velocity of the child relative to the woman on the stationary ground? ($\mathbf{v}_{C/W} = \mathbf{0.5}\ ^{\boldsymbol{m}}/_{\boldsymbol{s}}\ \boldsymbol{East}$)

5. A pilot is flying with a velocity of 87.2 $^{m}/_{s}$ at 24.1° North of West relative to the air. However, the air is moving with a velocity of 15.2 $^{m}/_{s}$ at 52.0° East of North relative to the ground. How fast and in what direction (velocity) is the pilot moving relative to the ground? ($\boldsymbol{81.2\ ^{m}/_{s}\ at\ 33.6°\ North\ of\ West}$)