Using Vector Components to Analyze Equilibrium Situations

Read from **Lesson 3** of the **Vectors and Motion in Two-Dimensions** chapter at **The Physics Classroom**:

http://www.physicsclassroom.com/Class/vectors/u3l3b.html
http://www.physicsclassroom.com/Class/vectors/u3l3c.html

MOP Connection: Forces in Two Dimensions: sublevels 3 and 4

Many physical situations involve forces exerted at angles to the coordinate axes. A proper analysis of these situations demands that the forces be resolved into components that lie along the horizontal and vertical axes. This involves the use of trigonometric functions.

1. For the following situations, draw and label the force components as the projection onto the axes. Then use trigonometric functions to determine the magnitude of each component. Label the magnitudes of the component on the diagram. **PSYW**

   a. Lon Mauer pulls up with a force of 75.0 N at an angle of 45° to the horizontal on the handle of his manual lawn mower.

   b. Jean Yuss yanks on Spot's dog chain with a force of 12.0 N at an angle of 60° to the horizontal.

Use *your noodle* (that's your brain) to logically think through the following two questions.

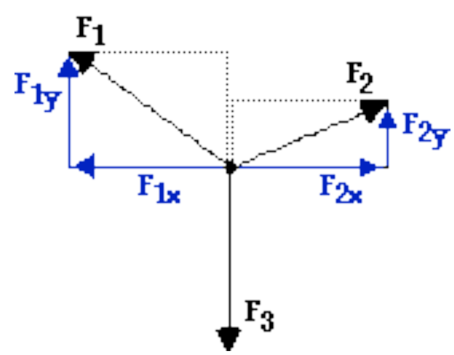
2. Which of the following statements is **ALWAYS** true of an object at equilibrium?
   a. The object is at rest.
   b. The object is maintaining its state of motion.
   c. The object's velocity is not changing.
   d. The net force on the object is 0 Newtons.
   e. The object is NOT accelerating.
   f. The individual forces acting on the object are balanced.
   g. All individual forces acting on the object are equal in magnitude.

3. The following statements were made about an object. In which case could you conclude that the object is at equilibrium?
   a. The object is at rest.
   b. The object has a constant velocity.
   c. The object is moving.
   d. The object has a constant speed.
   e. The object is stationary.
   f. The acceleration of the object is 0 m/s/s.
   g. The individual forces acting on the object are balanced.

4. Three forces - F_1, F_2, and F_3 - are acting upon an object. Their relative magnitude and direction are shown at the right. The x- and y-components are also shown. Complete the following mathematical statements by placing >, <, and = symbols in the blanks.

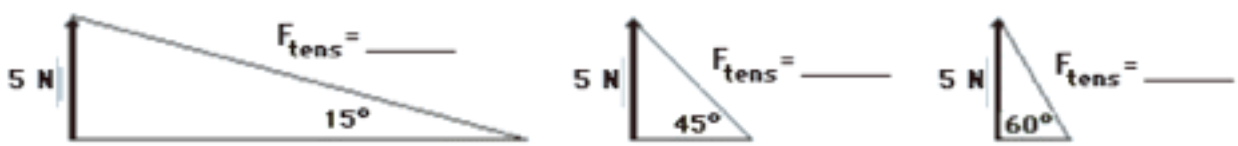
   F_{1x} ____ F_{2x} F_{1y} ____ F_3

   F_{2y} ____ F_3 $F_{1y} + F_{2y}$ ____ F_3



Physics Tip: When a sign is hung *at equilibrium*, the downward pull of gravity must be balanced by the upward pull of the wires (cables, strings, etc.). In most cases, the wires are oriented diagonally such that the tension force has both a horizontal and vertical component. If the sign is hung symmetrically, then each wire pulls with the same amount of force and at the same angle. The vertical component of the tension will be the same in each wire. And if there are two wires, each wire must supply sufficient up pull to balance one-half the weight of the sign.

5. The three identical signs below are supported by wires at three different angle orientations. Since each sign has a weight of 10.0 N, each wire must exert a vertical component of force of 5.0 N. Use a trigonometric function to determine the tension in each wire. A diagram of each situation is shown.



If hanging the above sign with a given wire, which one of the above angles would provide for the safest arrangement? ____________ Explain.

6. Suppose that a student pulls with two large forces (F_1 and F_2) in order to lift a 1-kg book by two cables. If the cables make a 1-degree angle with the horizontal, then what is the tension in the cable?