1. Mary sits on a merry-go-round that rotates with a constant angular velocity. Which one of the following remains constant as she moves?
   A. her acceleration  
   B. her position  
   C. her velocity  
   D. her speed

2. Which of the following defines the value of the sine of the angle $\theta$ in the triangle shown on the right?
   A. $B / C$  
   B. $B / A$  
   C. $A / C$  
   D. $A / B$

3. Carrie throws a ball from center field towards home plate. Which of the following statements correctly describes the motion of the ball if air resistance is negligible?
   A. The horizontal component of the ball’s velocity remains constant.  
   B. The vertical component of the ball’s velocity remains constant.  
   C. The speed of the ball at its highest point is zero.  
   D. The acceleration of the ball at its highest point is zero.

4. Bob drops a rock off a cliff at the same instant that Lynn throws a ball horizontally with a speed of 20 m/s. Both land in the lake below. Which of the following is a correct statement about their motion?
   A. The vertical velocity of the ball is greater than the vertical velocity of the rock when they hit the water.  
   B. The ball and rock have the same speed when they hit the water.  
   C. The rock lands in the water before the ball does.  
   D. They hit the water at the same instant.

5. Which of the following statements correctly describes the motion of a satellite orbiting just above the earth, moving in a circle with a speed of 8000 m/s?
   A. The acceleration of a satellite in orbit is zero.  
   B. The tangential velocity accelerates at a rate of 9.8 m/s$^2$.  
   C. Each second the satellite falls 4.9 m from where it would be if it continued with straight line motion.  
   D. The speed of the satellite increases as it falls towards the center of the earth.

6. A boat is moving eastward with respect to the water in a river that is flowing southward with a speed of 3 m/s. If the boat’s speed with respect to the water is 5 m/s what is its speed with respect to someone watching it while standing on the shore?
   A. 4 m/s  
   B. 5.8 m/s  
   C. 8 m/s  
   D. 6.6 m/s
7.(6) Lynn throws a ball off a cliff horizontally with a speed of 15 m/s. The ball is initially 44.1 m above the lake at the base of the cliff.

A. Show that the ball lands 3 s after Lynn throws it.

B. How far from the base of the cliff is the ball when it hits the water? Assume that the base of the cliff is directly below the point where Lynn released the ball.

8.(4) A. Draw a vector to represent the velocity of the boat with respect to the river in question 6 and another vector to represent the velocity of the river with respect to the shore.

B. In a complete sentence state how to add two vectors.

C. Draw the two vectors in part A in place to show their vector sum. Label each vector and the vector sum. Let 1 inch represent 1 m/s.
Solutions and Answers:

1. D. Her speed remains constant. The directions of her position, velocity and acceleration change as she rotates.

2. A. The sine of an angle is defined as the ratio of the length of the opposite side to the length of the hypotenuse.

3. A. The vertical component of the velocity changes because of the acceleration of gravity and this makes the speed change as well. At the top the vertical component of velocity is zero so that the speed at the top is equal to the horizontal component of velocity. The horizontal component remains constant because there is no acceleration in the horizontal direction.

4. D. The horizontal and vertical motions are independent. Since both the rock and ball start at the same time with zero vertical velocity and fall the same height they will land at the bottom at the same instant. The ball will be moving faster since it also has a horizontal component of velocity when it hits the water.

5. C. In one second a satellite moving with a speed of 8000 m/s would move 8000 m. If there were no gravity it would move in a straight line and the curving of the earth’s surface drops 4.9 m below this straight line motion at the point of 8000 m from the starting point. In one second because of gravity an object that is dropped falls 4.9 m. Thus a satellite moving with a speed of 8000 m/s falls toward the earth at exactly the same rate that the earth curves away from straight line motion.

6. B. The velocity of the boat as observed by someone on shore is the vector sum of the velocity of the river plus the velocity of the boat with respect to the river. Since these velocities are at right angles the speed of the boat is the square root of the sum of the squares of these two velocities, \((5 \text{ m/s})^2 + (3 \text{ m/s})^2 = 34 \text{ m}^2 / \text{s}^2\). The square root of 34 is 5.8.

7. Part A.: The time to fall is determined from analysis of the vertical motion. \(d = \frac{1}{2} \times g \times t^2\). Solving this for the time to fall gives \(t = \sqrt{\frac{2d}{g}} = \sqrt{\frac{2 \times 44.1 \text{ m}}{9.8 \text{ m} / \text{s}^2}} = \sqrt{\frac{9 \text{ s}^2}{s^2}} = 3 \text{ s}\)

7. Part B: The distance from the base is just the horizontal component of the velocity times the fall time of 3 s. It is 15 m/s times 3 s = 45 m.

8. Part B: To add two vectors draw the first vector showing its head as an arrow. Then draw the second vector with its tail at the head of the first vector taking care to preserve its direction. Draw the sum of these vectors as the vector with its tail at the tail of the first vector and its head at the head of the second vector.