1. If you drop one rock from rest, and throw another down with velocity $v_0$, is the difference in their velocities when they hit the ground more than, less than, or equal to $v_0$?

Both rocks will have the same acceleration, 9.8 m/s$^2$ downward. The rock that is thrown down will reach the ground first and thus spend less time being accelerated. The rock that is dropped from rest will reach the ground later and spend more time being accelerated. Thus, the thrown rock will have a smaller increase in velocity than the dropped rock. The difference in their velocities, initially $v_0$, will be less than $v_0$ after they have hit the ground.

2. Under what conditions is the magnitude of the vector sum $\vec{A} + \vec{B}$ equal to the sum of the magnitudes of the two vectors?

If the two vectors are pointing in the same direction or in opposite directions (they are colinear). In both cases you can add the magnitudes just like scalars since the resultant vector points along the same line.

3. Can two vectors of equal magnitude sum to zero? Can two vectors of unequal magnitude?

Yes, two vectors of equal magnitude that are pointing in opposite directions will sum to zero. Two vectors of unequal magnitude can never sum to zero. If they point along the same line, since their magnitudes are different, the sum will not be zero. If they point in different directions, then you can always decompose one vector into two components: one along the other vector and one perpendicular to the other vector. In this case, the perpendicular component can never be eliminated.

4. Three objects are released from the same height, one from rest, one with horizontal velocity component $v_x$, the other with horizontal velocity component $2v_x$. Compare the times each is in the air. Compare the horizontal distances traveled by each.

Each of the three objects has no initial vertical velocity component. The motion in the vertical direction will then be entirely determined by the acceleration and the initial height. Since all three are released from the same height and have the same acceleration ($g$), they will be in the air the same amount of time. There are no horizontal forces, so each will travel with constant velocity in the horizontal direction. The one dropped from rest will travel a
horizontal distance of zero. The one with initial x-velocity $v_x$ will travel distance $v_x \Delta t$ and the one with initial x-velocity $2v_x$ will travel twice as far.

5. **An object moves in the spiral path shown below. Must its speed increase, decrease, or remain the same if the magnitude of its centripetal acceleration is to remain constant?**

The centripetal acceleration is proportional to the square of the speed and inversely proportional to the radius. The radius of the spiral is increasing as the object moves away from the center. To maintain constant centripetal acceleration, the speed of the object must be increasing (though not as quickly as the radius is increasing).

6. **Does the length of time that a force is applied to an object affect that object’s acceleration? Does it affect the object’s final velocity? Explain.**

The acceleration is determined from the force by Newton’s second law. The time of application does not change the magnitude or direction of the force and therefore does not affect the acceleration. The final velocity is determined by the acceleration and the amount of time that the object accelerates. The final velocity is therefore affected by the time of application of the force, since it is the force that determines the acceleration.

7. **An elevator contains a spring scale on which a mass of 10 kg hangs. Is the scale reading more than, less than, or equal to 98 N when the elevator is (a) stationary; (b) first starts moving upward; (c) moves steadily upward; (d) slows down on its way up; (e) starts moving downward; (f) moves steadily downward; (g) slows down on its way down?**

The reading on the scale is determined by the acceleration of the elevator. At any point, the forces on the mass are the upward force from the spring scale and the downward force from gravity. The sum of these two forces must be equal to the mass times the total acceleration, by Newton’s second law. When the acceleration is upward, the force exerted by the scale must be greater than the weight and the scale reading will be more than 98 N. When the acceleration is downward, the force exerted by the scale must be less than the weight and the scale reading will be less than 98 N. When there is no acceleration (constant velocity), the force of the scale and the weight must be equal so the reading will be equal to 98 N. Following this logic, the answers are: (a) equal, (b) more than, (c) equal, (d) less than, (e) less than, (f) equal, (g) more than.
8. Having learned the features of uniform circular motion, you observe that the planets orbit the sun in nearly circular orbits. You note that planets that are farther from the sun take longer to go around the sun not just because they have larger orbits, but also because they move more slowly. What is the centripetal force keeping the planets in orbit and what can you deduce about the dependence of its magnitude on distance? Explain.

The centripetal force keeping the planets in orbit is the gravitational force between the planet and the sun. Since the planets move more slowly as the orbits get larger, the centripetal force is decreasing with distance. Thus the magnitude of the gravitational force must decrease with distance. (A more detailed analysis would show that it decreases as \( \frac{1}{r^2} \).)