ANSWERS TO MULTIPLE CHOICE QUESTIONS

1. Once the arrow has left the bow, it has a constant downward acceleration equal to the free-fall acceleration, g. Taking upward as the positive direction, the elapsed time required for the velocity to change from an initial value of 15.0 m/s upward (υ_0 = +15.0 m/s) to a value of 8.00 m/s downwardward (υ_f = –8.00 m/s) is given by

$$\Delta t = \frac{\Delta v}{a} = \frac{v_f - v_0}{-g} = \frac{-8.00\ \text{m/s} - (+15.0\ \text{m/s})}{-9.80\ \text{m/s}^2} = 2.35\ \text{s}$$

Thus, the correct choice is (d).

2. The maximum height (where $\upsilon = 0$) reached by a freely falling object shot upward with an initial velocity υ_0 = +225 m/s is found from $v^2 = v_0^2 + 2a(\Delta y)$ as

$$(\Delta y)_{\text{max}} = \frac{0 - (v)_0^2}{2(-g)} = \frac{0 - (225\ \text{m/s})^2}{2(-9.80\ \text{m/s}^2)} = 2.58 \times 10^3\ \text{m}$$

Thus, the projectile will be at the $\Delta y = 6.20 \times 10^2\ \text{m}$ level twice, once on the way upward and once coming back down. The elapsed time when it passes this level coming downward can be found by using $\Delta y = v_0 t - \frac{1}{2} g t^2$ and obtaining the largest of the two solutions to the resulting quadratic equation:

$$6.20 \times 10^2\ \text{m} = (225\ \text{m/s})\,t - \frac{1}{2}(9.80\ \text{m/s}^2)\,t^2$$

or

$$(4.90\ \text{m/s}^2)\,t^2 - (225\ \text{m/s})\,t + 6.20 \times 10^2\ \text{m} = 0$$

The quadratic formula yields

$$t = \frac{-(-225\ \text{m/s}) \pm \sqrt{(-225\ \text{m/s})^2 - 4(4.90\ \text{m/s}^2)(6.20 \times 10^2\ \text{m})}}{2(4.90\ \text{m/s}^2)}$$

with solutions of t = 43.0 s and . t = 2.94 s The projectile is at a height of $6.20 \times 10^2\ \text{m}$ and coming downward at the largest of these two elapsed times, so the correct choice is seen to be (e).

3. The derivation of the equations of kinematics for an object moving in one dimension (Equations 2.6, 2.9, and 2.10 in the textbook) was based on the assumption that the object had a constant acceleration. Thus, (b) is the correct answer. An object having constant acceleration would have constant velocity only if that acceleration had a value of zero, so (a) is not a necessary condition. The speed (magnitude of the velocity) will increase in time only in cases when the velocity is in the same direction as the constant acceleration, so (c) is not a correct response. An object projected straight upward into the air has a constant acceleration. Yet its position (altitude) does not always increase in time (it eventually starts to fall back downward) nor is its velocity always directed downward (the direction of the constant acceleration). Thus, neither (d) nor (e) can be correct.

4. The bowling pin has a constant downward acceleration $\left(a = -g = -9.80\ \text{m/s}^2\right)$ while in flight. The velocity of the pin is directed upward on the upward part of its flight and is directed downward as it falls back toward the juggler's hand. Thus, only (d) is a true statement.

5. The initial velocity of the car is $\upsilon_0 = 0$ and the velocity at time t is υ. The constant acceleration is therefore given by $a = \Delta v/\Delta t = \left(v - v_0\right)/t = \left(v - 0\right)/t = v/t$ and the average velocity of the car is $\overline{v} = \left(v + v_0\right)/2 = \left(v + 0\right)/2 = v/2$ The distance traveled in time t is $\Delta x = \overline{v}t = vt/2$ In the special case where $a = 0$ $\left(\text{and hence } v = v_0 = 0\right)$, we see that statements (a), (b), (c), and (d) are all correct. However, in the general case ($a \neq 0$, and hence $v \neq 0$) only statements (b) and (c) are true. Statement (e) is not true in either case.

6. We take downward as the positive direction with y =0 and t =0 at the top of the cliff. The freely falling pebble then has $v_0 = 0$ and $a = g$ = +9.8 m s^2. The displacement of the pebble at t = 1.0 s is given: y_1 =4.9 m. The displacement of the pebble at t = 3.0 s is found from

$$y_3 = v_0 t + \frac{1}{2}at^2 = 0 + \frac{1}{2}\left(9.8\,\text{m/s}^2\right)\left(3.0\,\text{s}\right)^2 = 44\ \text{m}$$

The distance fallen in the 2.0 s interval from t = 1.0 s to t = 3.0 s is then

$$\Delta y = y_3 - y_1 = 44\ \text{m} - 4.9\ \text{m} = 39\ \text{m}$$

and choice (c) is seen to be the correct answer.

7. In a position vs. time graph, the velocity of the object at any point in time is the slope of the line tangent to the graph at that instant in time. The speed of the particle at this point in time is simply the magnitude (or absolute value) of the velocity at this instant in time. The displacement occurring during a time interval is equal to the difference in x-coordinates at the final and initial times of the interval $\left(\Delta x = x\big|_{t_f} - x\big|_{t_i}\right)$.

The average velocity during a time interval is the slope of the straight line connecting the points on the curve corresponding to the initial and final times of the interval $\left[\bar{v} = \Delta x/\Delta t = (x_f - x_i)/(t_f - t_i)\right]$ Thus, we see how the quantities in choices (a), (e), (c), and (d) can all be obtained from the graph. Only the acceleration , choice (b), *cannot be obtained* from the position vs. time graph.

8. The elevator starts from rest ($\upsilon_0 = 0$) and reaches a speed of $\upsilon = 6$ m/s after undergoing a displacement of $\Delta y = 30$ m. The acceleration may be found using the kinematics equation $v^2 = v_0^2 + 2a(\Delta y)$ as

$$a = \frac{v^2 - v_0^2}{2(\Delta y)} = \frac{(6\ \text{m/s})^2 - 0}{2(30\ \text{m})} = 0.6\ \text{m/s}^2$$

Thus, the correct choice is (c).

9. The distance an object moving at a uniform speed of $\upsilon = 8.5$ m/s will travel during a time interval of $\Delta t = 1/1\,000\ \text{s} = 1.0 \times 10^{-3}\ \text{s}$ is given by

$$\Delta x = v(\Delta t) = (8.5\ \text{m/s})(1.0 \times 10^{-3}\ \text{s}) = 8.5 \times 10^{-3}\ \text{m} = 8.5\ \text{mm}$$

so the only correct answer to this question is choice (d).

10. Once either ball has left the student's hand, it is a freely falling body with a constant acceleration $a = -g$ (taking upward as positive). Therefore, choice (e) cannot be true. The initial velocities of the red and blue balls are given by $v_{iR} = +v_0$ and $v_{iB} = -v_0$ respectively. The velocity of either ball when it has a displacement from the launch point of $\Delta y = -h$ (where h is the height of the building) is found from $v^2 = v_i^2 + 2a(\Delta y)$ as follows:

$$v_R = -\sqrt{v_{iR}^2 + 2a(\Delta y)_R} = -\sqrt{(+v_0)^2 + 2(-g)(-h)} = -\sqrt{v_0^2 + 2gh}$$

and

$$v_B = -\sqrt{v_{iB}^2 + 2a(\Delta y)_B} = -\sqrt{(-v_0)^2 + 2(-g)(-h)} = -\sqrt{v_0^2 + 2gh}$$

Note that the negative sign was chosen for the radical in both cases since each ball is moving in the downward direction immediately before it reaches the ground. From this, we see that choice (c) is true.

Also, the speeds of the two balls just before hitting the ground are

$$|v_R| = \left|-\sqrt{v_0^2 + 2gh}\right| = \sqrt{v_0^2 + 2gh} > v_0 \quad \text{and} \quad |v_B| = \left|-\sqrt{v_0^2 + 2gh}\right| = \sqrt{v_0^2 + 2gh} > v_0$$

Therefore, $|v_R| = |v_B|$, so both choices (a) and (b) are false. However, we see that both final speeds exceed the initial speed or choice (d) is true. The correct answer to this question is then (c) and (d).

11. At ground level, the displacement of the rock from its launch point is $\Delta y = -h$ where h is the height of the tower and upward has been chosen as the positive direction. From $v^2 = v_0^2 + 2a(\Delta y)$ the speed of the rock just before hitting the ground is found to be

$$|v| = \left|\pm\sqrt{v_0^2 + 2a(\Delta y)}\right| = \sqrt{v_0^2 + 2(-g)(-h)} = \sqrt{(12\ \text{m/s})^2 + 2\left(9.8\ \text{m/s}^2\right)(40.0\ \text{m})} = 30\ \text{m/s}$$

Choice (b) is therefore the correct response to this question.

12. Once the ball has left the thrower's hand, it is a freely falling body with a constant, nonzero, acceleration of $a = -$g Since the acceleration of the ball is not zero at any point on its trajectory, choices (a) through (d) are all false and the correct response is (e).