Tutorial 2 Solutions. 19/02/2016

1. **MC** An object is thrown vertically upward. Which of the following statements is true: (a) Its velocity changes non-uniformly; (b) its maximum height is independent of the initial velocity; (c) its travel time upward is slightly greater than its travel time downward; (d) the speed on returning to its starting point is the same as its initial speed? (d)
2. MC A dropped object in free fall (a) falls 9.8 m each second, (b) falls 9.8 m during the first second, (c) has an increase in speed of each second, (d) has an increase in acceleration of each second. (c)
3. CQ When a ball is thrown upward, what are its velocity and acceleration at its highest point? When it reaches the highest point, its velocity is zero (velocity changes from up to down, so it has to be zero), and its acceleration is still the constant 9.8 m/s2 downward. zero and downward
4. CQ A person drops a stone from the window of a building. One second later, she drops another stone. How does the distance between the stones vary with time? Increases

Taking $y_o = 0$, $y = y_o + v_o t - \frac{1}{2} g t^2 = -\frac{1}{2} g t^2$.

So $y_1 = -\frac{1}{2} g t^2$ and $y_2 = -\frac{1}{2} g (t-1)^2$.

The distance between the two positions is

$\Delta y = y_1 - y_2 = -\frac{1}{2} g\, [t^2 - (t-1)^2] = -\frac{1}{2} g\, [t^2 - t^2 + 2t - 1] = -\frac{1}{2} g\, [2t - 1]$.

Therefore, Δy $\boxed{\text{increases}}$ as t increases.

5. A student drops a ball from the top of a tall building; the ball takes 2.8 s to reach the ground.

   (a) What was the ball's speed just before hitting the ground?

   (b) What is the height of the building?

a) Given: $v_o = 0$, $t = 2.8$ s. Find: v (take $y_o = 0$).

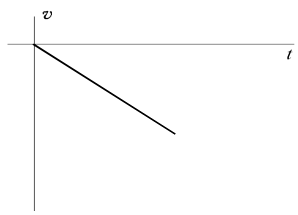
$v = v_o - gt = 0 - (9.80\ \text{m/s}^2)(2.8\ \text{s}) = -\boxed{27\ \text{m/s}}$.

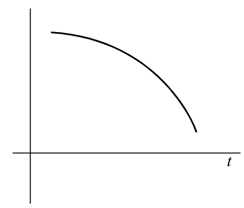
(b) $y = y_o + v_o t - \frac{1}{2} g t^2 = 0 + 0 - \frac{1}{2}(9.80\ \text{m/s}^2)(2.8\ \text{s})^2 = -\boxed{38\ \text{m}}$.

6. For the motion of a dropped object in free fall, sketch the general forms of the graphs of (a) v versus t and (b) y versus t.

(a) A straight line (linear), slope = $-g$.

(b) A parabola.





7. The ceiling of a classroom is 3.75 m above the floor. A student tosses an apple vertically upward, releasing it 0.50 m above the floor. What is the maximum initial speed that can be given to the apple if it is not to touch the ceiling?

The maximum initial velocity corresponds to the apple reaching maximum height just below the ceiling.

Given: $v = 0$ (max height), $(y - y_o) = 3.75 \text{ m} - 0.50 \text{ m} = 3.25 \text{ m}$. Find: v_o.

$v^2 = v_o^2 - 2g(y - y_o)$, ☞ $v_o = \sqrt{v^2 + 2g(y - y_o)} = \sqrt{0 + 2(9.80 \text{ m/s}^2)(3.25 \text{ m})} = 7.98 \text{ m/s}$.

Therefore it is $\boxed{\text{slightly less than 8.0 m/s}}$.

8. You throw a stone vertically upward with an initial speed of 6 m/s from a third-story office window. If the window is 12 m above the ground, find (a) the time the stone is in flight and (b) the speed of the stone just before it hits the ground.

Given: $v_o = 6.0 \text{ m/s}$, $y = -12 \text{ m}$ (take $y_o = 0$). Find: t and v.

(a) $y = y_o + v_o t - \frac{1}{2}gt^2$, ☞ $-12 \text{ m} = 0 + (6.0 \text{ m/s})t - \frac{1}{2}(9.80 \text{ m/s}^2)t^2$.

Or $4.9t^2 - 6.0t - 12 = 0$. Solving, $t = \boxed{2.3 \text{ s}}$ or -1.1 s. The negative time is discarded.

(b) $v = v_o - gt = 6.0 \text{ m/s} - (9.80 \text{ m/s}^2)(2.29 \text{ s}) = -\boxed{16 \text{ m/s}}$.

9. A photographer in a helicopter ascending vertically at a constant rate of 12.5 m/s^2 accidentally drops a camera out the window when the helicopter is 60.0 m above the ground.
(a) How long will the camera take to reach the ground?
(b) What will its speed be when it hits?

(a) Given: $v_o = 12.50$ m/s (ascending), $y = -60.0$ m (take $y_o = 0$). Find: t.

$y = y_o + v_o t - \frac{1}{2}gt^2$, ☞ $-60.0 \text{ m} = 0 + (12.50 \text{ m/s})t - (4.90 \text{ m/s}^2)t^2$.

Reduce to a quadratic equation: $4.90t^2 - 12.50t - 60.0 = 0$.

Solve for $t = \boxed{5.00 \text{ s}}$ or -2.45 s, which is physically meaningless.

(b) $v = v_o - gt = 12.50 \text{ m/s} - (9.80 \text{ m/s}^2)(5.00 \text{ s}) = -36.5 \text{ m/s} = \boxed{36.5 \text{ m/s}}$ downward.

10. A tennis ball is dropped from a height of 10.0 m. It rebounds off the floor and comes up to a height of only 4.00 m on its first rebound. (Ignore the small amount of time the ball is in contact with the floor.)
(a) Determine the ball's speed just before it hits the floor on the way down.
(b) Determine the ball's speed as it leaves the floor on its way up to its first rebound height.
(c) How long is the ball in the air from the time it is dropped until the time it reaches its maximum height on the first rebound?

(a) Given: $v_o = 0$, $(y - y_o) = -10.0$ m (downward). Find: v.

$v^2 = v_o^2 - 2g(y - y_o) = -2(9.80 \text{ m/s}^2)(-10.0 \text{ m}) = 196 \text{ m}^2/\text{s}^2$. So $v = -14.0 \text{ m/s} = \boxed{14.0 \text{ m/s}}$ downward.

(b) Given: $v = 0$ (max height), $(y - y_o) = 4.00$ m. Find: v_o.

$v^2 = v_o^2 - 2g(y - y_o)$, ☞ $v_o = \sqrt{v^2 + 2g(y - y_o)} = \sqrt{0 + 2(9.80 \text{ m/s}^2)(4.00 \text{ m})} = \boxed{8.85 \text{ m/s}}$.

(c) Falling: $v = v_o - gt$, ☞ $t_1 = \dfrac{v_o - v}{g} = \dfrac{0 - (-14.0 \text{ m/s})}{9.80 \text{ m/s}^2} = 1.43$ s.

Rising: $t_2 = \dfrac{8.85 \text{ m/s} - 0}{9.80 \text{ m/s}^2} = 0.90\text{s}$.

Therefore the total time is $1.43 \text{ s} + 0.903 \text{ s} = \boxed{2.33 \text{ s}}$.