Assignment 2.05 - Vertical Motion KEY

1. You step off the 5-m high-dive into a pool.
   (a) How long does it take you to hit the water?

$$\downarrow + \qquad d = \cancel{v_i t}^{0} + \tfrac{1}{2}at^2 \Longrightarrow t = \sqrt{\tfrac{2d}{a}} = \sqrt{\tfrac{2(5m)}{9.81m/s^2}} \approx 1.010s$$

   (b) What is the speed that you hit the water at?

$$v_f = v_i + at = 0m/s + (9.81m/s)(1.010s) \approx 9.905m/s$$

2. Ashley drops a rock off of a bridge. It takes the rock 4.81 seconds to hit the ground. How tall is the bridge?

$$\downarrow + \qquad d = \cancel{v_i t}^{0} + \tfrac{1}{2}at^2 = \tfrac{1}{2}(9.81m/s^2)(4.81s)^2 \approx 114.483m$$

3. A monkey is on the ground. He jumps at a velocity of 10 m/s directly up.
   (a) What is the time that it takes the monkey to reach the top his jump?

$$\uparrow + \qquad v_f = v_i + at \Longrightarrow t = \tfrac{v_f - v_i}{a} = \tfrac{0m/s - 10m/s}{-9.81m/s^2} \approx 1.019s$$

   (b) How high does he jump?

$$d = v_i t + \tfrac{1}{2}at^2 = 10m/s \cdot 1.019s + \tfrac{1}{2}(-9.81m/s^2)(1.019s)^2 \approx 5.097m$$

   (c) What is the total time that the monkey was in the air?

$$t_{total} = 2 \cdot t_{up} = 2 \cdot 1.019s \approx 2.039s$$

4. A man stands on top of a building. He throws a rock at a speed of 25 m/s directly up. The distance from the ground to the point where the rock was thrown is 25 meters.
   (a) How long does it take for the rock to reach the top of its trajectory?

$$\uparrow + \qquad v_f = v_i + at \Longrightarrow t = \tfrac{v_f - v_i}{a} = \tfrac{0m/s - 25m/s}{-9.81m/s^2} \approx 2.548s$$

   (b) How high (measured from the man) does the rock go?

$$d = v_i t + \tfrac{1}{2}at^2 = 25m/s \cdot 2.548s + \tfrac{1}{2}(-9.81m/s^2)(2.548s)^2 \approx 31.855m$$

   (c) The rock then falls to the ground. How long does the rock take to reach the ground?

$$d = \cancel{v_i t}^{0} + \tfrac{1}{2}at^2 \Longrightarrow t = \sqrt{\tfrac{2d}{a}} = \sqrt{\tfrac{2 \times -(31.855m + 25m)}{-9.81m}} = 3.405s$$

   (d) How fast is the rock going when it hits the ground?

$$v_f = v_i + at = 0m/s + (-9.81m/s^2)(3.405s) = 33.403m/s$$

5. A volcano is 1,250 m taller than the surrounding land. During an eruption, a rock is shot out of the volcano directly up at a speed of 475 m/s.

   (a) How high does the rock go?

$$\uparrow + \qquad v_f^2 = v_i^2 + 2ad \Longrightarrow d = \frac{v_f^2 - v_i^2}{2a} = \frac{(0m/s)^2 - (475m/s)^2}{2(-9.81m/s^2)} \approx 11499.745m$$

   (b) As the rock is in the air, the volcano blows itself apart. The rock lands at the same height as the surrounding land. What is the speed that the rock is going when it hits the ground? (Ignore air resistance).

$$v_f^2 = v_i^2 + 2ad \Longrightarrow v_f = \sqrt{v_i^2 + 2ad} = \sqrt{(0m/s^2) + 2(-9.81m/s)(11499.745m + 1250m)}$$
$$\approx 500.150m/s$$

6. A baseball player hits a foul ball into the stands behind home plate. If the ball left his bat with a vertical velocity of 22.5 m/s,

   (a) What is the greatest height that the ball will reach?

$$\uparrow + \qquad v_f = v_i + at \Longrightarrow t = \frac{v_f - v_i}{a} = \frac{0m/s - 22.5m/s}{-9.81m/s^2} \approx 2.294s$$

$$d = v_i t + \frac{1}{2}at^2 = (22.5m/s)(2.294s) + \frac{1}{2}(-9.81m/s^2)(2.294)^2 \approx 25.803m$$

   (b) If the stands are 4 meters higher than the baseball player, what is the total amount of time it takes from when he hits the ball until the baseball lands in the stands?

$$d = \cancel{v_i t}^{\,0} + \frac{1}{2}at^2 \Longrightarrow t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2 \times -(25.803m - 4m)}{-9.81m}} = 2.108s$$

   (c) What is the velocity of the baseball when it is caught by an adoring fan?

$$v_f = v_i + at = 0m/s + (-9.81m/s^2)(2.108s) = 20.683s$$