Assignment 2.04 - The Kinematic Equations KEY

1. You are in a plane that is taking off. It starts from a stop and accelerates at a rate of 5 m/s^2 until it leaves the ground 675 meters away.

   (a) What is the velocity that the plane is traveling with when it leaves the ground?

   $$v_f{}^2 = v_i{}^2 + 2ad \Longrightarrow v_f = \sqrt{v_i{}^2 + 2ad} = \sqrt{(0m/s)^2 + 2(5m/s^2)(675m)} \approx 82.158m/s$$

   (b) How long does it take the plane to travel the distance of the runway?

   $$v_f = v_i + at \Longrightarrow t = \frac{v_f - v_i}{a} = \frac{82.158m/s - 0m/s}{5m/s^2} \approx 16.432s$$

2. A cart is rolling down an inclined plane, and accelerates from rest at a constant rate of 0.5 m/s^2.

   (a) How far will the cart travel in 0.75 seconds?

   $$d = v_i t + \frac{1}{2}at^2 = (0m/s)(0.75s) + \frac{1}{2}(0.5m/s^2)(0.75s)^2 \approx 0.141m$$

   (b) What is the final velocity of the cart after 0.75 seconds?

   $$v_f = v_i + at = 0m/s + (0.5m/s)(0.75s) = .375m/s$$

3. A major league pitcher can cause a baseball to go from 0 m/s to 42 m/s over the distance of 1.2 meters.

   (a) Calculate the acceleration of the baseball.

   $$v_f{}^2 = v_i{}^2 + 2ad \Longrightarrow a = \frac{v_f{}^2 - v_i{}^2}{2d} = \frac{42^2 - 0^2}{2(1.2m)} = 735m/s^2$$

   (b) How long does it take the pitcher to throw the ball (from when he starts to throw until the ball leaves his hand)?

   $$v_f = v_i + at \Longrightarrow t = \frac{v_f - v_i}{a} = \frac{42m/s - 0m/s}{735m/s^2} \approx 0.057s$$

4. The Space Shuttle Discovery begins its final launch from Cape Canaveral, Florida. At t=0s, the main engines start, and Discovery climbs toward the sky. 10 minutes later, Discovery is traveling 7.823 x 10^3 m/s. Note: 10 minutes = 600 s

   (a) What is Discovery's average acceleration?

$$v_f = v_i + at \Longrightarrow a = \frac{v_f - v_i}{t} = \frac{7.823\times10^3 m/s - 0m/s}{600s} \approx 13.038 m/s^2$$

   (b) How far does Discovery travel during this time?

$$d = v_i t + \frac{1}{2}at^2 = 0m/s \cdot 600s + \frac{1}{2}(13.038m/s^2)(600s)^2 \approx 2.347 \times 10^6 m$$

5. Kirk and McCoy step off the edge of a 50-m high cliff on an alien planet. If gravity causes them to accelerate at 2.3 m/s^2,

   (a) What is their speed when they hit the water below?

$$v_f{}^2 = v_i{}^2 + 2ad \Longrightarrow v_f = \sqrt{v_i{}^2 + 2ad} = \sqrt{0m/s^2 + 2(2.3m/s^2)(50m)} \approx 15.166 m/s$$

   (b) How long are they falling toward the water?

$$v_f = v_i + at \Longrightarrow t = \frac{v_f - v_i}{a} = \frac{15.166m/s - 0m/s}{2.3m/s^2} \approx 6.594s$$

6. A man is pushing a baby stroller on a hill when he is distracted by a text message. Starting from rest, the baby stroller begins to roll down the hill, accelerating at 0.1 m/s^2. If the man can run at a speed of 12 m/s, what is the longest amount of time he can spend reading his text message and still catch the stroller?

   Time for stroller to reach 12 m/s: $v_f = v_i + at \Longrightarrow t = \frac{v_f - v_i}{a} = \frac{12m/s - 0m/s}{0.1m/s^2} = 120s$

   Distance stroller rolls in that time: $d = v_i t + \frac{1}{2}at^2 = 0m/s \cdot 120s + \frac{1}{2}(0.1m/s^2)(120s)^2 = 720m$

   Time for man to run that distance: $d = v_i t + \frac{1}{2}\cancel{at^2}^{\,0} \Longrightarrow t = \frac{d}{v_i} = \frac{720m}{12m/s} = 60s$

   Time man can stand around reading message: $120s - 60s = \underline{60s}$