Worksheet 1.7

Motion in the Y-Direction

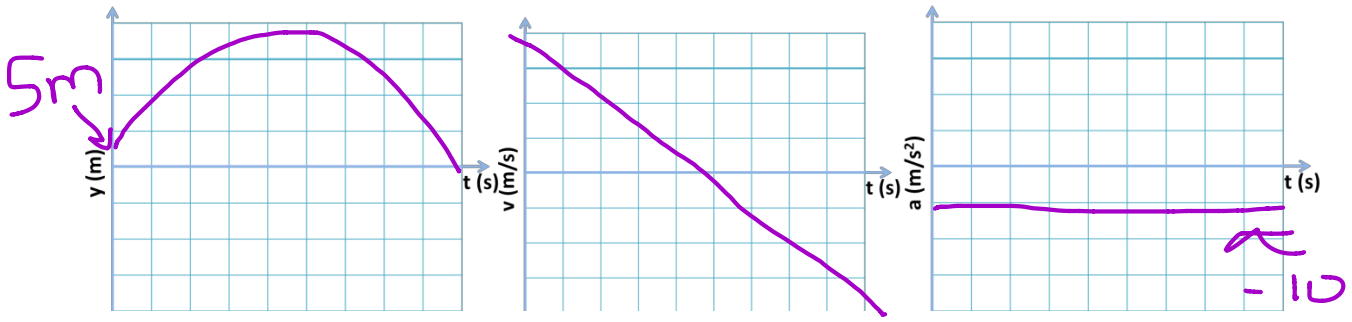
1. Write down the equations that describe motion in the y-direction.

$v_f = at + v_i$ $\quad \Delta y = \frac{t}{2}(v_f + v_i)$

$y_f = \frac{1}{2}at^2 + v_i t + y_i$

$v_f^2 = v_i^2 + 2a\Delta y$

2. A group celebrating rebels in Libya fire their guns into the air. One man stands on his roof 5 m above the ground, leans over the edge and fires his gun vertically. The bullet leaves his gun with a velocity of 900 m/s. Draw the y vs t, v vs t, and a vs t graphs for the bullet's travel until it reaches the ground. $a = -10 m/s^2$



Rewrite the equations from (1) using the information provided in the question.

$v_f = -10t + 900$

$y_f = \frac{1}{2}(-10)t^2 + 900t + 5m$ $\quad y_f - 5 = \frac{t}{2}(v_f + 900)$

$v_f^2 = 900^2 + 2(-10)(y_f - 5)$

How long does it take for the bullet to reach its maximum height?

max height occurs @ $v_y = 0$

$0 = -10t + 900$

$t = 90s$

What is the maximum height of the bullet?

$y_f = \frac{1}{2}(-10)90^2 + 900(90) + 5 = 40{,}505\ m$

What is the velocity of the bullet as it hits the ground? Approach this problem from the time when the initial velocity in the y-direction is zero (at its maximum height) and treat it as an object falling from its maximum height.

$t_{total} = 90s +$ time to fall from max height

$0 = \frac{1}{2}(-10)t^2 + 0t + 40{,}505$

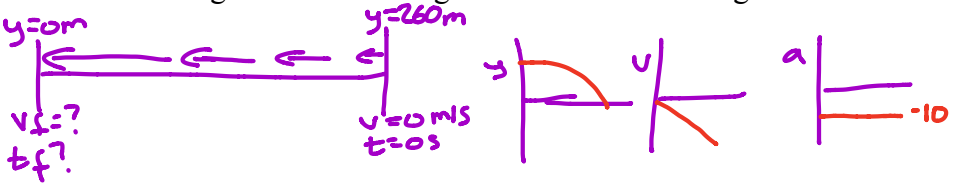
$y_f \quad 0 = -5t^2 + 40{,}505 \quad t = \sqrt{8{,}101} = 90.005$ sec $\rightarrow t_{total} = 90s + 90.005s = 180.005s$

Now, $v_f = -10(180.005) + 900 = -900.005\ m/s$

For the following questions, draw the motion diagram associated with each question along with the x vs t, v vs t, and a vs t graphs that describe the motion.

3. Steph Curry drops a basketball from the top of the Transamerica Building in SF (h=260 m). Knowing that gravity accelerates the basketball at a rate of –9.8 m/s^2 with what velocity does the basketball hit the ground? How long does it take to hit the ground?

$y_i = 260m$, $a = -10 m/s^2$, $v_i = 0 m/s$, v_f?, t_f?



Calculate t_f

$0 = -\frac{1}{2}(-10)t^2 + 0t + 260m$

$-5t^2 + 260 = 0$

$t_f = 7.22s$

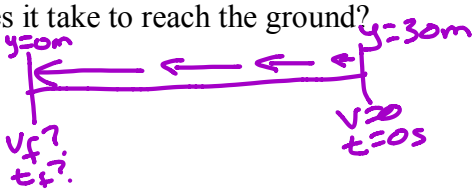
Calculate v_f

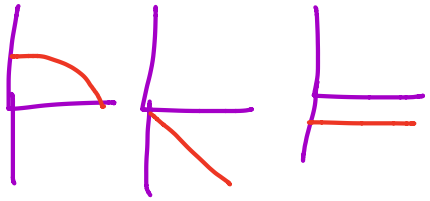
$v_f = -10(7.22) + 0$

$v_f = -70.22 m/s$

4. A hot air balloon is floating at a constant height 30 m above the ground when someone onboard releases an apple core. What is the velocity when the apple core hits the ground? How long does it take to reach the ground?

$y_i = 30m$, $a = -10m/s^2$, $v_i = 0 m/s$, v_f?, t_f?





Calculate t_f

$0 = \frac{1}{2}(-10)(t^2) + 0t + 30$

$-5t^2 + 30 = 0$

$t = 2.45s$

Calculate v_f

$v_f = -10(2.45) + 0$

$= -24.5 m/s$

5. A person standing at the edge of a 100 m cliff drops one ball straight down and throws another ball straight down with an initial velocity of -10 m/s. Neglecting air resistance, with what velocities do the two balls hit the ground below the cliff? How much time passes between the two balls hitting the ground?

$y_i = 100m$

$v_{i\,ball2} = -10 m/s$, $v_{i\,ball1} = 0 m/s$

$a = -10 m/s^2$

v_f for both?

t_f for both?

t_f's

① $0 = \frac{1}{2}(-10)t^2 + 0t + 100$

$t_f = 4.45 sec$

② $0 = \frac{1}{2}(-10)t^2 + (-10)t + 100$

$t = 3.6 sec$

v_f's: ① $v_f = -10(4.45) + 0 = -44.5 m/s$

② $v_f = -10(3.6) - 10 = -46 m/s$

Time between impacts: $4.45 sec - 3.6 sec = .85 sec$

6. A ball is thrown vertically ~~from~~ to the ground from a tower 120 m in height. The ball hits the ground 2 seconds later. What was the initial velocity of the ball when thrown? What is the velocity of the ball when it hits the ground?

$y_i = 120m$ $\quad v_f?$
$t_f = 2s$ $\quad v_i?$
$a = -10 m/s^2$

calculate v_i

$0 = \frac{-10(2^2)}{2} + v_i(2) + 120$

$0 = -20 + 2v_i + 120$

$-100 = 2v_i$

$v_i = -50 m/s$

v_f

$v_f = -10(2) - 50 = -70 m/s$

7. A ball is thrown vertically from the ground at a velocity 30 m/s, when another ball is dropped along the same line, simultaneously from the top of a tower 120 m in height. Find the time when the two balls meet (same place at the same time).

① $v_i = 30 m/s$
$a = -10 m/s^2$
$y_i = 0$

② $v_i = 0 m/s$
$a = -10 m/s^2$
$y_i = 120m$

if @ same place, $y_{f①} = y_{f②}$ @ the same t

set $y_{f①} = y_{f②}$

$\frac{-10}{2}t^2 + 30t + 0 = \frac{-10}{2}t^2 + 0t + 120$

$30t = 120$

$t = 4s$

position: $y_f = -10/2(4)^2 + 30(4) + 0 = 40m$