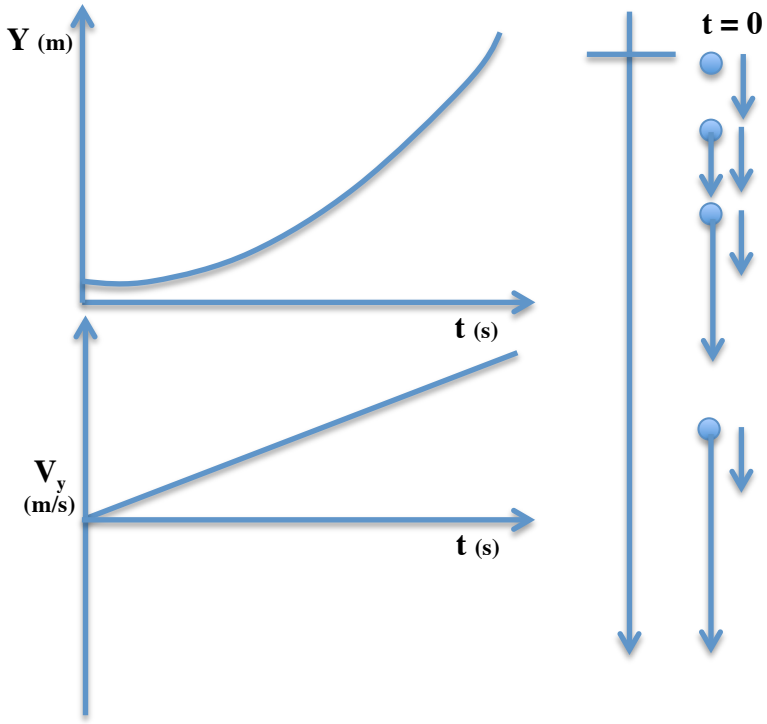
Unit 6 **HOMEWORK / Classwork**

*For your solutions to these problems, show the **force diagram** for the object of interest in each problem, and sketch a **motion map**, including acceleration, for the entire trajectory of the object in question. Also show some **graph on graph paper** of your choosing to represent the motion of interest. Finally, show any **mathematical relationship** that you will use in your solution in algebraic form (with variables in letters, not with numbers substituted yet). Identify all relevant variables by labeling them in your motion maps and force diagrams. Let's assume air resistance is negligible.*

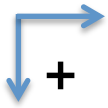
1. A brick is dropped from a bridge. It is seen to hit the water below 3.1 s later. How high is this bridge?



$V_x = 0.0$ m/s $\quad \Delta y = ???$

$V_{yi} = 0.0$ m/s $\quad g = 10.\ m/s^2$

$\Delta t = 3.1$ s

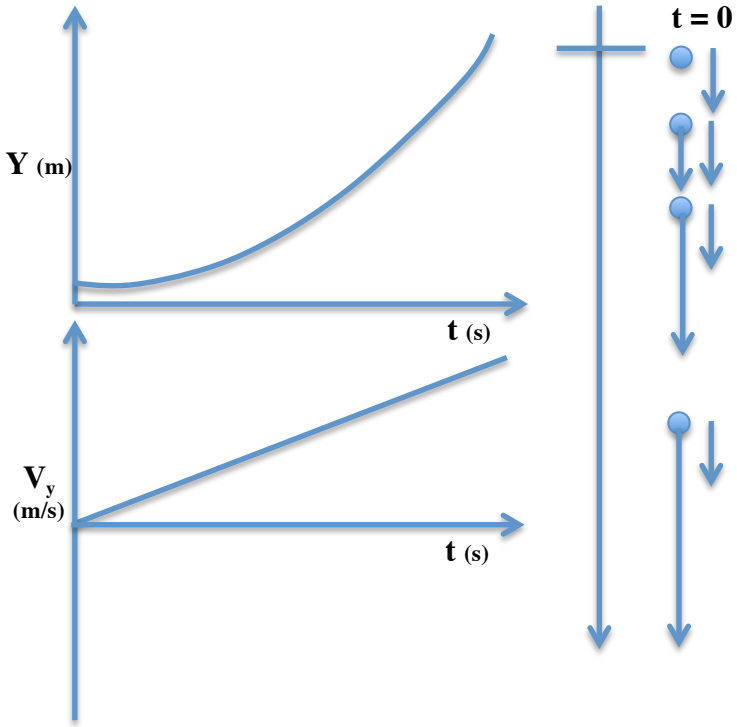


$$\Delta y = \cancel{V_{yi}}^{0} * \Delta t + \tfrac{1}{2} * g * \Delta t^2$$

$$\Delta y = \tfrac{1}{2} * 10.\ m/s^2 * (3.1\ s)^2$$

$$\boxed{\Delta y = 48.1\ m}$$

2. The Sears Tower is nearly 400. m high. How long would it take a steel ball to reach the ground if dropped from the top? What will be its velocity the moment before it touches the ground?



$V_x = 0.0$ m/s $\Delta y = 400.$ m
$V_{yi} = 0.0$ m/s $g = 10.$ m/s^2
Δt = ??? V_{yf} = ???

+

$\Delta y = \cancel{V_{yi}}^{0} * \Delta t + \frac{1}{2} * g * \Delta t^2$ $\Delta t = \sqrt{((2 * \Delta y) / g)}$

$\Delta t = \sqrt{((2 * 400.\text{ m}) / 10.\text{ m/s}^2)}$

$\Delta t = 8.94$ s

$V_{yf}^2 = \cancel{V_{yi}^2}^{0} + 2 * g * \Delta y$ $V_{yf} = \sqrt{(2 * 10\text{m/s}^2 * 400.\text{m})}$

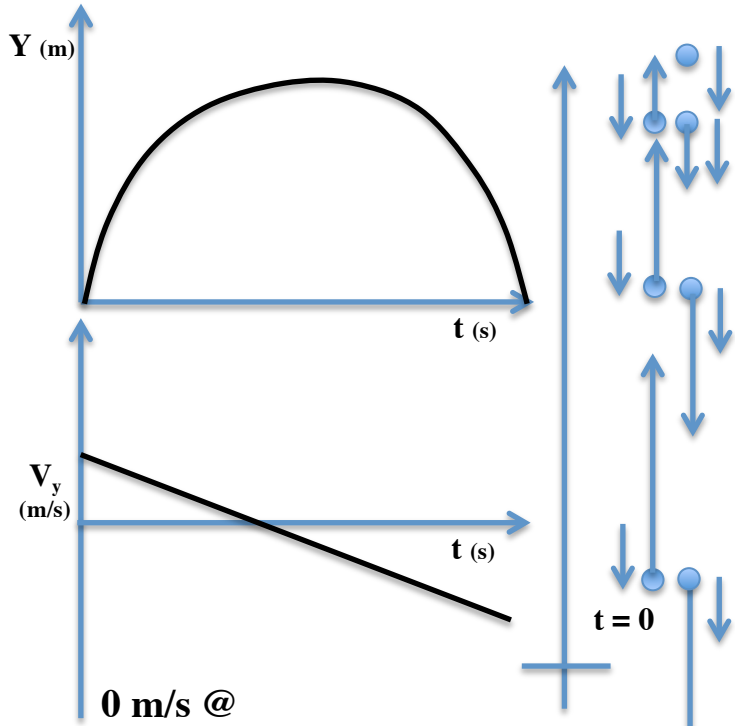
$V_{yf} = 89.4$ m/s

OR

$V_{yf} = \cancel{V_{yi}}^{0} + g * \Delta t$ $V_{yf} = 10\text{m/s}^2 * 8.94$ s

$V_{yf} = 89.4$ m/s

3. A rock is thrown straight up at a velocity of +30. m/s from a height of 2 m above the ground. How high does it go? How long will it take to fall back to the same height from which it was thrown?



$V_x = 0.0$ m/s $\Delta y = ???$

$V_{yi} = 30.0$ m/s $g = -10.$ m/s^2

$\Delta t = ???$ $y_i = 2.0$ m

+

0 m/s @ Highest Point

$V_{yf}^2 = V_{yi}^2 + 2 * g * \Delta y$ $\Delta y = V_{yi}^2 / (2 * g)$

$\Delta y = (30.0 \text{ m/s})^2 / (2 * 10 \text{m/s}^2) = 900. \text{ m}^2/\text{s}^2 / 20. \text{ m/s}^2$

$\Delta y = 45$ m $\Delta y = y_f - y_i$ $y_f = \Delta y + y_i$ $y_f = 45$ m $+ 2.0$ m

$y_f = 47$ m

0 m/s @ Highest Point

$V_{yf} = V_{yi} + g * \Delta t_{½Way}$ $\Delta t_{½Way} = V_{yi} / g$

$\Delta t_{½Way} = 30. \text{ m/s} / 10 \text{m/s}^2$

$\Delta t_{½Way} = 3.0$ s $\Delta t = 2 * \Delta t_{½Way}$ $\Delta t = 3.0$ s $* 2$

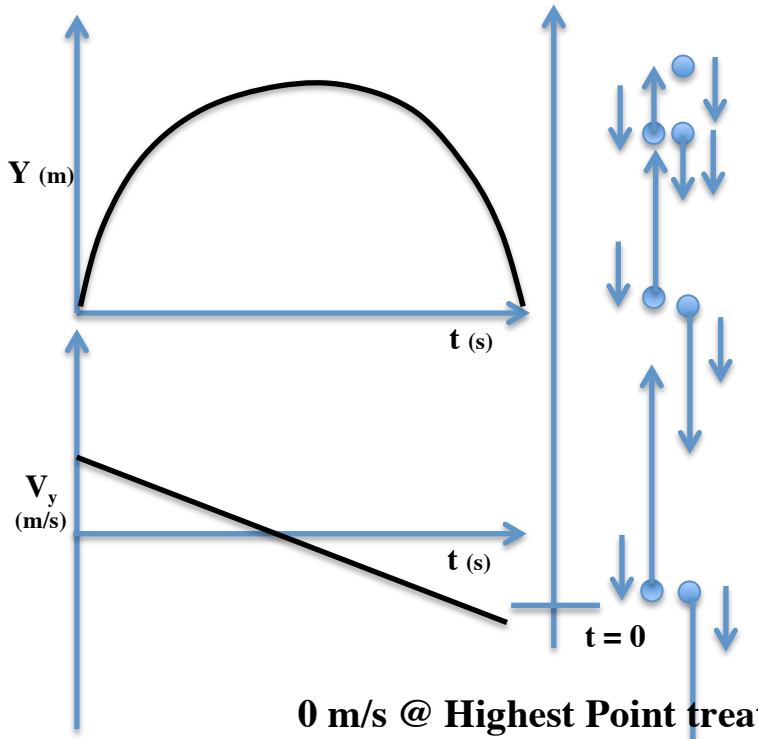
$\Delta t = 6.0$ s

4. A person has a vertical leap of 1.0 m. Not too bad! How much time is this person in the air? With what velocity does this person leave the ground?

$V_x = 0.0$ m/s $\Delta y = 1.0$ m

$V_{yi} = ???$ $g = -10.\ m/s^2$

$\Delta t = ???$



0 m/s @ Highest Point treat this as an object that falls from 1.0 m

$\Delta y = V_{yi} * \Delta t_{½Way} + ½ * g * \Delta t_{½Way}^2$ $\Delta t_{½Way} = \sqrt{((2 * \Delta y) / g)}$

$\Delta t_{½Way} = \sqrt{((2 * 1.0\ m) / 10.\ m/s^2)}$

$\Delta t_{½Way} = 0.447$ s * 2 → $\Delta t = 0.894$ s

0 m/s @ Highest Point

$V_{yf}^2 = V_{yi}^2 + 2 * g * \Delta y$ $V_{yf} = \sqrt{(2 * 10 m/s^2 * 1.0\ m)}$

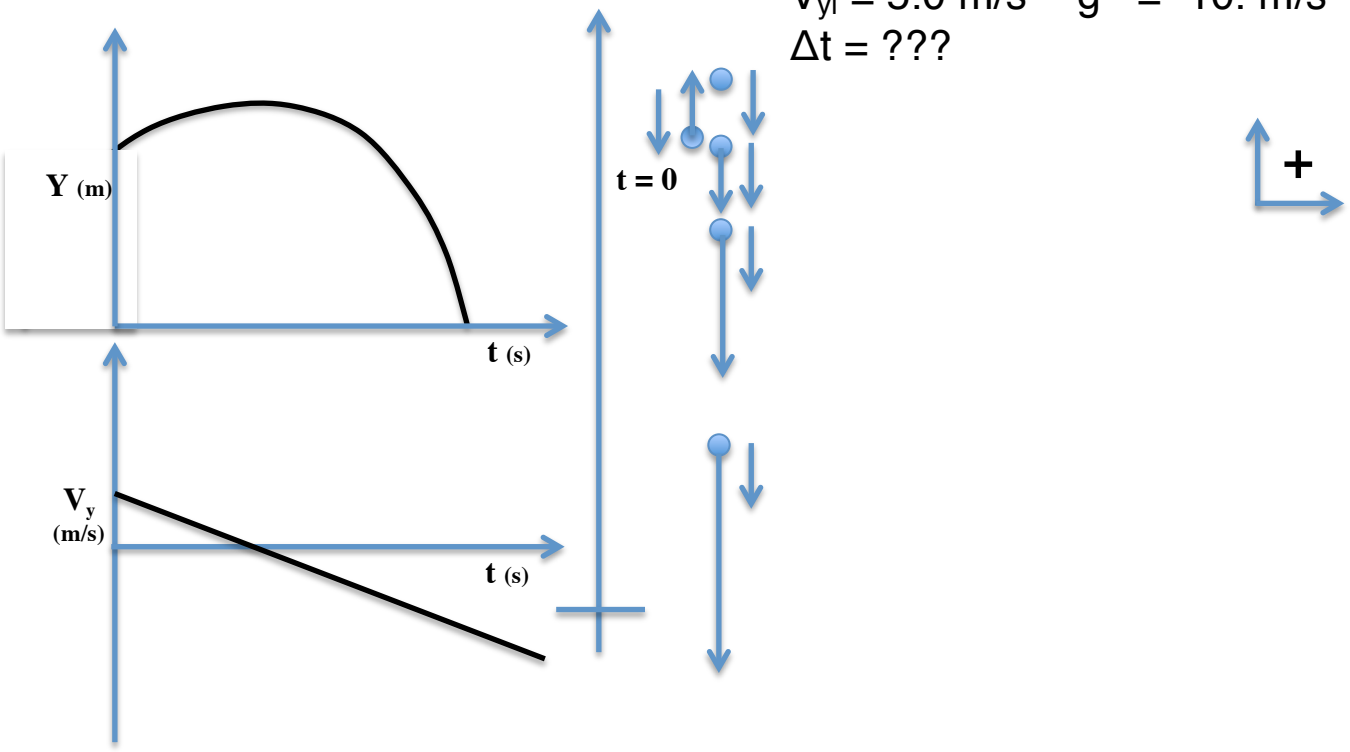
$V_{yi} = 4.47$ m/s

5. A hot air balloon is ascending with a velocity of 5.0 m/s. A little scary maybe? A 5.0 kg mass is dropped from this balloon at a height of 80 m. How much time will pass before the mass hits the ground?

$V_x = 0.0$ m/s $\Delta y = 80.$ m

$V_{yi} = 5.0$ m/s $g = -10.$ m/s^2

Δt = ???



$V_{yf}^2 = V_{yi}^2 + 2 * g * \Delta y$ $V_{yf} = \sqrt{((5.0 \text{ m/s})^2 + 2 * -10 \text{m/s}^2 * -80.\text{m})}$

$V_{yf} = -40.3$ m/s

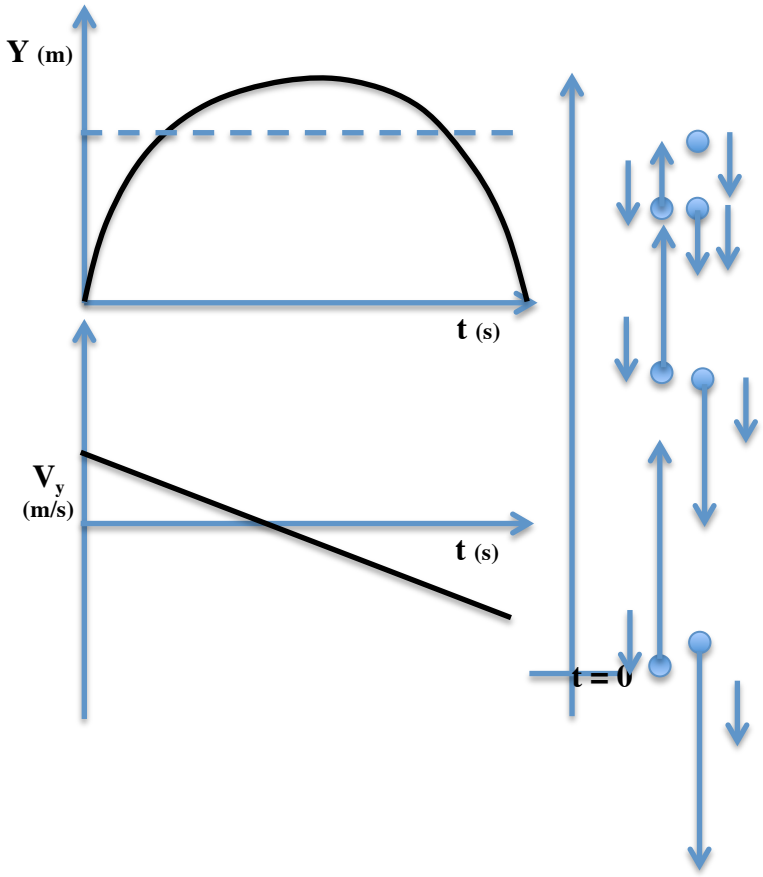
It is dropping down and up is positive, so V_{yf} has to be negative!

$V_{yf} = V_{yi} + g * \Delta t$ $\Delta t = (V_{yf} - V_{yi}) / g$

$\Delta t = (-40.3 \text{ m/s} - 5.0 \text{ m/s}) / -10. \text{ m/s}^2$

$\Delta t = 4.53$ s

6. A ball is thrown vertically from the ground with a speed of 24 m/s. How fast is it moving when it is 20. m above the ground? How much time is required to attain this height?



$V_x = 0.0$ m/s $\Delta y = 20.$ m
$V_{yi} = 24$ m/s $g = -10.$ m/s^2
$V_{yF} = ???$
$\Delta t = ???$

+

$V_{yf}^2 = V_{yi}^2 + 2 * g * \Delta y$ $V_{yf} = \sqrt{(24\ m/s)^2 + 2 * -10 m/s^2 * 20.m)}$

V_{yf} = **+13.27 m/s and -13.27 m/s**

Both answers are needed to be correct since it goes up then comes back down.

$V_{yf} = V_{yi} + g * \Delta t$ $\Delta t = (V_{yf} - V_{yi}) / g$

$\Delta t = (-13.27\ m/s - (-24.0\ m/s)) / -10 m/s^2$

$\Delta t = 1.073$ s **Time for trip up.**

$V_{yf} = V_{yi} + g * \Delta t$ $\Delta t = (V_{yf} - V_{yi}) / g$

$\Delta t = (13.27\ m/s - (-24.0\ m/s)) / -10 m/s^2$

$\Delta t = 3.73$ s **Time for trip down.**

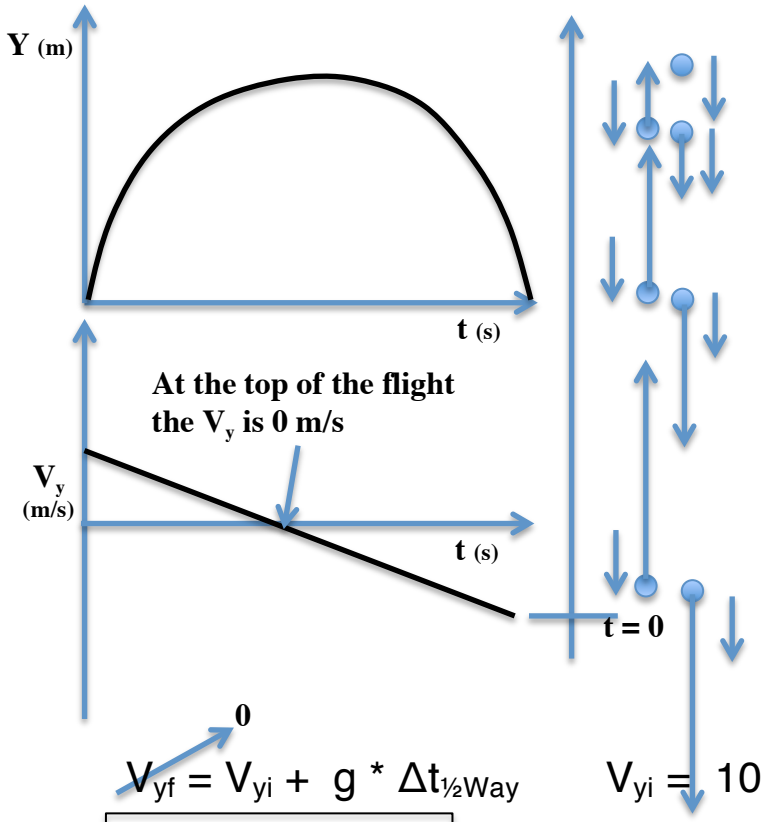
7. If you throw a ball upward and catch it 3.0 s later, with what speed did you throw it? How high did it go?

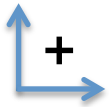
$V_x = 0.0$ m/s $\Delta y = ???$

$V_{yi} = ???$ $g = -10.\ m/s^2$

$\Delta t = 3.0$ s

$\Delta t_{½Way} = 1.5$ s





0

$V_{yf} = V_{yi} + g * \Delta t_{½Way}$ $V_{yi} = 10.\ m/s^2 * 1.5$ s

$V_{yi} = 15.0$ m/s

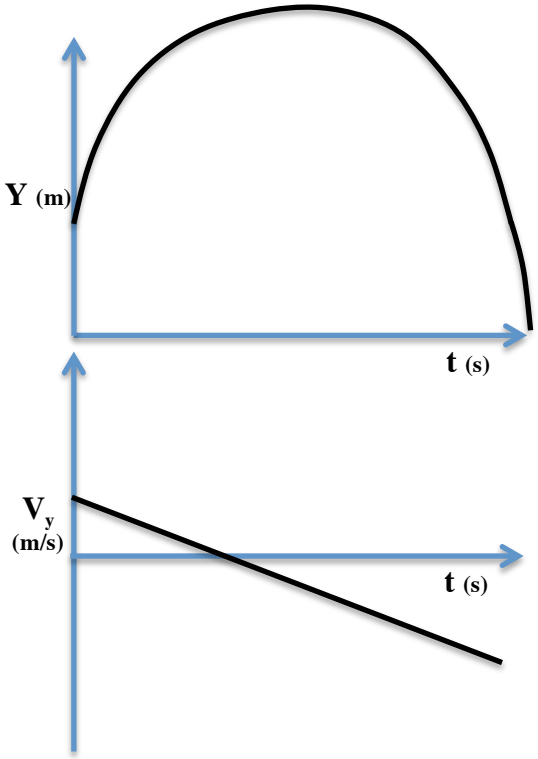
0

$V_{yf}^2 = V_{yi}^2 + 2 * g * \Delta y$ $\Delta y = - V_{yi}^2 / 2 * g$

$\Delta y = (15.0\ m/s)^2 / 2 * 10 m/s^2$

$\Delta y = 11.3$ m

8. A piece of granite is thrown upward with a speed of 25 m/s from a cliff that is 80 m high. How much time goes by before it hits the water below? What is its velocity at impact? What will its average velocity be? What will its average speed be?

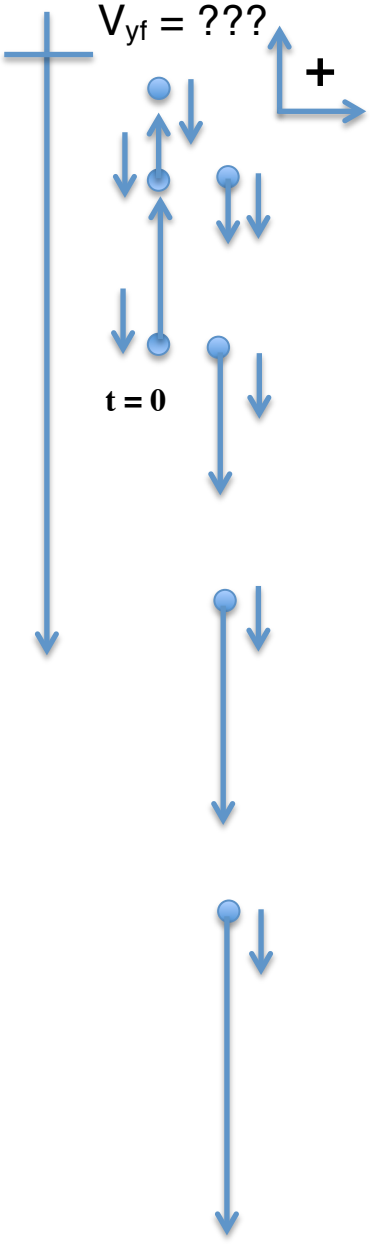


$V_x = 0.0$ m/s $\quad \Delta y = 80.$ m

$V_{yi} = 25.0$ m/s $\quad g = -10.$ m/s^2

$V_{ave} = ???$ $\quad V_{sp} = ???$

$\Delta t = ???$ $\quad V_{yf} = ???$



8. A piece of granite is thrown upward with a speed of 25 m/s from a cliff that is 80 m high. How much time goes by before it hits the water below? What is its velocity at impact? What will its average velocity be? What will its average speed be?

$V_x = 0.0$ m/s $\Delta y = 80.$ m
$V_{yi} = 25.0$ m/s $g = -10.$ m/s^2
$V_{ave} =$??? $V_{sp} =$???
$\Delta t =$??? $V_{yf} =$???

$V_{yf}^2 = V_{yi}^2 + 2 * g * \Delta y$ $V_{yf} = \sqrt{((25 \text{ m/s})^2 + 2 * -10 \text{ m/s}^2 * -80.\text{m})}$

$V_{yf} = \pm 47.2$ m/s **-47.2 m/s it is going down so the negative answer is the correct one, since up is positive.**

$V_{yf} = V_{yi} + g * \Delta t$ $\Delta t = (V_{yf} - V_{yi}) / g$

$\Delta t = (-47.2 \text{ m/s} - 25.0 \text{ m/s}) / (-10 \text{m/s}^2)$

$\Delta t = 7.22$ s

$V_{ave} = \Delta y / \Delta t$

$V_{ave} = -80 \text{ m/s} / 7.22 \text{ s}$

$V_{ave} = -11.1$ m/s

0 m/s @ Highest Point

$V_{yf}^2 = V_{yi}^2 + 2 * g * \Delta y_1$ $\Delta y_1 = -V_{yi}^2 / (2 * g)$

$\Delta y_1 = -(25 \text{ m/s})^2 / (2 * -10 \text{ m/s}^2) =$ 31.3 m

Distance travelled = $\Delta y_{1Up} + \Delta y_{1Down} + \Delta y = 31.3 \text{ m} * 2 + 80. \text{ m} = 142.6$ m

$V_{speed} =$ distance / Δt

$V_{speed} = 142.6 \text{ m} / 7.22 \text{ s}$

$V_{speed} = 19.8$ m/s

OR

$V_{speed} = | V_{ave} |$

$V_{speed} = | -11.1 \text{ m/s} |$

$V_{speed} = 11.1$ m/s