McComb's WS: Throwing Up and Falling Down **Name:** Key
aka: ACCELERATION DUE TO GRAVITY

Directions: Solve each of the following problems.

1. A stone dropped from the top of a building, strikes the ground in 4.2 seconds. How tall is the building?

$y = 86.4 m$

2. Silas McEvil pushes a safe off the top of a building 200 meters tall. How much time does his victim on the ground below have to move out of the way? At what speed will the safe hit the ground?

$t = 6.4 s$ $v = 62.72 m/s$ down

3. An airplane at a height of 400 meters is traveling horizontally with a speed of 120 km/hr. A paratrooper . If his parachute must open 200 meters above the ground, how long does he have for the chute to open?

$t = 6.4 s$

4. Farsley Henworth hits a pop-foul directly upward in a baseball game. 4.2 seconds later, the catcher drops the ball. How high was the ball hit into the air (above the level from which it was hit)?

$y = 21.6 m$

5. A bomb dropped from an airplane is given an initial downward speed of 10.4 m/sec. What is its final velocity if it hits the ground 4.03 seconds after being released?

$v_f = 49.9 m/s$ down

6. An empty propane tank dropped from a hot air balloon hit the ground with a speed of 148.3 m/sec. From what height was the tank dropped?

$y = 1122.1 m$

7. A baseball is tossed from a mechanical device from ground level. It is thrown directly upward with an initial speed of 25 m/sec. How high will the ball rise? How long does the ball take to reach its highest point? What is its velocity when it hits the ground again?

$y = 31.9 m$ $t = 2.55 s$ $v_f = 25 m/s$ down

8. A native sitting 30.0 meters up in a tree throws his spear at an armadillo on the ground directly below. He releases the spear at 5.5 m/sec. What is the speed with which the spear reaches the ground? How much time does the armadillo have to dodge the spear from the time it is released?

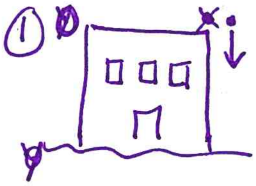
$v = 24.9 m/s$ down $t = 1.98 s$

9. A sniper is in a dugout preparing to shoot at a target. The muzzle-tip of his rifle is exactly at ground level. He fires a bullet directly upward with a speed of 330 m/sec. How far above the ground will the bullet be in 65 seconds?

$y = 747.5 m$

10. Joseph hurls a rock downward from a cliff 14.5 meters above a lake. One second later, the rock hits the lake. What initial speed did Josephus give the rock?

$v_0 = 9.6 m/s$ down

① 

$V_0 = 0\ m/s$
$t = 4.2\ s$
$a = 9.8\ m/s^2$
y = height of building = ?

↓ + down is positive

$$y = V_0 t + \frac{1}{2}at^2$$
$$y = (0\ m/s)(4.2\ s) + \frac{1}{2}(9.8\ m/s^2)(4.2\ s)^2$$
$$\boxed{y = 86.4\ m}$$

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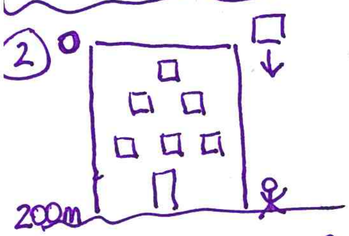
② 

$Y_0 = 0m$
$y = 200m$
$a = 9.8\ m/s^2$
$V_0 = 0\ m/s$
$t = ?$

↓ + down is positive

$$y = V_0 t + \frac{1}{2}at^2$$
$$200m = \frac{1}{2}(9.8\ m/s^2)\,t^2$$
$$t^2 = \frac{2(200m)}{9.8\ m/s^2}$$
$$t = \pm\sqrt{40.82\ s^2}$$
$$\boxed{t = +6.4\ \text{seconds}}$$

negative time doesn't make sense.

$$V = V_0 + at$$
$$= 0\ m/s + (9.8\ m/s^2)(6.4\ s)$$
$$= 62.72\ m/s$$

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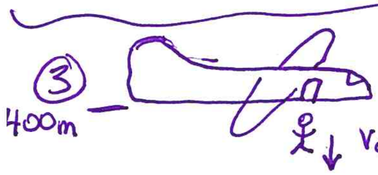
③ 

$V_0 = 120\ km/hr$ (plane)

(paratrooper) ↓ $V_0 = 0\ m/s$ down
$y = 200\ m$
$Y_0 = 400\ m$

$a = 9.8\ m/s^2$ down

↑ + up is positive

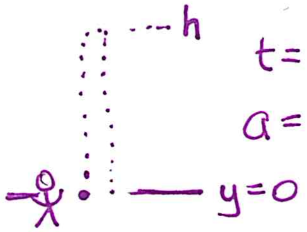
200m –

0m –

$$y = y_0 + V_0 t + \frac{1}{2}at^2$$
$$200m = 400m + (0\ m/s)(t) + \frac{1}{2}(-9.8\ m/s^2)(t^2)$$
$$\frac{200m - 400m}{\frac{1}{2}(-9.8\ m/s^2)} = t^2$$
$$40.82 = t^2$$
$$\boxed{6.4\ sec = t}$$

Note the velocity of the plane doesn't matter, only the vertical speed of the paratrooper matters.

(4)



$\uparrow +$ up is positive

$t = 4.2\,s$

$a = 9.8\ m/s^2 \downarrow$

at the highest point $v = 0\ m/s$

$v = v_0 + at$

$v - at = v_0$

$0\ m/s - (-9.8\ m/s^2)(~~4.2s~~\ 2.1s) = v_0$

the time it takes the ball to reach the top is $\frac{1}{2}$ of the total time

$v_0 = ~~40.06~~\ 20.58\ m/s$ (up)

$y = v_0 t + \frac{1}{2}at^2$

$y = (20.58\ m/s)(2.1\,s) + \frac{1}{2}(-9.8\ m/s^2)(2.1\,s)^2$

$\boxed{y = 21.6\,m}$

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(5) $\downarrow v = 10.4\ m/s$

$\downarrow +$ down is positive

$t = 4.03\,s$ $\quad a = 9.8\ m/s^2$ (note that accel. is positive b/c the down direction is defined as +)

$v_f = ?$

$v_f = v_0 + at$

$= 10.4\ m/s + (9.8\ m/s^2)(4.03\,s)$

$\boxed{v_f = 49.9\ m/s}$

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(6) 0m — □ ↓

$\downarrow$ down is positive

$v_f = 148.3\ m/s$

$a = 9.8\ m/s^2$

$v_0 = 0\ m/s$ (assume that the hot air balloon was not moving vertically)

y

$y = ?$

$v_f^2 = v_0^2 + 2ay$

$(148.3\ m/s)^2 = (0\ m/s)^2 + 2(9.8\ m/s^2)\,y$

$y = \dfrac{(148.3\ m/s)^2}{2(9.8\ m/s^2)}$

$\boxed{y = +1122.1\ m}$

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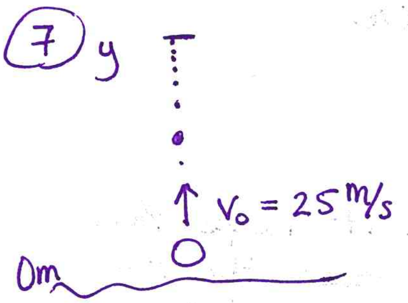


$\uparrow^{+}$ up is positive

$y = ?$

$t = ?$

v_f (at $y=0$) $= ?$

$a = -9.8\ m/s^2$

We know that at the highest point $v_f = 0\ m/s$

$v_f^2 = v_0^2 + 2ay$

$(0\ m/s)^2 = (25\ m/s)^2 + 2(-9.8\ m/s)y$

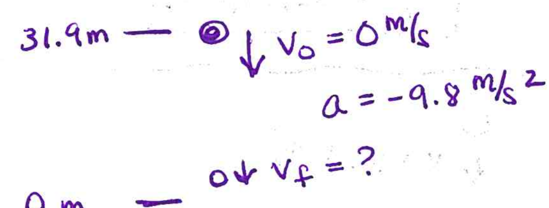
$y = \dfrac{(25\ m/s)^2}{2(+9.8\ m/s)}$

$\boxed{y = 31.9\ m}$

$v_f = v_0 + at$

$\dfrac{v_f - v_0}{a} = t$

$\dfrac{0\ m/s - 25\ m/s}{-9.8\ m/s^2} = \boxed{t = 2.55\ s}$



Going back down, $\uparrow^{+}$ up is positive

$v_0 = 0\ m/s$

$v_f = ?$

$y = -31.9\ m$ (b/c ball is starting at 31.9 m and going to 0 m)

$a = -9.8\ m/s^2$

$v_f^2 = v_0^2 + 2ay$

$v_f^2 = 2(-9.8\ m/s^2)(-31.9\ m)$

$v_f = \pm 25.0\ m/s$

since up is positive, and the ball is moving down, the negative velocity is the correct answer

$\boxed{v_f = -25.0\ m/s}$

(8) 30m ↓ $v_0 = -5.5$ m/s
$h = 30$ m
$a = -9.8$ m/s²

$v_f = ?$ $t = ?$

↑+ up is positive

Δy = final height − initial height
= 0m − 30m
$y = -30$ m

$$v_f^2 = v_0^2 + 2ay$$
$$v_f^2 = (-5.5\,\text{m/s})^2 + 2(-9.8\,\text{m/s}^2)(-30\,\text{m})$$
$$v_f^2 = 618.25$$
$$v_f = \pm\sqrt{618.25}$$
$$\boxed{v_f = -24.9\,\text{m/s}}$$

take the negative root b/c velocity is in the negative direction.

$$v_f = v_0 + at$$
$$-24.9\,\text{m/s} = -5.5\,\text{m/s} + (-9.8\,\text{m/s}^2)\,t$$
$$\frac{-24.9\,\text{m/s} + 5.5\,\text{m/s}}{-9.8\,\text{m/s}^2} = \boxed{t = 1.98\,\text{sec}}$$

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(9) −y m

$y_0 = 0$m
$t = 65$s
$a = -9.8$ m/s²

↑+ up is positive

↑ $v_0 = 330$ m/s

0m

$$y = v_0 t + \frac{1}{2}at^2$$
$$y = (330\,\text{m/s})(65\,\text{s}) + \frac{1}{2}(-9.8\,\text{m/s}^2)(65\,\text{s})^2$$
$$\boxed{y = 747.5\,\text{m}}$$

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(10) ↓ $v_0 = ?$

$h = 14.5$m

$t = 1$sec
$a = -9.8$ m/s²
$y =$ ~~14.5m~~ 0m
$y_0 = 14.5$m

0m lake

↑+ up is positive

$$y = y_0 + v_0 t + \frac{1}{2}at^2$$
~~$y = v_0 t + \frac{1}{2}at^2$~~
$$0\,\text{m} = 14.5\,\text{m} + v_0(1\,\text{s}) + \frac{1}{2}(-9.8\,\text{m/s}^2)(1\,\text{s})^2$$
$$-14.5\,\text{m} = v_0(1\,\text{s}) + \frac{1}{2}(-9.8\,\text{m/s}^2)(1\,\text{s})^2$$
$$-14.5\,\text{m} + \frac{1}{2}(9.8\,\text{m/s}^2)(1\,\text{s})^2 = v_0$$
$$\boxed{v_0 = -9.6\,\text{m/s}}$$ down.

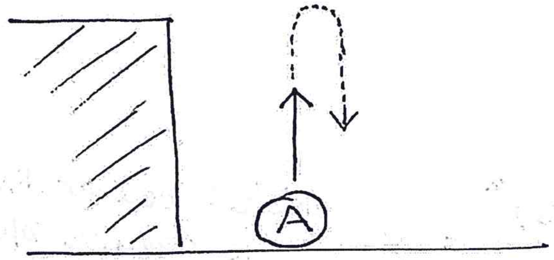
Basic Lab Rules When Working With Chemicals

(these rules always apply, additional rules may be assigned during an experiment)

1. Always wear safety glasses when working in the laboratory.
2. Always wear a safety smock.
3. Always add acid to water; never water to acid.
4. Never return unused reagents to stock bottles.
5. Be very cautious when testing for odors.
6. Never aim the opening of a test tube or flask at yourself or at anyone else, especially when heating the apparatus.
7. Avoid all contact of chemicals with exposed skin. Never wipe your hands off on your clothes or face. Rinse them with water!
8. Never leave a reaction unattended while it is being heated or is reacting rapidly.
9. Under no conditions are unauthorized or unsupervised experiments to be performed.
10. Report any accident, even minor ones, to the instructor.
11. Always thoroughly clean your work area after an experiment.
12. Never use flammable liquids near any source of ignition, spark, or flame.
13. Know the location for all personal safety and emergency equipment, eye wash, fire extinguisher, and chemical shower.
14. **AT ALL TIMES, THINK ABOUT WHAT YOU ARE DOING!!!**

Key

Freefall Exploration



Scenario 1: Ball Ⓐ is launched straight upward with $V_0 = 34.3\ m/s$. At its maximum height, it is level with the cliff. How

ⓐ high is the cliff?

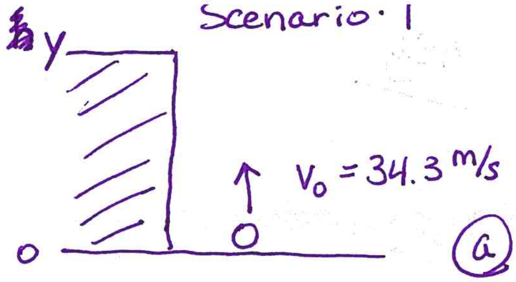
ⓑ How long did it take for the ball to reach max. height?

Scenario 2: Now, Ball Ⓐ begins to fall from this height.

ⓒ What is the velocity of the ball just before hitting the ground?

ⓓ How long did it take for the ball to fall?

Scenario 1



$g = 9.8\ m/s^2 \downarrow$

at max height $v = 0\ m/s$

↑+ up is positive

ⓐ $v^2 = v_0^2 + 2ay$

$$\frac{v^2 - v_0^2}{2a} = y$$

$$\frac{(0\ m/s)^2 - (34.3\ m/s)^2}{2(-9.8\ m/s^2)} = y$$

Note: acceleration is negative b/c it is pointing down.

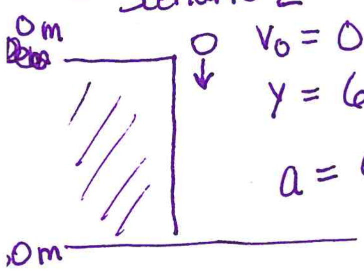
$\boxed{60.03\ m = y}$

ⓑ $v = v_0 + at$

$$\frac{v - v_0}{a} = t$$

$$\frac{0\ m/s - 34.3\ m/s}{-9.8\ m/s^2} = t \Rightarrow \boxed{t = 3.5\ sec}$$

Scenario 2



$V_0 = 0\ m/s$

$y = 60\ m$

$a = 9.8\ m/s^2 \downarrow$

find v_f at bottom.

↓+ down is positive

$V_f^2 = V_0^2 + 2ay$

$V_f^2 = (0\ m/s)^2 + 2(9.8\ m/s^2)(60\ m)$

$\sqrt{V_f^2} = \sqrt{1176\ m^2/s^2}$

ⓒ $\boxed{V_f = 34.3\ m/s}$

Take the positive root since velocity is in the positive direction.

ⓓ $v = v_0 + at$

$34.3\ m/s = 0\ m/s + 9.8\ m/s^2 \cdot t$

$$t = \frac{34.3\ m/s}{9.8\ m/s^2}$$

$\boxed{t = 3.5\ sec}$

Motion Map: