Chapter 3
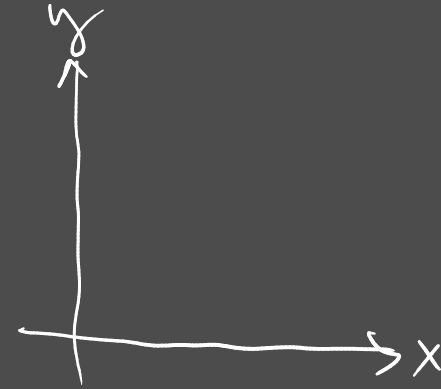
Chapter 3 - Free-fall and Projectile Motion

Free-fall
* constant acceleration -> g = 9.8 m/s^2
     10 m/s^2 is close enough in most cases
* can be positive or negative depending on
     your perspective
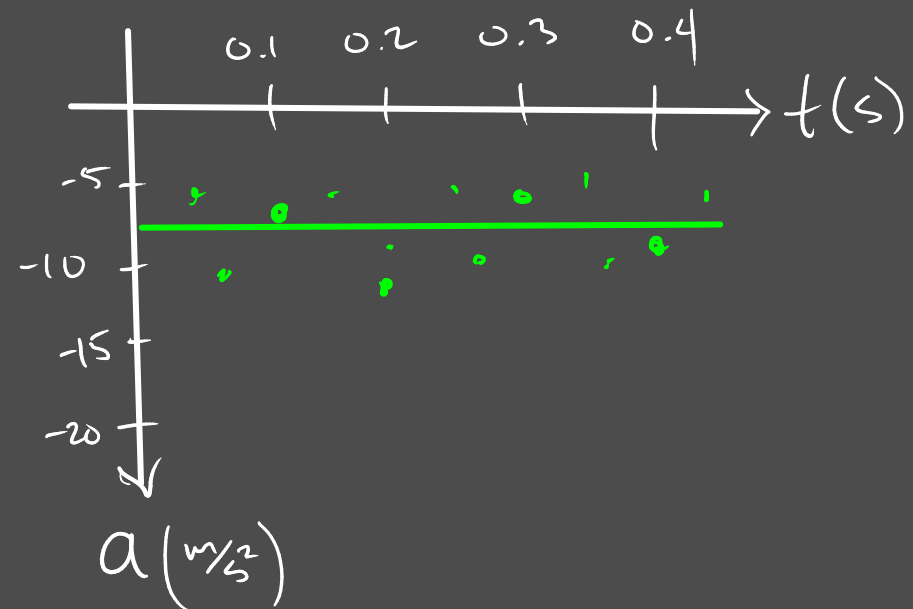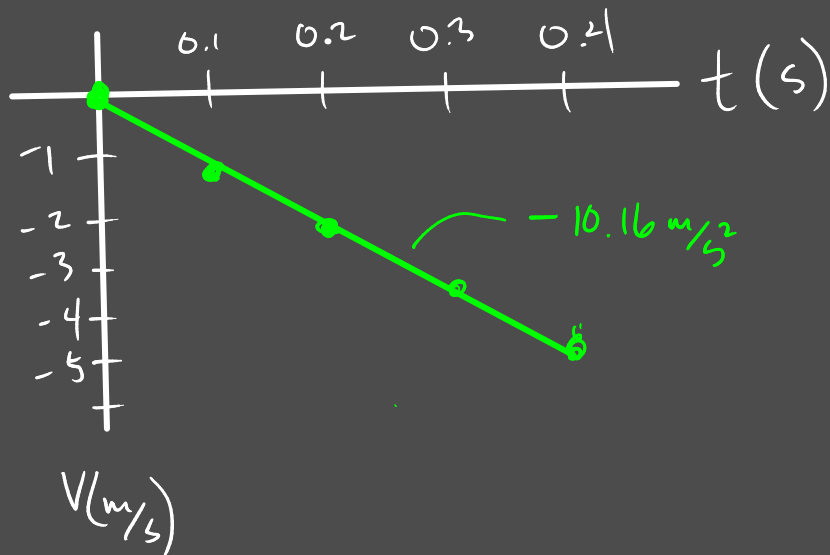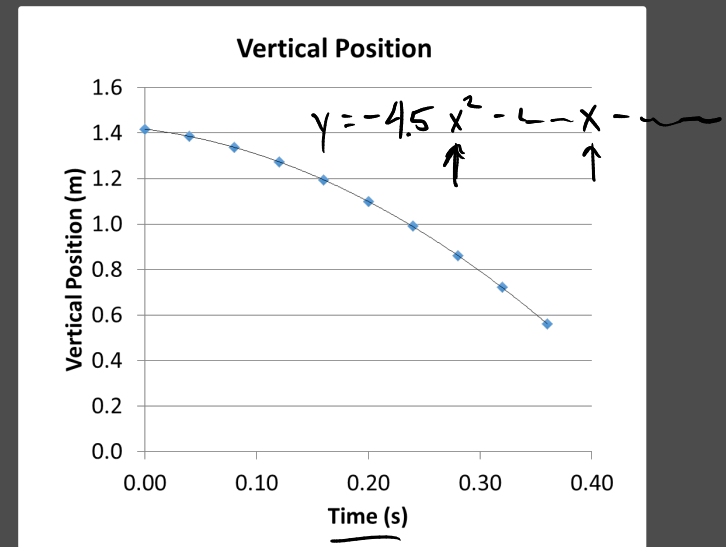* otherwise use the constant acceleration
     equations we have.
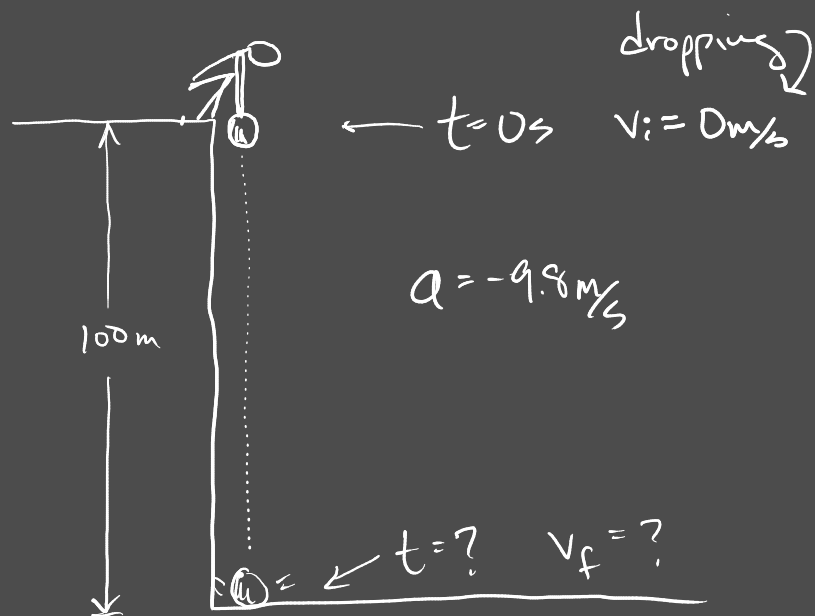
$$\rightarrow V_f = V_i + a \cdot t$$

$$g = (\pm 9.8 \, ^m/_{s^2})$$

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

$$g$$

Vertical Motion of Free-Fall Object

Time	Vertical Position, y	Vertical Position, y	Delta y	Vertical Velocity	Vertical Acceleration
(s)	(cm)	(m)	(m)	(m/s)	(m/s²)
0.00	15.80	1.417			
0.04	15.45	1.386	-0.031	-0.78	
0.08	14.90	1.336	-0.049	-1.23	-11.21
0.12	14.20	1.274	-0.063	-1.57	-8.41
0.16	13.30	1.193	-0.081	-2.02	-11.21
0.20	12.25	1.099	-0.094	-2.35	-8.41
0.24	11.05	0.991	-0.108	-2.69	-8.41
0.28	9.60	0.861	-0.130	-3.25	-14.01
0.32	8.05	0.722	-0.139	-3.48	-5.61
0.36	6.25	0.561	-0.161	-4.04	-14.01
				Average Acceleration	-10.16

Vertical Position

$y = -4.5 x^2 - \llcorner - x - \sim$

$-10.16 \, m/s^2$

dropping ⤵

$\leftarrow t = 0s \quad V_i = 0 \text{ m/s}$

$a = -9.8 \text{ m/s}$

100 m

$\swarrow t = ? \quad V_f = ?$

$\rightarrow Y_f = Y_i + V_i \cdot t + \frac{1}{2} a \cdot t^2$

$0 = +100m + 0 \cdot t + \frac{1}{2}(-9.8 \text{ m/s}^2) t^2$

$0 = 100m + (-4.9 \text{ m/s}^2) t^2$

$\frac{-100}{} \quad \frac{-100}{}$

$\frac{-100m}{-4.9 \text{ m/s}^2} = \frac{-4.9 \text{ m/s}^2 \cdot t^2}{-4.9 \text{ m/s}^2}$

$\sqrt{20.4 s^2} = \sqrt{t^2}$

$\boxed{4.52 s = t}$

$\overset{\swarrow 4.52s}{V_f = V_i + at}$

$V_f = 0 - 9.8 \text{ m/s}^2 \cdot 4.52s$

$V_f = -44.296 \text{ m/s}$

$\boxed{V_f = -44.3 \text{ m/s}}$

$Y_f = Y_i + V_i \cdot t + \frac{1}{2} at^2$

100m   0m   0 m/s   10 m/s²

$100m = 0 + 0 \cdot t + \frac{1}{2}(10 \text{ m/s}^2) t^2$

$100m = 5 \text{ m/s}^2 t^2$

$\sqrt{20 s^2} = \sqrt{t^2}$

$4.47s = t$

$V_f = V_i^{\,0} + a \cdot t$

$V_f = 10 \text{ m/s}^2 \cdot (4.47s)$

$V_f = +44.7 \text{ m/s}$

* A person drops a ball off a 100 m cliff,
and it falls ~~with an acceleration of 9.8 m/s/s,~~
find the final time and final velocity of the ball
when it hits the ground.

How could I word the description of the problem above?
* If I drop a ball from a 100 m high cliff, how long is it in the air? And how fast is it travelling when it hits the ground?
* How long would it take for a ball to drop 100 m with no resistance starting from stand still (rest) and
how fast is it traveling when it hits the ground?

What if I threw the object down to start with at 10 m/s initially?

quadratic equation → more math → more bad

Recall Quiz: If it takes 3.5 seconds for an object you drop to hit the ground, then how high are you above the ground?
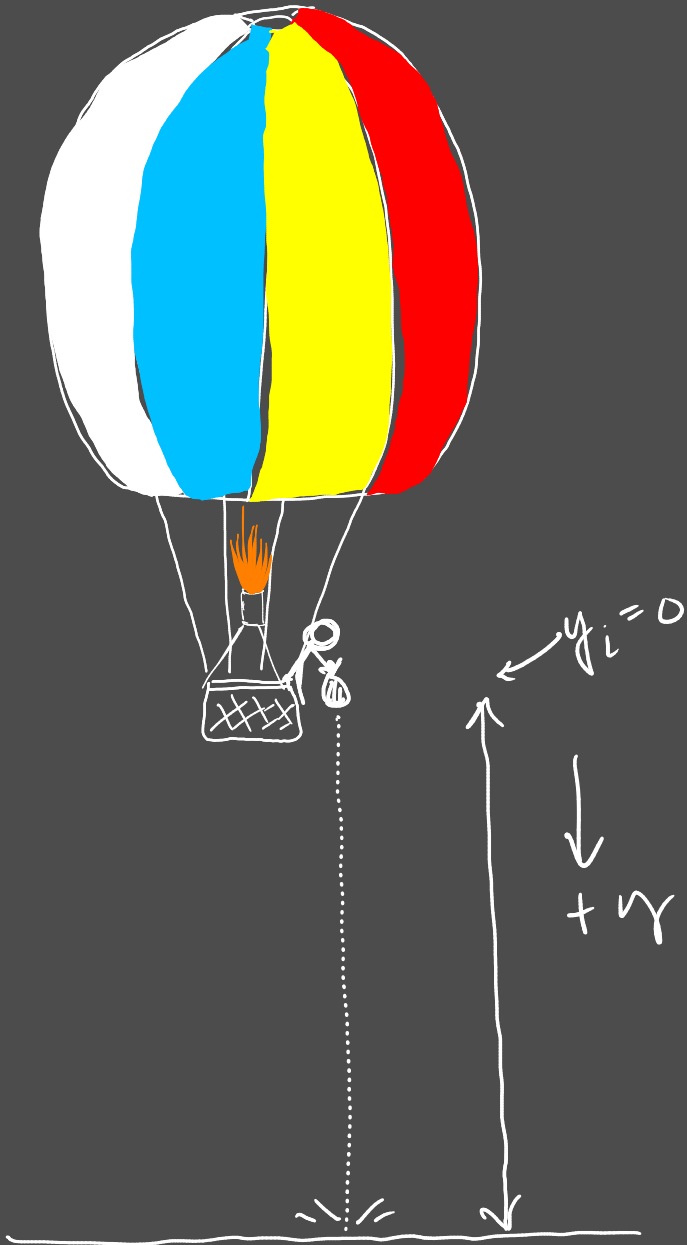
$$y_f = y_i + v_i \cdot t + \frac{1}{2}at^2$$

$$\uparrow \qquad \uparrow \qquad \uparrow$$

$$0 \qquad 0 \qquad +9.8 \, m/s^2$$

$$y_f = \frac{1}{2}(9.8 \, m/s^2)(3.5s)^2$$

$$y_f = 60.0 \, m$$

how fast is the object going?

$$v_f = \cancel{v_i}^0 + a \cdot t$$

$$v_f = +9.8 \, m/s^2 (3.5s)$$

$$v_f = 35 \, m/s$$

$y_i = 0$

$\downarrow$

$+y$

acc. in free fall

$\downarrow$

$$a = g = 9.8 \, \frac{m}{s^2}$$

$$\approx 10 \, m/s^2$$

An object thrown straight up.

$V = 0\,m/s$

$V = 3\,m/s$

$2s$

$V = 13\,m/s$

$+y$

$1s$

$V_i = 23\,m/s$

$y = 0\,m$
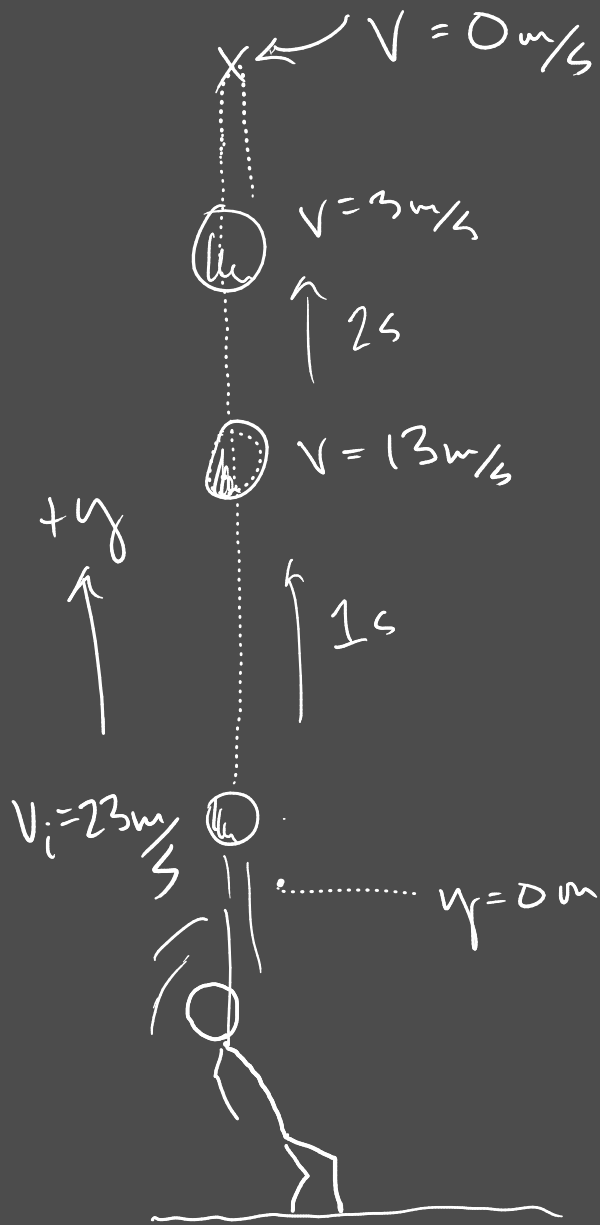
$$y_f = y_i + V_i \cdot t + \frac{1}{2}at^2$$

how far?
how long?

$$V_f = V_i + at$$

$0\,m/s$ $+23\,m/s$ $-9.8\,m/s^2$

$$0\,m/s = +23\,m/s - 9.8\,m/s^2 \cdot t$$

-23 -23

$$\frac{-23\,m/s}{-9.8\,m/s^2} = \frac{-9.8\,m/s^2 \cdot t}{-9.8\,m/s^2}$$

$$\boxed{2.35 = t}$$

$$y_f = 0\,m + 23\,m/s \cdot (2.35) + \frac{1}{2}\left(-9.8\,m/s^2\right)(2.35s)^2$$

$$V_f = 54.05\,m - 26.95\,m$$

$$V_f = 26.9\,m = \underline{27\,m}$$

Two dimensional projectile motion

Paths are in the shape of parabolas

V

V_y

V_x

Vertical
component

horizontal
component
of velocity
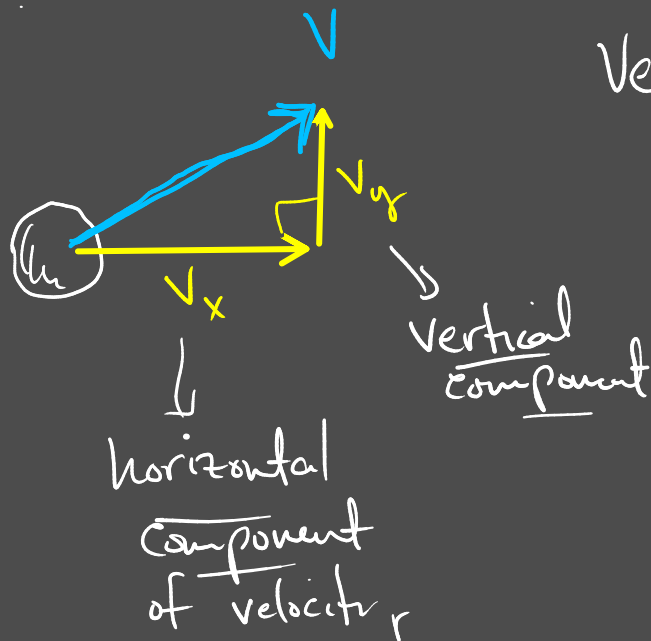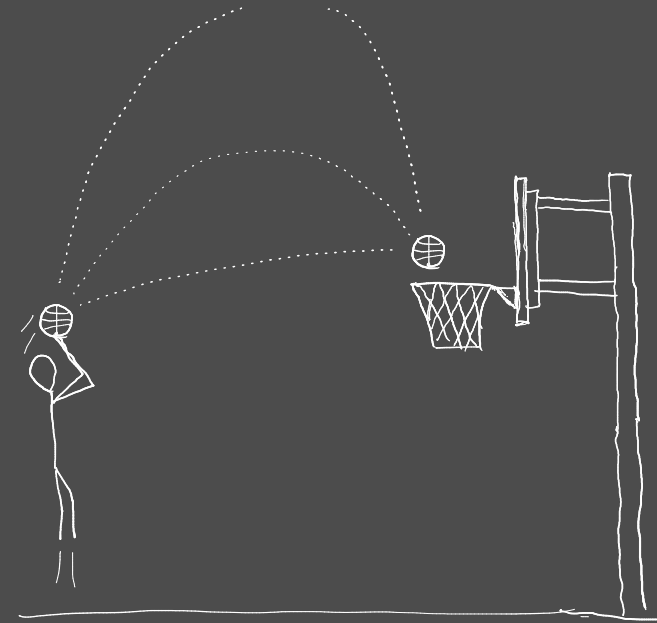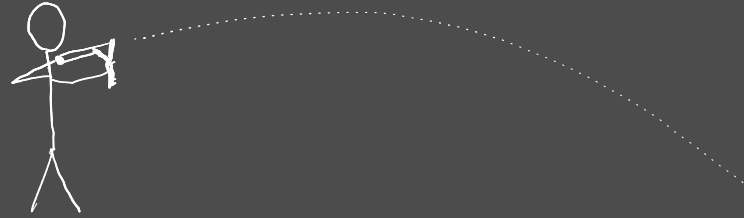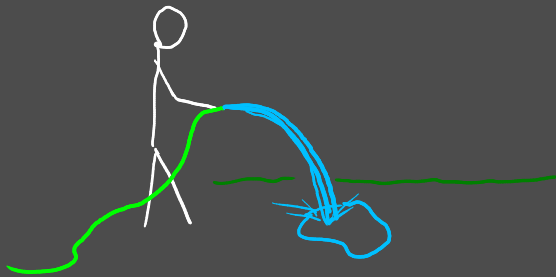
Velocity is a vector quantity

- length of the arrow is
  proportional to size
  of the quantity

- direction of the arrow
  is the direction of
  the quantity.

$\begin{cases} t=0s \\ V_x = 30 \text{m/s} \\ V_y = 0 \text{m/s} \end{cases}$

$\begin{cases} t=1s \\ V_x = 30 \text{m/s} \\ V_y = -10 \text{m/s} \end{cases}$

$\begin{cases} t=2s \\ V_x = \\ V_y = \end{cases}$

$\begin{cases} t=3s \\ V_x = \\ V_y = \end{cases}$