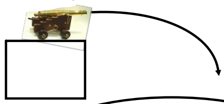
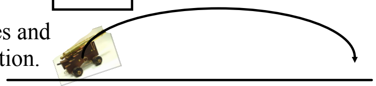
3.4 Projectile Motion – Part 2

Three Projectile Cases:

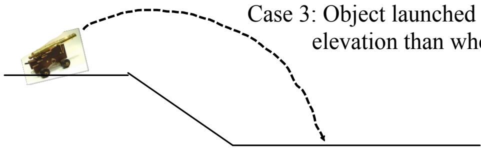
Case 1: Object launched horizontally: no vertical component of velocity.



Case 2: Object launches and lands at the same elevation.

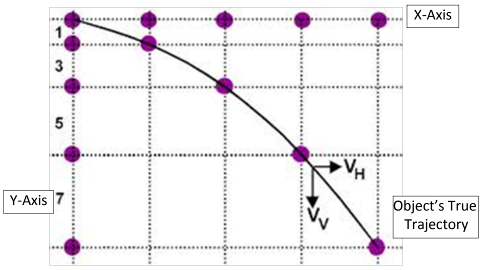


Case 3: Object launched at a different elevation than where it lands.



Case 1.

Graphically, you can plot a falling object that rolls off a surface along the x and y axes separately:



Case 1 Math

Initial component velocities:

v_{x0} = constant
v_{y0} = 0.0 m/s

Component velocity during flight:

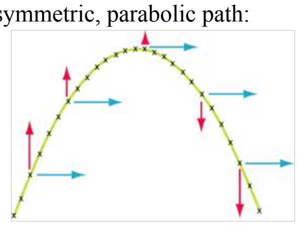
v_x = constant
v_y = -gt

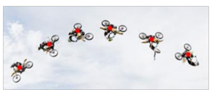
Position during flight:

$x = x_0 + v_{x0}t$
$y = y_0 – \frac{1}{2}gt^2$

Case 2.

A projectile starting and landing at the same elevation traces a symmetric, parabolic path:



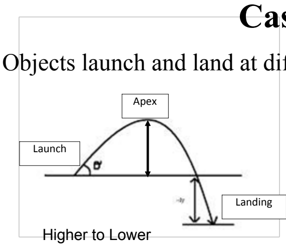


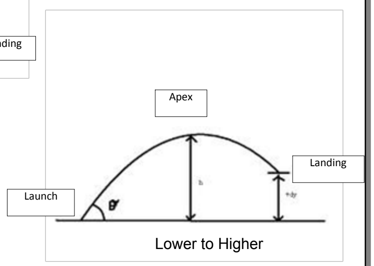
Kids, don't try this at home!

You have seen the equations for this already, although we didn't call it case 2.

Case 3.

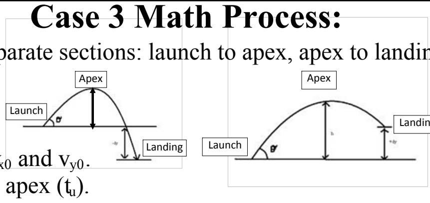
Objects launch and land at different elevations:





Case 3 Math Process:

0. Mentally separate sections: launch to apex, apex to landing.



1. Determine v_{x0} and v_{y0}.
2. Find time to apex (t_u).
3. Find y_{max}.

4. Determine the vertical distance(y_{max}) from apex to landing, then calculate how long this takes:

$$t = \sqrt{\frac{2y}{g}}$$

5. Find the total time of movement ($t = t_u + t_{apex\ to\ landing}$), then calculate how far in the x direction the object travels.

$$x = v_{0x} \bullet t$$

Case 3 Example:

A golf ball is hit at 60.0° with a velocity of 15.0 m/s. The ball lands on a ledge 5.00 m above launch.
How far from the golfer (x distance) will the ball land?

1. Decompose velocity:

$$v_{x_0} = 7.50\,m/s$$
$$v_{y_0} = 13.0\,m/s$$

2. Time to apex:

$$t_u = \frac{v_{y_0}}{g} = \frac{13.0\,m/s}{9.81\,m/s^2} = 1.33\,s$$

Case 3 Example:

3. Find max height:

$$y_{max} = y_0 + v_{y_0}t_u - \frac{1}{2}gt_u^2$$
$$= 0m + 13.0\,m/s \bullet 1.33\,s - \frac{1}{2}(9.81\,m/s^2)(1.33\,s)^2 = 8.61\,m$$

4. Apex to landing: 8.61 m – 5.00 m = 3.61 m

Time to landing from apex: $t = \sqrt{\frac{2y}{g}} = \sqrt{\frac{2 \bullet 3.61\,m}{9.81\,m/s^2}} = 0.858\,s$

Total time: $t = t_u + t_{apex\ to\ landing} = 1.33\ s + 0.858\ s = 2.19\ s$

5. Distance in x direction: $x = v_{0x} \bullet t$

$$= 7.5\,m/s \bullet 2.19\,s = 16.4\,m$$

Case 1 Example:

A ball rolls off a cliff at 2.0 m/s and falls for 3.0 seconds.
How far from the base of the cliff will it land?

$x = x_0 + v_{x_0}t$
$x = 0.0\ m + 2.0\ m/s \cdot 3.0\ s = 6.0\ m$

2. How tall is the cliff (how far does the ball fall)?

$y = y_0 - ½\,gt^2$
$0.0\ m = y_0 - ½\,(9.81 m/s^2)(3.0 s)^2$
$44\ m = y_0$

Homework

Read 3.4 in your books
3.4 Problems in your Booklets
Due: Next Class