ABRHS PHYSICS (CP) NAME: KEY

Projectile Motion Concept Sheet

Projectile motion is a combination of two separate motions: constant speed horizontally and constant acceleration due to gravity vertically. On this sheet, you will calculate what happens to the components of a projectile's velocity and position, and then graph the positions, much as you did on some previous concept sheets.

For this problem, we have a projectile launched upward with an initial horizontal velocity of 20 m/s and an initial vertical velocity of 30 m/s. Answer the following questions first:

1. What is the actual initial speed of the projectile?

$V_x = 20$ m/s

$V_{y_i} = 30$ m/s

$V^2 = V_x^2 + V_y^2 \rightarrow V^2 = (20)^2 + (30)^2 = 1300$

$V = 36.1$ m/s

2. What happens to the horizontal component of the velocity as the projectile flies through the air?

V_x stays constant and so does not change.

3. What happens to the vertical component of the projectile as it flies through the air?

V_y changes at the constant rate of -10 m/s². This means we subtract 10 m/s from V_y every second - which is due to gravity!

4. At the projectile's maximum height, what is the horizontal component of its velocity?

V_x still 20 m/s

5. At the projectile's maximum height, what is the vertical component of its velocity?

$V_y = 0$ m/s @ max height!

Now to fill out the chart on the other side by completing the following:

6. Fill out the column for the horizontal velocity (V_x) at each point in time. Explain how you filled the chart out, or show your calculations here.

V_x never changes, so it's alway 20 m/s

7. Fill out the column for the vertical velocity (V_y) at each point in time. Explain how you filled the chart out, or show your calculations here.

$V_y = at + V_{y_i}$

$a = -10$ m/s²

$V_{y_i} = 30$ m/s

∴ @ t=1 $V_y = (-10)(1) + 30 = 20$ m/s

@ t=2 $V_y = (-10)(2) + 30 = 10$ m/s

⋮

@ t=6 $V_y = (-10)(6) + 30 = -30$ m/s

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8. Fill out the column for the horizontal position (X) at each point in time. Explain how you filled the chart out, or show your calculations here.

$X = V_x t$

$V_x = 20 \, m/s$

∴ @ $t=1$ $X = (20)(1) = 20 \, m$

@ $t=2$ $x = (20)(2) = 40 \, m$

⋮

@ $t=6$ $x = (20)(6) = 120 \, m$

9. Fill out the column for the vertical position (Y) at each point in time. Explain how you filled the chart out, or show your calculations here.

$Y = \frac{1}{2}at^2 + V_{y_i} t$

$a = -10 \, m/s^2$

$V_{y_i} = 30 \, m/s$

∴ @ $t=1$

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

$= -5 + 30$

$Y = 25 \, m$

@ $t=2$

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

$= -20 + 60$

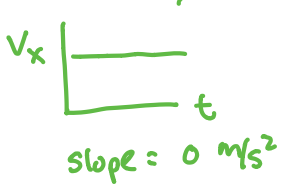
$= 40 \, m$

	Velocity		*Position*	
Time (s)	*V_x (m/s)*	*V_y (m/s)*	*X (m)*	*Y (m)*
0	20	30	0	0
1	20	20	20	25
2	20	10	40	40
3	20	0	60	45
4	20	-10	80	40
5	20	-20	100	25
6	20	-30	120	0

You can figure these out based on graph concepts too!

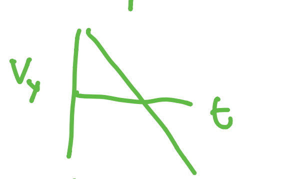
10. Mark each of the positions of the projectile (X,Y) on the coordinate shown below. Label each position "t=" with the appropriate time. The first position is already done for you.

11. At each position, draw vectors to represent both components of the velocity. Use the scale of 1 square = 10 m/s. The first position is already done for you.



slope = 0 m/s²

∴ never changes



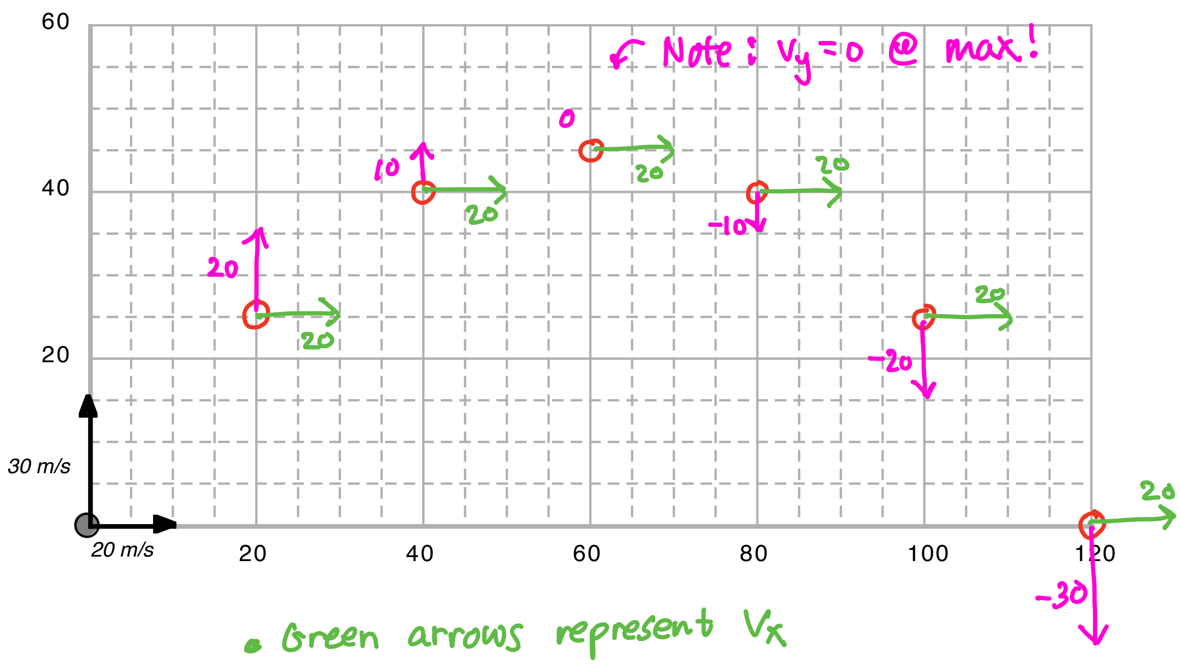
slope = -10 m/s²

∴ -10 m/s @ second

slope = 20 m/s

∴ +20 m @ second

Projectile Motion Concept Sheet



- Green arrows represent V_x
- Pink arrows represent V_y

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Questions:

1. Imagine that you did the same thing for a projectile with an initial V_x of 10 m/s and V_y of 30 m/s.
   a. What would be different?
   The horizontal parts of the motion would be different. (That means the X & V_x columns would be different.)
   b. What would be the same?
   The vertical parts of the motion (Y & V_y) would NOT change! They don't depend on V_x at all!
   c. How long would the projectile be in the air?
   So still 6 seconds.
   d. What would be the maximum height of this projectile?
   So still 45 m.
   e. How far away would the projectile land?
   $X = V_x t \longrightarrow X = (10)(6) = \boxed{60\text{ m}}$

2. Imagine that you did the same thing for a projectile with an initial V_x of 30 m/s and V_y of 30 m/s.
   a. What would be different?
   Just X & V_x
   b. What would be the same?
   Y & V_y
   c. How long would the projectile be in the air?
   6 seconds
   d. What would be the maximum height of this projectile?
   45 m
   e. How far away would the projectile land?
   $X = V_x t \rightarrow X = 30(6) = \boxed{180\text{ m}}$

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3. If you wanted the projectile to go higher,
   a. what should you change? Explain.

   Increase the v_y!

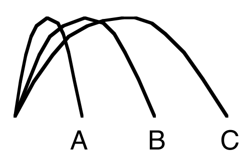
   b. would this affect the time in the air? Explain.

   Yes! If v_y is bigger & it goes higher it takes longer

   c. would this affect how far away the projectile landed? Explain.

   It would! Remember $x = v_x t$ so if it is in the air longer it will go farther as well.

4. Imagine that three different projectiles were launched across a level field. All the projectiles had the exact same maximum height, but they landed in different places. The paths of the projectiles are shown in the diagram to the right.



   a. Which projectile was in the air the longest time?

   all the same!

   b. Which projectile had the largest initial vertical velocity?

   all the same!

   c. Which projectile had the largest horizontal velocity?

   C. (went farthest in the same amount of time)

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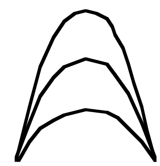
5. Imagine that three different projectiles were launched across a level field. All the projectiles landed in the same place, but had different maximum heights. The paths of the projectiles are shown in the diagram to the right.



   a. Which projectile was in the air the longest time?

   C

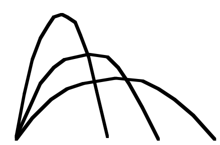
   b. Which projectile had the largest initial vertical velocity?

   C

   c. Which projectile had the largest horizontal velocity?

   A (They all had the same "x", but A did it in less time.)

6. Imagine that three different projectiles were launched across a level field. The projectiles all had different maximum heights and landed in different places. The paths of the projectiles are shown in the diagram to the right.



   a. Which projectile was in the air the longest time?

   A

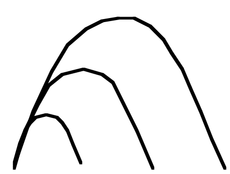
   b. Which projectile had the largest initial vertical velocity?

   A

   c. Which projectile had the largest horizontal velocity?

   C

7. Imagine that three different projectiles were launched across a level field. The projectiles all had different maximum heights and landed in different places. The paths of the projectiles are shown in the diagram to the right.



   a. Which projectile was in the air the longest time?

   C

   b. Which projectile had the largest initial vertical velocity?

   C

   c. Which projectile had the largest horizontal velocity? *(Be careful!)*

   not enough information to tell!