Projectile Motion Review Sheet

1. Calculate the speeds of the two velocities given below.

v_x = 25 m/s v_y = –15 m/s

$v^2 = v_x^2 + v_y^2 = (25)^2 + (-15)^2$

$v^2 = 850$

v = 29.2 m/s

v_x = 8 m/s v_y = 3 m/s

$v^2 = v_x^2 + v_y^2 = (8)^2 + (3)^2$

$v^2 = 73$

v = 8.54 m/s

2. What are the components of the following velocities?
A ball is kicked with a velocity of 14 m/s at an angle of 25° above the horizontal.

$\cos 25 = \frac{V_x}{14}$

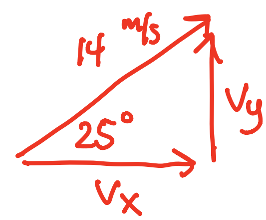
$V_x = 14 \cos 25$

v_x = 12.7 m/s

$\sin 25 = \frac{V_y}{14}$

$V_y = 14 \sin 25$

v_y = 5.9 m/s



A pen is thrown straight up with a velocity of 15 m/s.

↳ this means $\theta = 90°$ & $V_x = 0$ m/s

v_x = 0 m/s v_y = 15 m/s

3. A bullet is shot horizontally with a speed of 800 m/s from an initial height of 2 m.

$V_x = 800$ m/s
$a = -10$ m/s²
$Y = -2$ m
$V_{y_i} = 0$ m/s

a. How long is the bullet in the air?

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

$-2 = \frac{1}{2}(-10)t^2 + (0)t$

$-2 = -5t^2$

$t^2 = 0.4$

$t = \sqrt{0.4} = $ **0.63 s**

b. How far away does the bullet land?

$X = V_x t$

$X = (800)(0.63)$

X = 506 m

c. If the bullet was just dropped from that height, how long would it take to hit the ground?

That means $V_x = 0$, but that doesn't change V_{y_i} so it will be the same time, so **0.63 s**

4. A student throws a ball horizontally out of a window. It hits the ground in 0.9 seconds and lands 15 meters away (horizontally) from the window.

a. What was the initial velocity of the ball? Give both components.

$a = -10$ m/s²
$x = 15$ m
$t = 0.9$ s (to land)
$V_{y_i} = 0$ m/s

$X = V_x t$

$15 = V_x(0.9)$

$V_x = 16.7$ m/s & **$V_{y_i} = 0$ m/s**

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b. From what height was the ball thrown?

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

$Y = \frac{1}{2}(-10)(.9)^2 + (0)(.9)$

$Y = -4.05$ m

c. What is the final vertical velocity?

$V_y = at + V_{y_i}$

$V_y = (-10)(0.9) + 0$

$V_{y_i} = -9$ m/s

d. What is the final speed of the ball?

$v^2 = V_x^2 + V_y^2$

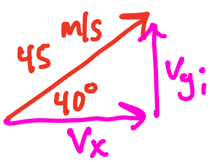
$v^2 = (16.7)^2 + (-9)^2$

$v^2 = 359.9$

$V = 19$ m/s

5. A baseball was hit with an initial velocity of 45 m/s at an angle of 40° above the horizontal. It was eventually caught at the same height from which it was hit.

a. What were the horizontal and vertical components of the intital velocity?



$\cos 40 = \frac{V_x}{45}$

$V_x = (45)(\cos 40)$

$V_x = 34.5$ m/s

$\sin 40 = \frac{V_{y_i}}{45}$

$V_{y_i} = (45)(\sin 40)$

$V_{y_i} = 28.9$ m/s

So
$V_x = 34.5$ m/s
$V_{y_i} = 28.9$ m/s
$a = -10$ m/s²

b. How long was it in the air?

$V_y = 0$ @ Max

$V_y = at + V_{y_i}$ → $0 = -10t + 28.9$

$t = 2.89$, but this is just to high point.

So Total Time $= (2)(2.89)$

$= 5.79$ s

c. How far did it travel horizontally?

$X = V_x t$

$X = (34.5)(5.79)$

$X = 200$ m

d. What was the baseball's maximum height?

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

$Y = \frac{1}{2}(-10)(2.89)^2 + (28.9)(2.89)$

$Y = -41.8 + 83.5$

$Y = 41.8$ m

e. What was the velocity of the baseball at its maximum height? Give both components.

$V_y = 0$ m/s & $V_x = 34.5$ m/s

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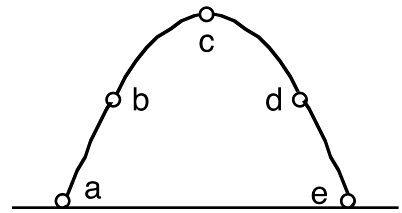
6. A soccer ball is kicked up in the air with some initial velocity. Imagine the path of the ball is shown in the diagram to the right. The letters are just some random positions of the ball. C is the maximum height of the ball, and points b and d are at the same height, and points a and e are the initial and final positions of the ball.



a. While the ball is going up (from a to c), what happens to the horizontal component of its velocity?

it stays constant & doesn't change.

b. While the ball is going up (from a to c), what happens to the vertical component of its velocity?

it slows down → @ second, 10 m/s is subtracted from V_y.

c. While the ball is going up (from a to c), what happens to the acceleration of the ball?

stays constant. 10 m/s² DOWN (so we usually call it −10 m/s²)
Just Gravity!

d. At point c (its maximum height) what is the horizontal component of its velocity?

whatever it was @ the start → it never changes

e. At point c (its maximum height) what is the vertical component of its velocity?

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

f. At point c (its maximum height) what is the acceleration of the ball?

Still −10 m/s² ! [i.e. still 10 m/s² DOWN]

g. While the ball is going down (from c to e), what happens to the horizontal component of its velocity?

Still doesn't change.

h. While the ball is going down (from c to e), what happens to the vertical component of its velocity? Still subtracting 10 m/s from V_y every second.

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i. While the ball is going down (from c to e), what happens to the acceleration of the ball?

Still $-10\ m/s^2$ → still just gravity.

j. How does the time from a to c compare to the time from c to e?

they are the same

7. Imagine that the horizontal velocity of a ball that is kicked across a level field is 15 m/s and the ball was in the air for a total of 4 seconds.

a. How far away does the ball land?

$V_x = 15\ m/s$
$t = 4$ seconds (total)
$a = -10\ m/s^2$

$X = V_x t$

$X = (15)(4)$

$X = 60\ m$

b. How many seconds would it take for the ball to reach its maximum height?

$\frac{1}{2}$ the total time, so only 2 seconds

c. What are the components of the velocity of the ball at its maximum height?

$V_x = 15\ m/s$

$V_y = 0\ m/s$

d. What was the initial vertical velocity of the ball?

$V_y = at + V_{y_i}$

$0 = (-10)(2) + V_{y_i}$ ← notice it's time to max height!

$V_{y_i} = 20\ m/s$

e. If you wanted the ball to stay in the air longer, what would you change?

Make the V_{y_i} bigger

f. Would the change (in e.) affect the height? If so, how (higher/lower)?

Yes - it would then go higher in the air.

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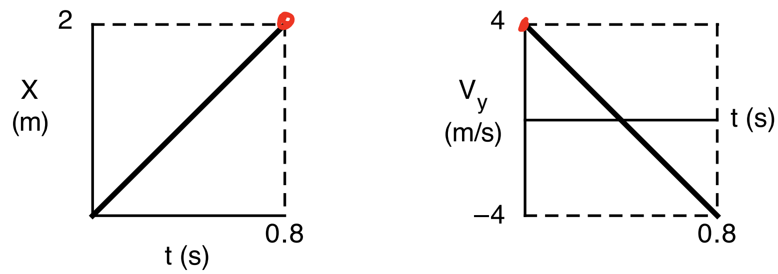
g. Would the change (in e.) affect how far away the ball lands? If so, how (farther/shorter)?

Yes, even though V_x stays the same, if the total time in the air is more, x will be more (because $x = V_x t$)

8. Some students did a lab in which they recorded a ball that was tossed between two students. They made the following graphs from their data:



a. What was the horizontal velocity of the ball?

Just the slope of the x–t graph. So $V_x = \frac{2}{0.8}$

$V_x = 2.5$ m/s

b. What was the initial vertical velocity of the ball?

It's the "y intercept" of the V_y–t graph, so $V_{y_i} = 4$ m/s

c. So what was the intial speed of the ball?

$V_i^2 = V_x^2 + V_{y_i}^2$

$V_i^2 = (2.5)^2 + (4)^2$

$V_i^2 = 22.25$

$V_i = 4.72$ m/s

d. What is the slope of the vertical velocity vs time graph? Does your answer make sense?

Gravity! It should be −10 m/s²!

Let's check: slope $= \frac{rise}{run} = \frac{-8}{0.8} = -10$ m/s²

e. What was the maximum height of the ball?

Total time in air was 0.8 seconds, So t to max = 0.4 s

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

$Y = \frac{1}{2}(-10)(0.4)^2 + (4)(0.4)$

$Y = -0.8 + 1.6$

$Y = 0.8$ m

f. Make the graphs of horizontal velocity (v_x) vs time and height (y) vs time.