ABRHS PHYSICS (CP) NAME: KEY

Projectile Motion Problems

1. A student tosses an eraser to his friend. The initial horizontal velocity of the eraser was 4.5 m/s and the initial vertical velocity was 5.36 m/s. The friend catches the eraser at the same level from which it was tossed.

   a. How long was the eraser in the air?

$v_x = 4.5$ m/s
$v_{y_i} = 5.36$ m/s
$a = -10$ m/s^2

$v_y = at + v_{y_i}$

To max height:

$0 = -10t + 5.36$

$t = .536$ s

$\therefore$ total time = $.536 + .536$

$= 1.07$ s

OR Total time

$-5.36 = -10t + 5.36$

$10.72 = 10t$

$t = 1.075$

→ $v_y = 0$ m/s @ max

→ $v_y = -5.36$ m/s when lands

   b. How far apart were the two friends?

$x = v_x t$

$x = (4.5)(1.07)$

$x = 4.82$ m

↑ total time!

   c. What was the maximum height of the eraser?

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

$y = \frac{1}{2}(-10)(.536)^2 + (5.36)(.536)$

↑ time to max height! ↗

$y = -1.44 + 2.87$

$y = 1.44$ m

   d. What were the components of the velocity at the top of its flight?

$v_x = 4.5$ m/s ; $v_y = 0$ m/s

2. A kangaroo is jumping across a field in the outback. The kangaroo jumps with an initial horizontal velocity of 8 m/s and an initial vertical velocity of 5 m/s.

   a. What was the initial speed of the kangaroo?

$v_x = 8$ m/s
$v_{y_i} = 5$ m/s
$a = -10$ m/s^2

$v^2 = v_x^2 + v_{y_i}^2$

$v^2 = (8)^2 + (5)^2$

$v^2 = 89$

$v = 9.43$ m/s

   b. How long was the kangaroo in the air?

$v_y = 0$ @ max height.

$v_y = at + v_{y_i}$

$0 = -10t + 5 \rightarrow t = 0.5$ s

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

$0.5 + 0.5 = 1$ s

   c. What was the maximum height of the kangaroo?

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

← make sure you use the time to max height!

$y = \frac{1}{2}(-10)(.5)^2 + (5)(.5)$

$y = -1.25 + 2.5$

$y = 1.25$ m

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d. What was the horizontal distance of the kangaroo's jump?

$X = V_x t$ ← need total time here!

$X = (8)(1)$ | $X = 8\ m$

3. Mary throws a ball to Suzy, who is standing 25 meters away. Suzy catches the ball from the same height at which it was thrown. If the ball was in the air for 4 seconds, calculate the following:

$X = 25\ m$

$t_{total} = 4\ s$

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

a. Horizontal velocity.

$X = V_x t$

$25 = V_x(4)$ | $V_x = 6.25\ m/s$

b. Initial vertical velocity.

Since total time is 4 s, it only took 2 s to reach its max height. (& $V_y = 0$ @ max height)

$\therefore \quad V_y = at + V_{y_i}$

$0 = (-10)(2) + V_{y_i}$

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

c. Maximum height of the ball.

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

$Y = \frac{1}{2}(-10)(2)^2 + (20)(2) \Rightarrow Y = -20 + 40$ | $Y = 20\ m$

d. What happens to the components of the velocity and the acceleration as the ball flies through the air?

V_x stays constant throughout.

V_{y_i} changes → $-10\ m/s$ every second

acceleration is also constant throughout: just $-10\ m/s^2$ directed down.

4. Larry tosses a volleyball to his wife, Lise, who catches it at the same height from which it was tossed. The volleyball has an initial velocity of 15 m/s at an angle of 30° above the horizontal.

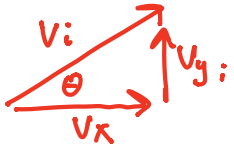
$V_i = 15\ m/s$

$\theta = 30^\circ$

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

a. What are the components of the initial velocity?

Vectors!



$\cos\theta = \frac{V_x}{V_i}$

$V_x = V_i \cos\theta$

$V_x = (15)\cos 30 =$ | $13\ m/s$ (V_x)

$\sin\theta = \frac{V_{y_i}}{V_i}$

$V_{y_i} = V_i \sin\theta$

$V_{y_i} = 15 \sin 30$

$V_{y_i} = 7.5\ m/s$

b. How many seconds does it take the volleyball to reach its maximum height?

$V_y = 0$ @ max height, so

$V_y = at + V_{y_i}$

$0 = -10t + 7.5$ | $t = 0.75\ s$

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c. How far apart are Lise and Larry?

total time in air is 0.75 + 0.75 = 1.5 s

$X = V_x t$

$X = (13)(1.5)$ $\quad X = 19.5$ m

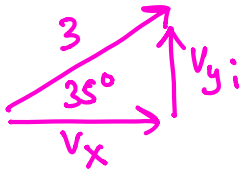
d. What was the acceleration of the volleyball after 1 second? Give the magnitude and direction.

10 m/s², Down

*5. An astronaut on the moon tosses a rock with an initial velocity of 3 m/s at an angle of 35° above the horizontal. The acceleration due to gravity on the moon is 1.7 m/s².

a. What were the components of the initial velocity of the rock?

VECTORS AGAIN!



$\cos 35 = \frac{V_x}{3}$

$V_x = (3)(\cos 35)$

$V_x = 2.46$ m/s

$\sin 35 = \frac{V_{y_i}}{3}$

$V_{y_i} = (3)(\sin 35)$

$V_{y_i} = 1.72$ m/s

b. How long was the rock "in the air?"

$V_x = 2.46$ m/s

$V_{y_i} = 1.72$ m/s

$a = -1.7$ m/s²

$V_y = 0$ @ Max height

$V_y = at + V_{y_i}$

$0 = (-1.7)t + 1.72$

$t = 1.01$ s

But this is only ½ the total time, so

$t = 2.02$ s

c. What was the maximum height of the rock?

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

$y = \frac{1}{2}(-1.7)(1.01)^2 + (1.72)(1.01)$

$y = -.87 + 1.74$

$y = .87$ m

d. What was the horizontal distance traveled by the rock?

$X = V_x t$

$x = (2.46)(2.02)$

$X = 4.97$ m

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Answers:

1. *a) 1.07 s* *b) 4.82 m* *c) 1.44 m* *d) v_x = 4.5 m/s & v_y = 0 m/s*
2. *a) v = 9.43 m/s* *b) 1.0 s* *c) 1.25 m* *d) 8 m*
3. *a) 6.25 m/s* *b) 20 m/s up* *c) 20 m*
   d) v_x = constant = 6.25 m/s & acceleration = constant = 10 m/s^2 down & v_y starts positive 20 m/s (up) decreases to 0 m/s at top and continues to decrease to -20 m/s (down) when finally caught
4. *a) v_x = 13 m/s & v_y = 7.5 m/s* *b) 0.75 s* *c) 19.5 m*
   d) acceleration = gravity = -10 m/s^2 so magnitude is 10 m/s^2 and direction is down
5. *a) v_x = 2.46 m/s & v_y = 1.72 m/s* *b) 2.02 s* *c) 0.87 m* *d) 4.97 m*