Projectile Motion Worksheet

(1)

x

$v = ?$

$d_x = 60m$

$t = ?$

y

$v = 0$

$a = -9.8\ m/s^2$

$d = -50m$

$t = ?$

(a) y direction

$d = \cancel{v_i t} + \frac{1}{2}at^2$

$t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2(-50)}{-9.8}} = \underline{3.19\ s}$

(b) x direction

$d = v_i t + \cancel{\frac{1}{2}at^2}$

$v = \frac{d}{t} = \frac{60}{3.19} = \underline{18.8\ m/s}$

(c) $v_i = 0$

$v_f = ?$

$a = -9.8\ m/s^2$

$d = -50m$

$v_f^2 = \cancel{v_i^2} + 2ad$

$v_f = \sqrt{2ad}$

$= \sqrt{2(-9.8)(-50)}$

$\underline{v_f = 31.3\ m/s}$ down

(2)

x	y
$v = ?$	$v = 0$
$d = 80m$	$a = -9.8\ m/s^2$
$t =$	$d = ?$
	$t = 4s$

(a) y-direction

$d = \cancel{v_i t} + \frac{1}{2}at^2$

$= \frac{1}{2}(-9.8)(4)^2$

$d = -78.4\ m$

so building height is $\underline{78.4\ m.}$

(b) $v_i = 0$

$v_f = ?$

$a = -9.8\ m/s^2$

$t = 4s$

$v_f = \cancel{v_i} + at$

$v_f = (-9.8)(4)$

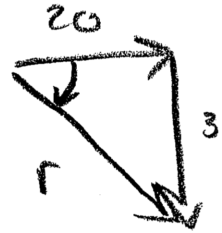
$\underline{v_f = -39.2\ m/s}$

(c) x-direction

$d = v_i t + \cancel{\frac{1}{2}at^2}$

$v = \frac{d}{t} = \frac{80}{4} = \underline{20\ m/s}$

(d)



$r = \sqrt{20^2 + 39.2^2}$

$\underline{r = 44.0\ m/s}$

$\theta = \tan^{-1}\left(\frac{39.2}{20}\right) = \underline{63° \text{ S of E}}$

③

x	y
$v = 16$ m/s	$v = 0$
$d =$	$a = -9.8$ m/s²
$t =$	$d = -45$m
	$t =$

(a) y-direction

$$d = \cancel{v_i t} + \frac{1}{2}at^2$$

$$t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2(-45)}{-9.8}} = \underline{9.18\ s}$$

(b) x-directions

$$d = vt$$

$$= 16(9.18)$$

$$d = \underline{146.9\ m}$$

(c) $v_i = 0$

$v_f = ?$

$a = -9.8$

$d = -45$

$$v_f^2 = \cancel{v_i^2} + 2ad$$

$$v_f = \sqrt{2ad}$$

$$= \sqrt{2(-9.8)(-45)}$$

$$\underline{v_f = 29.7\ m/s}$$

(4)

x	y
$v = 5.0$ m/s	$v = 0$
$d = ?$	$a = -9.8$ m/s^2
$t =$	$d = -169.16$ m
	$t =$

(a) y-direction

$$d = \cancel{v_i t} + \frac{1}{2}at^2$$

$$t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2(-169.16)}{-9.8}} = 5.88\,s$$

x-direction

$$d = v_i t + \cancel{\frac{1}{2}at^2}$$

$d = 5(5.88) = \underline{29.4\ m}$ from the base

(b) y-direction

$v_i = 0$

$v_f = ?$

$a = -9.8$

$d = -169.16$

$$v_f^2 = \cancel{v_i^2} + 2ad$$

$$v_f = \sqrt{2ad}$$

$$= \sqrt{2(-9.8)(-169.16)}$$

$$\underline{v_f = 57.6\ m/s}$$

(5)

x	y
$v = 2.5$ m/s	$v = 0$
$d = 1.96$ m	$a = -9.8$ m/s^2
$t =$	$d =$
	$t =$

(a) x-direction

$d = v_i t + \cancel{\frac{1}{2}at^2}$

$t = \frac{d}{v_i} = \frac{1.96}{2.5} = 0.784$

y-direction

$d = \cancel{v_i t} + \frac{1}{2}at^2$

$= \frac{1}{2}(-9.8)(0.784)^2$

$d = -3.01$

so height is $\underline{3.0 \text{ m}}$

(b) It will take the same amount of time to fall. The vertical motion is independent of the horizontal motion.

6

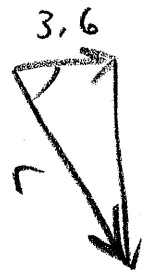
x	y
$v = 3.60\ m/s$	$v = 0$
$d =$	$a = -9.8\ m/s^2$
$t =$	$d = -108\ m$
	$t =$ ___

y-direction

$v_f^2 = \cancel{v_i^2} + 2ad$

$v_f = \sqrt{2ad} = \sqrt{2(-9.8)(-108)}$

$v_f = 46\ m/s.$

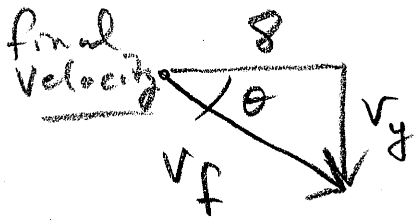


$r = \sqrt{3.6^2 + 46^2} = \underline{46\ m/s}$

$\theta = \tan^{-1}\left(\frac{46}{3.6}\right) = 85^\circ$ below the horizontal

7

x	y
$v = 8$	$v = 0$
$d = 3$	$a = -9.8$
$t =$	$d =$
	t



$\theta = 45°$

x-direction

$d = v_i t + \cancel{\frac{1}{2}at^2}$

$t = \frac{d}{v_i} = \frac{3}{8} = 0.375\,s$

y-direction

$d = \cancel{v_i t} + \frac{1}{2}at^2$

$= \frac{1}{2}(-9.8)(.375)^2$

$d = 0.69\ m$

(8)

x	y
$v = ?$	$v = 0$
$d = 20\ m$	$a = -9.8\ m/s^2$
$t =$	$d = -2\ m$
	$t =$

y-direction

$$d = \cancel{v_i t} + \frac{1}{2}at^2$$

$$t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2(-2)}{-9.8}} = 0.64\ s$$

x-direction

$$d = v_i t + \cancel{\frac{1}{2}at^2}$$

$$v = \frac{d}{t} = \frac{20}{0.64} = \underline{31.3\ m/s}$$

9

x	y
$v = 6.75\ m/s$	$v = 0$
$d = 8.95\ m$	$a = ?$
$t =$	$d = -1.20\ m$
	t

x-direction

$d = v_i t + \cancel{\frac{1}{2}at^2}$

$t = \frac{d}{v_i} = \frac{8.95}{6.75} = 1.326\ s$

y-direction

$d = \cancel{v_i t} + \frac{1}{2}at^2$

$a = \frac{2d}{t^2} = \frac{2(-1.20)}{(1.326)^2} = -1.36$

The acceleration of gravity is $\underline{1.36\ m/s^2}$ down.

(10) (a)

x	y
$v = 32\ m/s$	$v = 0$
$d = 18\ m$	$a = -9.8\ m/s^2$
$t = ?$	$d = ?$
	t

x-direction

$d = v_i t + \cancel{\frac{1}{2}at^2}$

$t = \frac{d}{v_i} = \frac{18}{32} = 0.5625\,s$

y-direction

$d = \cancel{v_i t} + \frac{1}{2}at^2$

$= \frac{1}{2}(-9.8)(.5625)^2$

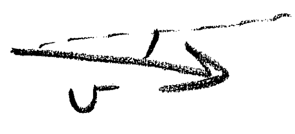
$d = -0.155$

The ball drops $\underline{0.16\ m}$

(b) If the speed is increased, the drop distance will decrease. The ball arrives at the catcher in less time and therefore it has less time to fall.

10. (c) The drop distance would decrease. Since the acceleration due to gravity is less, the ball will fall more slowly and will not drop as far.

(11)



x	y
$v = 4.3 \cos 15$ m/s	$v = -4.3 \sin 15$ m/s
$d = ?$	$a = -9.8$ m/s^2
$t =$	$d = -0.8$ m
	$t = ?$

y-direction

$$d = v_i t + \frac{1}{2} a t^2$$

$$-.8 = -4.3 \sin 15\, t + \frac{1}{2}(-9.8)\, t^2$$

$$4.9t^2 + 1.11t - .8 = 0$$

$$t = \frac{-1.11 \pm \sqrt{(1.11)^2 - 4(4.9)(-.8)}}{2(4.9)}$$

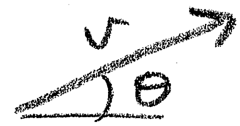
$t = 1.612$ s

x-direction

$$d = v_i t + \cancel{\frac{1}{2} a t^2}$$

$$d = (4.3 \cos 15)(1.612) = \underline{6.70 \text{ m}}$$

(12)



x	y
$v_i = 2.7\cos 60$ m/s	$v_i = 2.7\sin 60$ m/s
$d = ?$	$a = -9.8$ m/s^2
$t = ?$	$d = -1.0$ m
	$t = ?$

(a) $d = v_i t + \frac{1}{2}at^2$

$-1 = (2.7\sin 60)t + \frac{1}{2}(-9.8)t^2$

$-1 = 2.34t - 4.9t^2$

$4.9t^2 - 2.34t - 1 = 0$

$$t = \frac{-(-2.34) \pm \sqrt{(-2.34)^2 - 4(4.9)(-1)}}{2(4.9)}$$

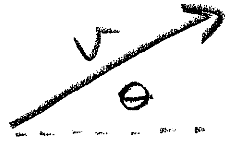
$\underline{t = 2.8 \text{ s}}$

(b) $d = v_i t + \cancel{\frac{1}{2}at^2}$

$d = (2.7\cos 60)(2.8)$

$\underline{d = 3.78 \text{ m}}$

(13)



$v = 25$ m/s
$\theta = 35°$

x	y
$v = 25\cos 35$	$v = 25\sin 35$ m/s
$d = ?$	$a = -9.8$ m/s^2
$t = ?$	$d = ?$
	$t = ?$

To hit the highest possible fire, we need the time to get to the maximum height. The maximum height occurs when $v_f = 0$.

y-direction

$$v_f = v_i + at$$

$$t = \frac{-v_i}{a} = \frac{-25\sin 35}{-9.8} = 1.463\,s$$

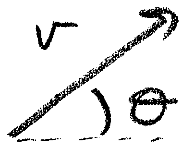
use this time to calculate horizontal distance.

x-direction

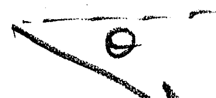
$$d = v_i t ~~+ \tfrac{1}{2}at^2~~$$

$$= (25\cos 35)(1.463) = 29.96 = \underline{30.0\,m}$$

(14)



x	y
$v = ?$	$v = ?$
$d = ?$	$a = -9.8\ m/s^2$
$t = ?$	$d = 7.5m$
	$t = ?$



$v = 36\ m/s$
$\theta = 28°$

The initial and final horizontal velocities will be the same. (horizontal v is constant)

$V_x = 36 \cos 28 = 31.786\ m/s.$

We can use the final velocity in the y-direction to calculate the initial velocity in the y-direction.

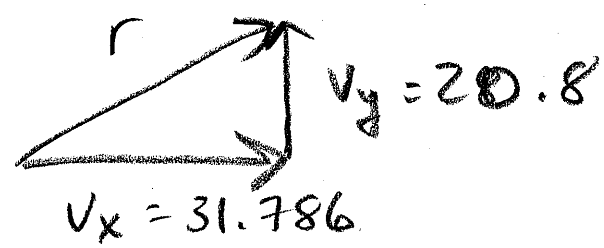
$V_{fy} = 36 \sin 28 = -16.9$ (- is down)

$$V_f^2 = V_i^2 + 2ad$$

$$V_i = \sqrt{V_f^2 - 2ad} = \sqrt{(-16.9)^2 - 2(-9.8)(7.5)}$$

$V_i = 20.8\ m/s$ ← vertical velocity

14 now we can put the two velocities together.

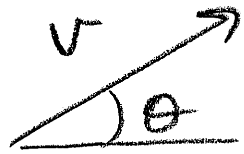


$$r = \sqrt{(31.786)^2 + (20.8)^2}$$

$$r = 37.987 = \underline{38.0 \text{ m/s}}$$

$$\theta = \tan^{-1}\left(\frac{20.8}{31.786}\right) = \underline{33.2^\circ}$$ above the horizontal

(15)



$v = ?$

$\theta = 63^\circ$

x	y
$v = v\cos 63$ m/s	$v = v\sin 63$ m/s
$d = ?$	$a = -9.8$ m/s^2
$t = 4.5$ s	$d = 0$
	$t = 4.5$ s

y-direction

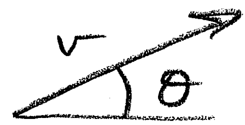
$$d = v_i t + \frac{1}{2}at^2$$

$$v_i = \frac{-\frac{1}{2}a t^{\cancel{2}}}{\cancel{t}}$$

$$v \cancel{\sin 63} = \frac{-\frac{1}{2}(-9.8)(4.5)}{\sin 63}$$

$$\underline{v = 24.7 \text{ m/s}}$$

(16)



$v = 2.25\ m/s$

$\theta = 35°$

x

$v = 2.25 \cos 35\ m/s$

y

$v = 2.25 \sin 35\ m/s$

$a = -9.8\ m/s^2$

$d = ?$

$t = 1.60\ s$

y-direction

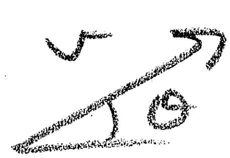
$d = v_i t + \frac{1}{2} a t^2$

$= 2.25 \sin 35 (1.60) + \frac{1}{2}(-9.8)(1.60)^2$

$= -10.479$

She was <u>10.5 m</u> above the water.

(17)



$v = 10.2$ m/s

$\theta = 25°$

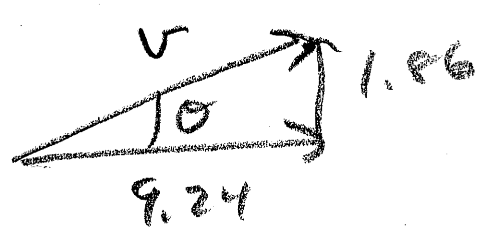
x	y
$v = 10.2 \cos 25$ m/s	$v = 10.2 \sin 25$ m/s
$d = ?$	$a = -9.8$ m/s²
$t = ?$	$d =$
	t

(a) The horizontal velocity is constant.

$$v_x = 10.2 \cos 25 = 9.24 \text{ m/s.}$$

V_y at $t = .25$ s

$$V_f = V_i + at$$
$$= 10.2 \sin 25 + (-9.8)(.25)$$
$$= 1.86 \text{ m/s.}$$



$$V = \sqrt{(9.24)^2 + (1.86)^2} = \underline{9.43 \text{ m/s}}$$

$$\theta = \tan^{-1}\left(\frac{1.86}{9.24}\right) = \underline{11.4°} \text{ above the horizontal}$$

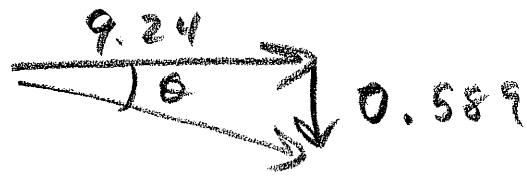
17 a

V_y at $t = 0.5$ s

$V_f = V_i + at$

$= 10.25 \sin 25 + (-9.8)(.5)$

$= -0.589$ m/s

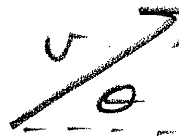


$V = \sqrt{9.24^2 + 0.589^2} = \underline{9.26 \text{ m/s}}$

$\theta = \tan^{-1}\left(\frac{.589}{9.24}\right) = \underline{3.65}°$ below the horizontal

(b) The ball is at its greatest height before 0.5 seconds. At 0.25 s, the vertical velocity was positive (up). At 0.5 s, the vertical velocity was negative (down). Therefore, the highest point (when vertical velocity is zero) would be between those two points.

(18)



$v = 13$ m/s

$\theta = 20°$

x

$V = 13 \cos 20$ m/s

$d = 5.2$

$t = ?$

y

$V = 13 \sin 20$ m/s

$a = -9.8$ m/s²

$d =$

$t =$

(a) x-direction

$$d = v_i t + \cancel{\tfrac{1}{2} a t^2}$$

$$t = \frac{d}{v_i} = \frac{5.2}{13 \cos 20} = \underline{0.43 \text{ s}}$$

(b) y-direction

$$d = v_i t + \tfrac{1}{2} a t^2$$

$$= 13 \sin 20 (0.43) + \tfrac{1}{2}(-9.8)(0.43)^2$$

$$\underline{d = 1.0 \text{ m}}$$

(c) horizontal velocity is constant

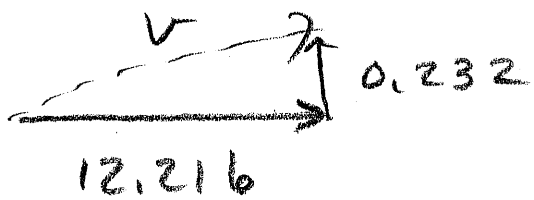
$$V_x = 13 \cos 20 = 12.216 \text{ m/s}$$

18 (c) vertical velocity.

$$V_f = V_i + at$$

$$= 13 \sin 20 + (-9.8)(.43)$$

$$V_f = 0.232$$

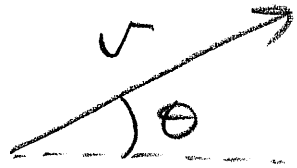


$$v = \sqrt{(12.216)^2 + (0.232)^2} = \underline{12.2 \text{ m/s}}$$

$$\theta = \tan^{-1}\left(\frac{0.232}{12.216}\right) = \underline{1.09°} \text{ above the horizontal}$$

(d) The ball has <u>not</u> reached its highest point. The vertical velocity is positive when it hits the wall. This means that the ball could have went higher if the wall was not there.

(19)



$v = 12$ m/s

$\theta = 30°$

x

$v = 12\cos 30$ m/s

$d =$

$t =$

y

$v = 12\sin 30$ m/s

$a = -9.8$ m/s^2

$d = ?$

$t =$

(a) maximum height $v_f = 0$

$$\cancel{V_f^2} = V_i^2 + 2ad$$

$$d = \frac{-V_i^2}{2a} = \frac{-(12\sin 30)^2}{2(-9.8)} = \underline{1.8 \text{ m}}$$

(b) total time. $d = 0$

$$\cancel{d} = V_i t + \frac{1}{2}at^2$$

$$-V_i \cancel{t} = \frac{1}{2}at^{\cancel{2}}$$

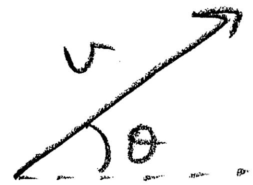
$$t = -\frac{2V_i}{a} = \frac{-2(12\sin 30)}{-9.8} = 1.22$$

ball caught at $t = 1.22 - .5 = 0.72$ s

$$d = (12\sin 30)(.72) + \frac{1}{2}(-9.8)(0.72)^2$$

$\underline{d = 1.8 \text{ m}}$

20



$v = 2.3\ m/s$

x	y
$v = 2.3\cos\theta$	$v = 2.3\sin\theta$
$d =$	$a = -9.8\ m/s^2$
$t =$	$d = 0.03\,m$
	$t =$

(a) If the water is moving horizontally, the the water is at its heighest point, $v_f = 0$.

$\cancel{v_f^2} = v_i^2 + 2ad$

$v_i = \sqrt{-2ad}$

$\cancel{2.3}\sin\theta = \dfrac{\sqrt{-2(-9.8)(0.03)}}{2.3} = 0.105$

$\underline{\theta = 6.05^\circ}$ above the horizontal.

20 (b) $v_f = v_i + at$ $(v_f = 0)$

$$t = -\frac{v_i}{a} = -\frac{2.3 \sin 6.05}{-9.8} = \underline{0.0247\ s}$$

(c) x - direction

$$d = v_i t + \cancel{\tfrac{1}{2}at^2}$$

$$= 2.3 \cos(6.05)(0.0247)$$

$$= \underline{0.0565\ m}$$