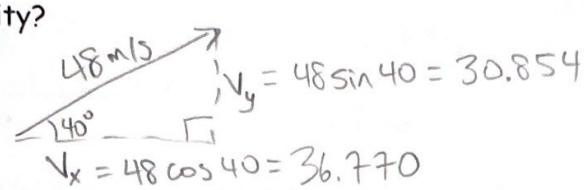
Kinematics #3 : Projectiles

Key (name)

1. A golf ball was struck from the first tee at Lunar Golf and Country Club. It was given a velocity of 48 $^m/_s$ at an angle of 40° to the horizontal. On the moon, g = 1.6 $^m/_{s^2}$. (a) What are the vertical and horizontal components of the ball's initial velocity?



v_x = 37 m/s

v_y = 31 m/s

(b) For what interval of time is the ball in flight?

$t = ?$
$a = -1.6$
$V_{iy} = 30.854$
$V_{fy} = -30.854$

$V_f = V_i + at$

$t = \frac{V_f - V_i}{a}$

$= 38.5675$

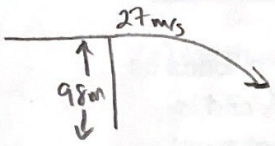
t = 39 s.

(c) How far will the ball travel horizontally?

$v = \frac{d}{t}$, $d = vt = (36.770\ ^m/_s)(38.5675)$

d_y = 1.4×10^3 m.

2. A rock is thrown horizontally from the top of a cliff 98 m high, with a horizontal speed of 27 $^m/_s$. (a) For what interval of time is the rock in the air?



$t = ?$
$V_{vi} = 0$
$d = -98$
$a = -9.81$

$d = \cancel{V_i^0 t} + \frac{1}{2} a t^2$

$t = \sqrt{\frac{2d}{a}} = 4.4699$ s

t = 4.5 s.

(b) How far from the base of the cliff does the rock land?

$d_h = V_h t$

$= \left(27 \frac{m}{s}\right)(4.4699 s) = 120.686$ m

d_x = 120 m.

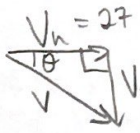
(c) With what velocity does the rock hit?

① $V_{vf} = ?$
$d = -98$ m
$a = -9.81\ ^m/_{s^2}$
$t = 4.4699$ s
$V_{vi} = 0$

$V_f^2 = \cancel{V_i^0} + 2ad$

$V_f = \sqrt{2ad}$

$= 43.849\ ^m/_s$

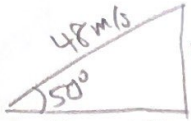
② 

$V = \sqrt{27^2 + 43.849^2}$

$\tan\theta = \frac{43.849}{27} = 58°$

v = 51 m/s [58° above horiz]

3. An earth bound golfer strikes a golf ball giving it a velocity of 48 m/s at an angle of 50° to the horizontal.(a) What are the vertical and horizontal components of the ball's initial velocity?



$V_y = 48 \sin 50° = 36.770$

$V_x = 48 \cos 50° = 30.854$

$v_x =$ 31 m/s.

$v_y =$ 37 m/s.

(b) How long is the ball in the air?

$t = ?$
$V_{vi} = 36.77$
$V_{vf} = -36.77$
$a = -9.81$

$V_f = V_i + at$

$t = \frac{V_f - V_i}{a} = 7.4964$

t = 7.5 s.

(c) What is the horizontal distance covered by the ball while in flight?

$d_h = V_x t = (30.854)(7.4964) = 231.29$

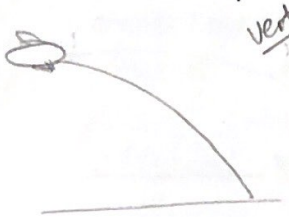
$d_x =$ 230m.

(d) What velocity does the ball have at the top of its trajectory?

only horizontal which is constant

v = 31 m/s.

4. A rescue pilot wishes to drop a package of emergency supplies so that it lands as close as possible to a target. If the plane travels with a velocity of 81 m/s and is flying 125 m above the target, how far away (horizontally) from the target must the rescue pilot drop the package?



vertical: $t = ?$, $d = -125$ m, $a = -9.8$ m/s, $V_{iv} = 0$

$d = \cancel{V_i t}^{0} + \frac{1}{2} a t^2$

$t = \sqrt{\frac{2d}{a}} = 5.048$ s

horizontal: $d_h = V_h t$

$= 81 \frac{m}{s} (5.048 s)$

$= 408.9$

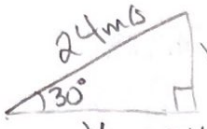
$d_x =$ 410 m.

Answers: 1. a) ~~30.8~~ 37 m/s, ~~36.8~~ 31 m/s b) ~~38.5~~ 39 s c) 1.4×10^3 ~~m~~ 2. a) 4.5 s b) 120 m
c) ~~52 m/s, 59° down~~ 51 m/s [58° ~~above~~ below horiz] 3. a) ~~36.7~~ 37 m/s, ~~30.8~~ 31 m/s b) 7.5 s c) 230 m d) ~~30.8~~ 31 m/s 4. 410 m

Kinematics #4

(name)

1. A ball is thrown with a velocity of 24 m/s at an angle of 30° to the horizontal.
(a) What are the vertical and horizontal components of the initial velocity?



$V_v = 24 \sin 30° = 12$ m/s

$V_h = 24 \cos 30° = 20.7846$

$v_x =$ 21 m/s.

$v_y =$ 12 m/s.

(b) How long is the ball in the air?

$t = ?$

$V_{vi} = 12$ m/s

$V_{vf} = -12$ m/s

$a = -9.81$

$t = \frac{V_f - V_i}{a}$

$= 2.4465$

$t =$ 2.4 s.

(c) How far away will the ball land?

$d_h = V_h t = (20.7846)(2.4465)$

$= 50.849$

$d_x =$ 51 m.

(d) To what maximum height will the ball rise?

or $V_f = 0$

$d_v = ?$

$t = 2.4465 \text{ s} \div 2$

$V_{iv} = 12$ m/s

$a = -9.81$ m/s²

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

$= (12)(\frac{2.4465}{2}) + \frac{1}{2}(-9.81)(\frac{2.4465}{2})^2$

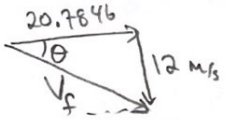
$= 7.3394$

$d_y =$ 7.3 m.

(e) With what velocity will the ball land?

same as V_{vi} → $V_{vf} = -12$ m/s

$V_h = 20.7846$ m/s



$\tan\theta = \frac{12}{20.7846}$

$\theta = 30°$

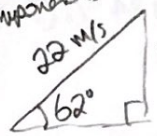
$V_f = \sqrt{20.7846^2 + 12^2}$

$= 23.99999$

$v =$ 24 m/s [30° above horiz]

2. A youngster hits a baseball giving it a velocity of 22 m/s at an angle of 62° with the horizontal. How far will the ball travel before a fielder (assuming the fielder catches the ball at the same height that it is hit) ~~catches it~~?

① components



$V_{vi} = 22 \sin 62° = 19.4248$ m/s

$V_h = 22 \cos 62° = 10.3284$ m/s

② time from vertical

$t = ?$

$V_{vi} = 19.4248$ m/s

$V_{vf} = -19.4248$ m/s

$a = -9.81$ m/s²

$t = \frac{V_{vf} - V_{vi}}{a} = 3.9602$ s

③ horizontal

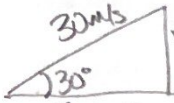
$d_h = V_h t$

$= (10.3284 \text{ m/s})(3.9602 \text{ s})$

$= 40.903$

$d_x =$ 41 m.

3. A pebble is fired from a slingshot with a velocity of 30 m/s. (a) If it is fired at an angle of 30° to the horizontal, what height will it reach?



$V_{vi} = 30\sin 30° = 15\ m/s$

$V_h = 30\cos 30° = 25.981\ m/s$

$d_v = ?$
$V_{vi} = 15\ m/s$
$V_f = 0$
$a = -9.81\ m/s^2$

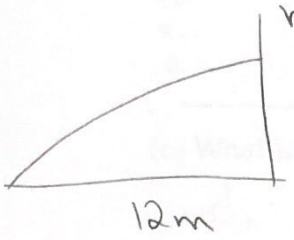
$V_f^2 = V_i^2 + 2ad$

$d = \frac{V_f^2 - V_i^2}{2a}$

$= 11.46789$

$d_y =$ 11 m.

(b) If its flight is interrupted be a vertical wall 12 m away, ~~where~~ how high above the ground will it hit the wall ? ~~in relation to the starting position?~~



horiz.

$t = \frac{d_h}{V_h}$

$= \frac{12m}{25.981}$

$= 0.4619s$

vert

$d_v = ?$
$V_{vi} = 15\ m/s$
$a = -9.81\ m/s^2$
$t = 0.4619s$

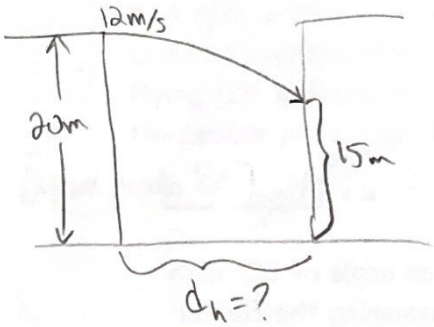
$d = V_i t + \frac{1}{2}at^2$

$= 15(0.4619) + \frac{1}{2}(-9.81)(0.4619)^2$

$= 5.882$

$d_y =$ 5.9 m above ground

4. A fireman is standing on top of a building 20 m high. He finds that if he holds the hose so that water issues from it horizontally at 12 m/s, the water will hit a burning wall of an adjacent building at a height of 15 m above the ground. What is the horizontal distance from the fireman to the building?



vertical

$t = ?$
$V_{vi} = 0$
$d = -5m$
$a = -9.81\ m/s^2$

$d = \cancel{V_i t}^{0} + \frac{1}{2}at^2$

$t = \sqrt{\frac{2d}{a}} = 1.0096s$

horizontal

$d_h = V_h t$

$= (12\frac{m}{s})(1.0096s)$

$= 12.1157\ m$

$d_x =$ 12m.

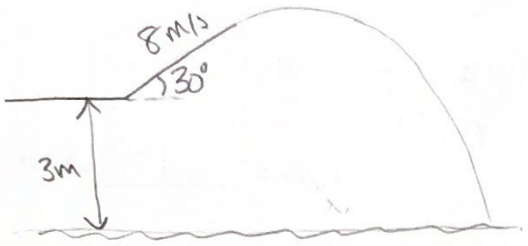
Answers: 1. a) 12~~0~~ m/s, ~~20.8~~ 21 m/s b) 2.4~~5~~ s c) 51 m d) 7.3 m e) 24 m/s [30° above horiz]
2. 41 m 3. a) 11~~5~~ m b) 5.9 m up 4. 12~~4~~ m

Kinematics #5

3.0

_____ (name)

1. A diver takes off with a speed of 8.0 m/s from a 3-m high diving board at 30° above the horizontal. How much later does she strike the water?



① components

$V_v = 8 \sin 30° = 4 \text{ m/s}$

$V_h = 8 \cos 30° = 6.928 \text{ m/s}$

$t = ?$

$V_{vi} = 4 \text{ m/s}$

$d = -3 \text{ m}$

$a = -9.81 \text{ m/s}^2$

② either $d = v_i t + \frac{1}{2} a t^2$ then quadratic formula

or ② find v_f first

$v_f^2 = v_i^2 + 2ad$

$v_f = \sqrt{4^2 + 2(-9.81)(-3)}$

$= -8.652 \text{ m/s}$ ← (neg since down)

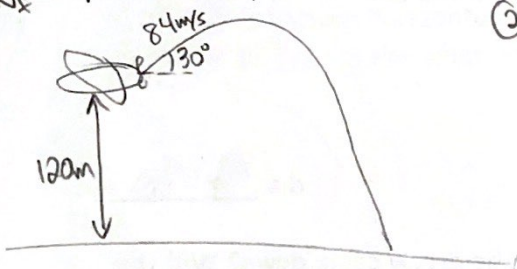
then $v_f = v_i + at$

$t = \frac{v_f - v_i}{a} = 1.2897$

t = 1.3 s.

2. A pilot cuts loose two fuel tanks in an effort to gain altitude. At the time of release, the plane was 120 m above the ground and travelling upward at 30° to the horizontal, with a speed of 84 m/s. For how long did the tanks fall and with what speed did they hit the ground?

$v_f = ?$ $t = ?$



① components

$V_{vi} = 84 \sin 30° = 42 \text{ m/s}$

$V_h = 84 \cos 30° = 72.746 \text{ m/s}$

② $V_{fv} = ?$

$V_{iv} = 42 \text{ m/s}$

$d = -120 \text{ m/s}$

$a = -9.81 \text{ m/s}^2$

$v_f^2 = v_i^2 + 2ad$

$v_f = \sqrt{42^2 + 2(-9.81)(-120)}$

$= -64.175 \text{ m/s}$

③ $t = ?$

$V_{vf} = -64.175 \text{ m/s}$

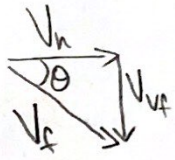
$V_{iv} = 42 \text{ m/s}$

$a = -9.81 \text{ m/s}^2$

$t = \frac{v_f - v_i}{a} = 10.823$

t = 11 s.

④ $V = ?$



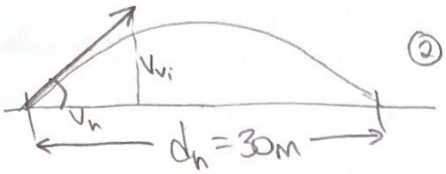
$V_f = 97 \text{ m/s}$ [41° above horiz]

⑤ $\tan\theta = \frac{64.175}{72.746}$

$V_f = \sqrt{64.175^2 + 72.746^2}$

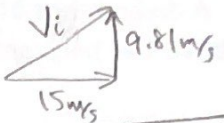
$= 97.0073$

3. On level ground, a ball is thrown forward and upward. The ball is in the air 2.0 s and strikes the ground 30. m from the thrower. What was the ball's initial velocity?



① $V_h = \frac{d}{t} = \frac{30\,m}{2s} = 15\,m/s$

② $-V_{vi} = V_{vf} = ?$
$t = 2s$
$a = -9.81\,m/s$
$V_f = V_i + at$
$-V_i = (-9.81)(1)$
$V_{iv} = 9.81\,m/s$

③ 

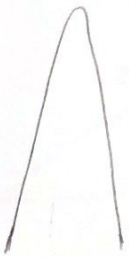
④ $\tan\theta = \frac{9.81}{15}$
$\theta = 33°$

$V_i = \sqrt{15^2 + 9.81^2}$
$= 17.923$

V_i = 18 m/s [33° above horiz]

4. An archer standing on the back of a pickup truck moving at 28 m/s fires an arrow straight up at a duck flying directly overhead. The archer misses the duck! The arrow was fired with an initial velocity of 49 m/s relative to the truck.

(a) For how long will the arrow be in the air?



$t = ?$
$V_i = 49\,m/s$
$V_f = -49\,m/s$
$a = -9.81\,m/s^2$

$t = \frac{V_f - V_i}{a}$
$= \frac{-49 - 49}{-9.81} = 9.9898$

t = 10. s.

(b) How far will the truck travel while the arrow is in the air?

$d_h = V_h t$
$= (28\,m/s)(9.9898) = 279.7$

d = 280 m.

(c) Where, in relation to the luckless archer, will the arrow come down? Will the archer have to 'duck'?

since arrow will have truck's horizontal velocity, it will move along sideways with the truck, so will come back down right on top of the archer. (serves him right for trying to kill a duck!)

Answers: 1. 1.3 s 2. ~~10.8~~ 11 s, 97 m/s 3. 18 m/s [33° above horizon]
4. a) 10. s b) 280 m c) yes [41° below horiz]