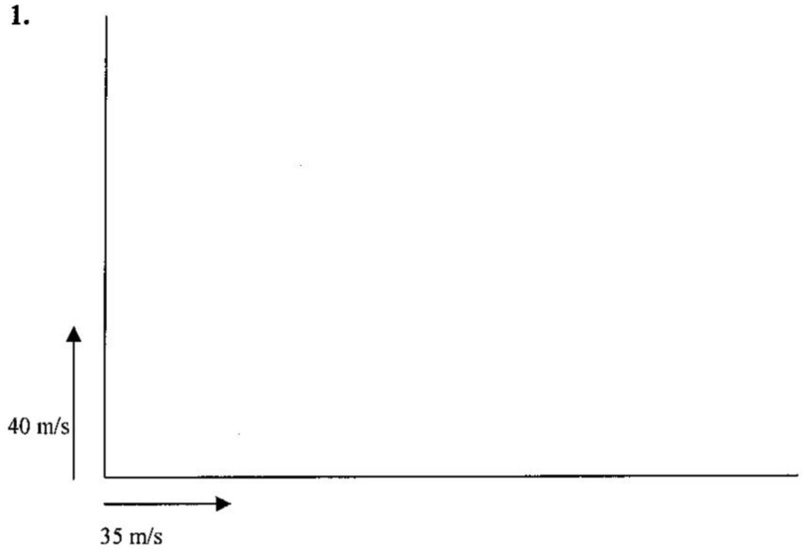
C1 page 1 A

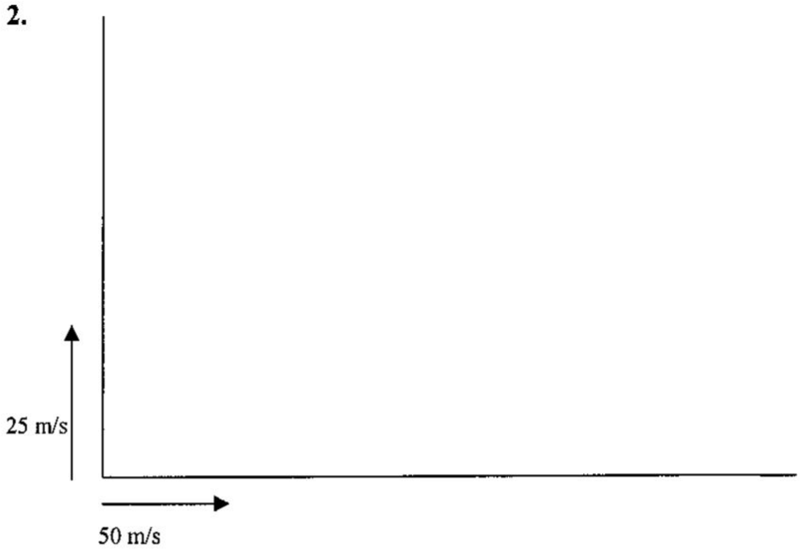
**PHY 111 Introduction to projectile motion**

a) In each case, determine the number of seconds the projectile will be in flight.
b) Determine the forward distance travelled.
c) Determine the maximum height.
d) Trace the path. Write the position coordinates of the peak.
e) Write the velocity of the projectile at the peak.

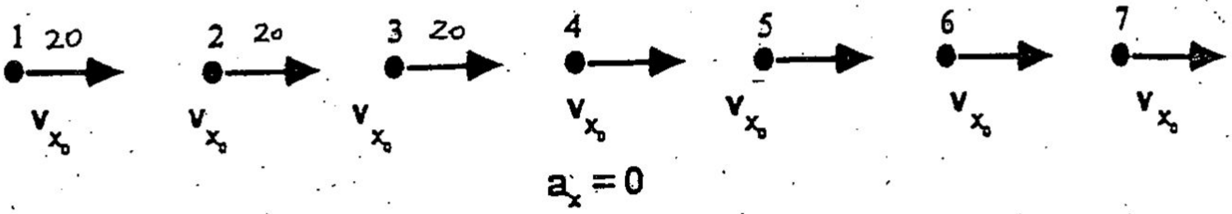
**1.**



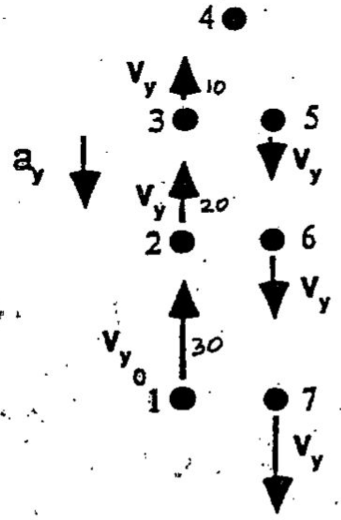

**2.**

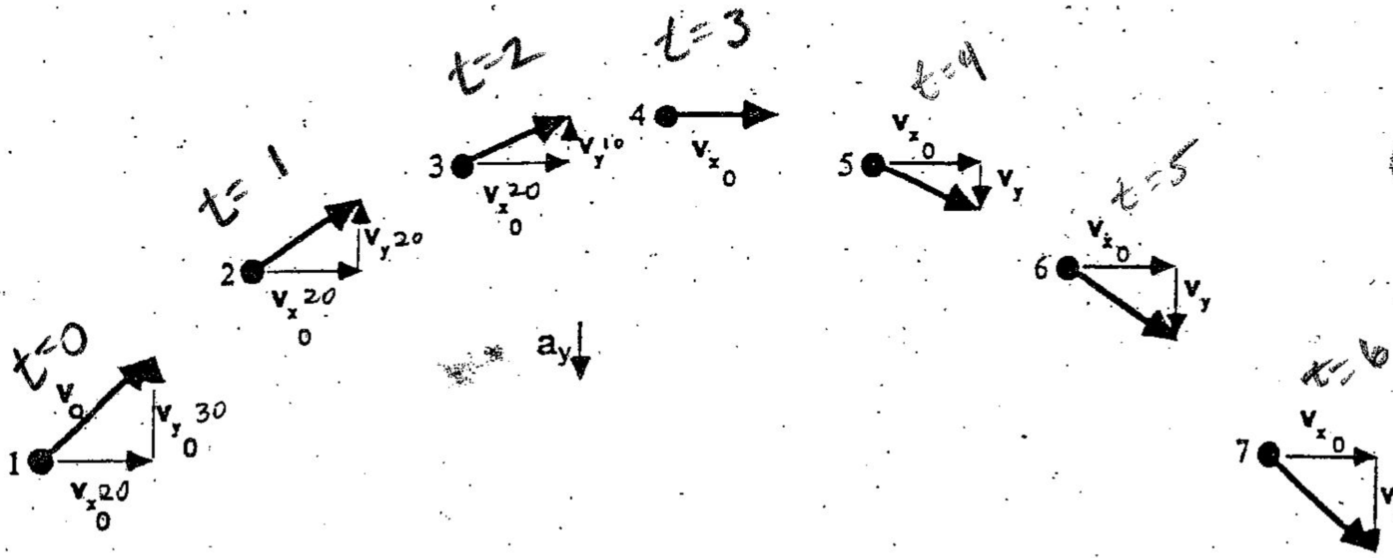


## Motion Diagram for a Projectile

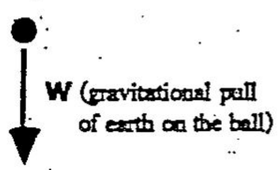



Construct a vertical motion diagram for an object with an initial upward velocity (its initial vertical speed is the vertical component of its initial velocity) and which experiences a constant, downward acceleration. Displace the position dots for the upward motion slightly to the left side of the position dots for the downward motion. Assume that the time interval separating each dot is the same for the vertical motion diagram as for the horizontal motion diagram.




Finally, construct a free-body diagram for the projectile. Ignore air resistance. Does the direction of the resultant force acting on the object point in the same direction as the acceleration shown above?



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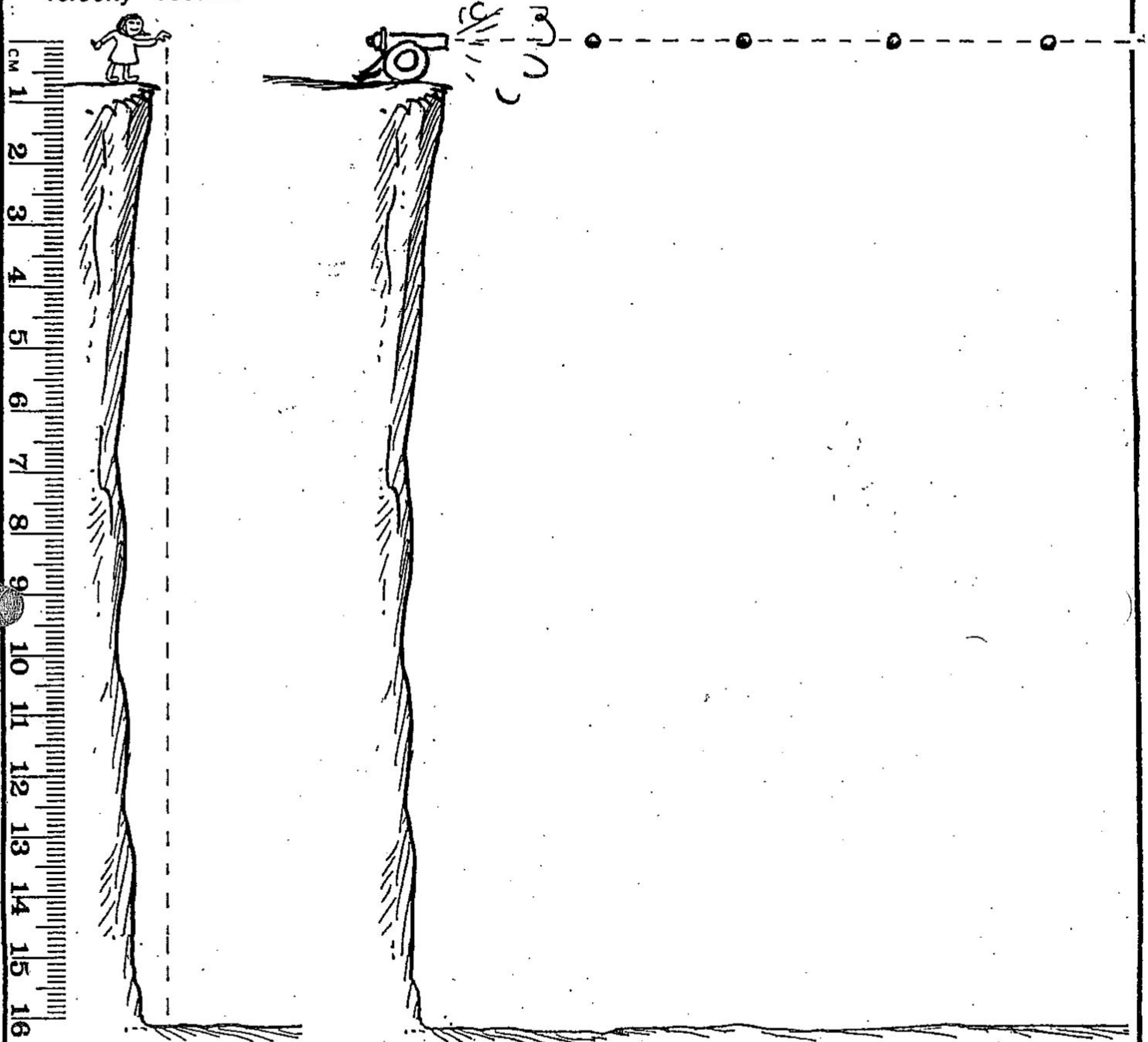
Name ______________________________ Date __________

CONCEPTUAL **Physics** PRACTICE SHEET

Chapter 3: Nonlinear Motion

*Velocity Vectors*




1. Above left: Use the scale 1 cm = 5 m and draw the positions of the ball at 1-second intervals dropping from the cliff. Neglect air drag and assume $g = 10\ m/s^2$. Estimate the number of seconds the ball is in the air.

________________seconds.

2. Above right: The four positions of the canonball with no gravity are at 1-second intervals. At 1 cm = 5 m, carefully draw the positions of the cannonball *with* gravity. Neglect air drag and assume $g = 10\ m/s^2$. Connect your positions with a smooth curve to show the path of the cannonball. How is the motion in the vertical direction affected by motion in the horizontal direction?

______________________________________________________________________________

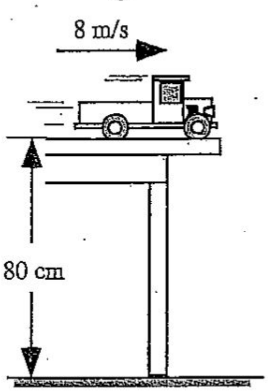
Hewitt Drew it!

**PHY 111** **Toy Trucks off Tables**

Each of the six figures shows a toy truck rolling off a table. The height of the table and the speed of the truck are given.

**How far forward will each truck go before hitting the floor?**

C

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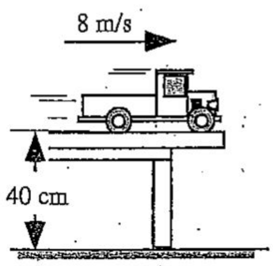
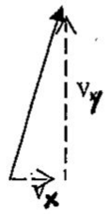


4

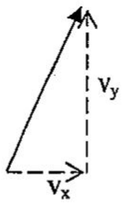
**PHY 111** **Getting $v_x$ and $v_y$ from $v_o$ and the angle $\theta$**

**You are given the initial velocity $v_o$ and the angle $\theta$. Find the components of the velocity, $v_x$ and $v_y$.**



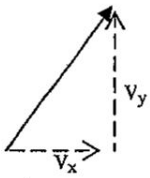

$v_o = 50$ m/s $\qquad$ $v_x =$

$\theta = 60°$ $\qquad$ $v_y =$



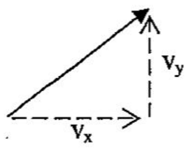

$v_o = 50$ m/s $\qquad$ $v_x =$

$\theta = 53°$ $\qquad$ $v_y =$



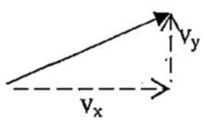

$v_o = 50$ m/s $\qquad$ $v_x =$

$\theta = 45°$ $\qquad$ $v_y =$




$v_o = 50$ m/s $\qquad$ $v_x =$

$\theta = 37°$ $\qquad$ $v_y =$



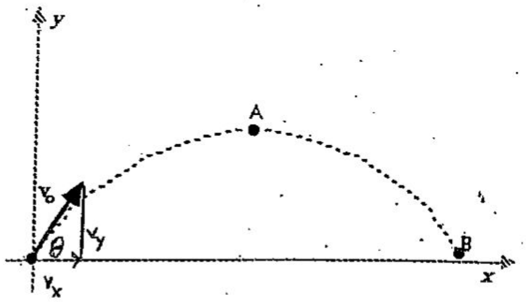

$v_o = 50$ m/s $\qquad$ $v_x =$

$\theta = 30°$ $\qquad$ $v_y =$

5

**PHY 111** **How far does it go? #1**

**1.** You are given the initial velocity $v_o$ and the angle $\theta$ of a projectile launched from the ground and returning to the ground.
a) Find the components of the velocity, $v_x$ and $v_y$.
b) What is the total air time for the projectile (time up + time down)?
c) Determine the forward distance the projectile travels while in flight.
**2.** You are given the components of the initial velocity, $v_{xo}$ and $v_{yo}$ of a projectile launched from the ground and returning to the ground.
a) Find the initial velocity $v_o$ and the angle $\theta$.
b) What is the total air time for the projectile (time up + time down)?
c) Determine the forward distance the projectile travels while in flight.




**1.** $v_o = 80$ m/s

$\theta = 30°$

$v_{xo} =$

$v_{yo} =$

air time =

forward distance =

velocity at point A =

**2.** $v_{xo} = 30$ m/s

$v_{yo} = 50$ m/s

$v_o =$

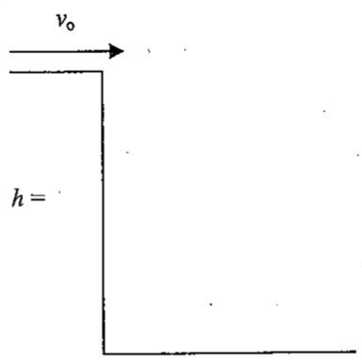
$\theta =$

air time =

forward distance =

velocity at point A =

**3.**




$v_o = 30$ m/sec

$h = 125$ m

$v_{xo} =$

$v_{yo} =$

air time =

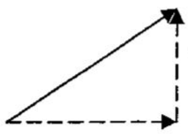
forward distance =

Trace the trajectory.

6

**PHY 111 The forward distance of a projectile**

A projectile is launched from the ground with an initial velocity of 64 m/sec at an angle of 38.7°. The projectile returns to the ground. We will want to know what horizontal distance the projectile travels.




a) Find the x and y components of the velocity vector.

$v_x$ =

$v_y$ =

b) Focusing on the vertical motion only, how many seconds will the projectile be in flight (up and down)?

c) Focusing on the horizontal motion and knowing the flight time, what is the forward distance that the projectile travels?

---

**How far would that same projectile go if it were launched from the surface of Mars where $g = 4\ m/sec^2$?**

a) Would the components $v_x$ and $v_y$ be the same as on Earth?

b) Focusing on the vertical motion only, how many seconds will the projectile be in flight (up and down)?

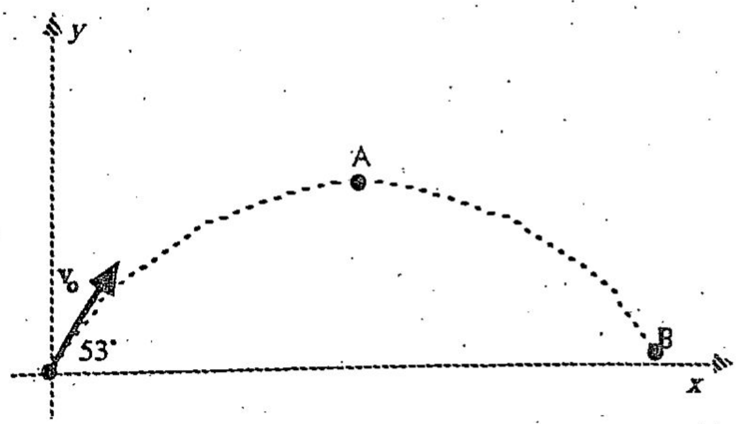
c) Focusing on the horizontal motion and knowing the flight time, what is the forward distance that the projectile travels?

# Projectile Motion Question 1

A ball is projected from the origin with initial velocity $v_o$, as shown at the right. The initial speed of the ball is 50 m/s. Assume that. $g = 10\ m/s^2$.

(a) Determine the $x$ component of the initial velocity?

(b) Determine the $y$ component of the initial velocity?




c) Determine the forward distance of the ball while in flight.

(e) Complete the table below indicating the position components and the velocity components at one-second time intervals beginning at time zero when the ball leaves the ground.

| time (s) | $x$ velocity (m/s) | $x$ position (m) | $y$ velocity (m/s) | $y$ position (m) |
|---|---|---|---|---|
| 0 | | 0 | | 0 |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |

(f) Determine the ball's velocity (magnitude and direction) at position A.

g) Write the parametric equations of motion

$x(t) =$

$y(t) =$

8

**PHY 111 Horizontal distance of a baseball: Earth vs. Mars**

**There is speculation that Mars could one day be made into a planet with a breathable atmosphere, sufficient water, and permanent human inhabitants. If those inhabitants had an interest in baseball, how would the weaker gravity affect the game?**

**A baseball comes off the bat at a speed 40 m/sec directed at an angle of 30° above the horizontal. We will calculate the horizontal distance the ball would travel on Earth and as well as the horizontal distance it would travel on Mars. We are assuming the ball is caught at the same altitude from which it was hit.**

**Earth: $g = 10$ m/s/s.**

1. Determine the $x$ and $y$ components of the initial velocity: $v_{ox}$ and $v_{oy}$.

2. Determine the flight time.

3. Determine the horizontal distance the ball travels.

4. Write the parametric equations of motion for the ball while in flight.

   $x(t) =$

   $y(t) =$

5. What is the highest altitude the ball reaches? What will its speed be at that altitude?

6. Assuming the ball is caught at the same level from which it was hit and neglecting the effects of air resistance, what is the speed of the ball as it comes to the fielder's glove?

**Mars: $g = 4$ m/s/s**

1. Determine the $x$ and $y$ components of the initial $\vec{v}$elocity: $v_{ox}$ and $v_{oy}$.

2. Determine the flight time.

3. Determine the horizontal distance the ball travels.

4. Write the parametric equations of motion for the ball while in flight.

   $x(t) =$

   $y(t) =$

5. What is the highest altitude the ball reaches? What will its speed be at that altitude?

**Graphing:**
Graph both trajectories on the same screen.
Sketch the graph. Label axes and give coordinates of important points.

**Questions:**
1. What part of the ball's motion is the same on Mars as it is on Earth?

2. Why does a lower value of $g$ on Mars cause the ball to go further?

3. Because balls hit on Mars would travel considerably further than on Earth, the outfield would have to be considerably enlarged. Does this necessarily mean that more fielders would have to be placed in the outfield to cover the larger area? Explain.

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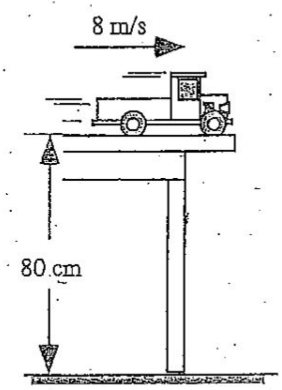
**PHY 111** **Toy Trucks off Tables**

Each of the six figures shows a toy truck rolling off a table. The height of the table and the speed of the truck are given.

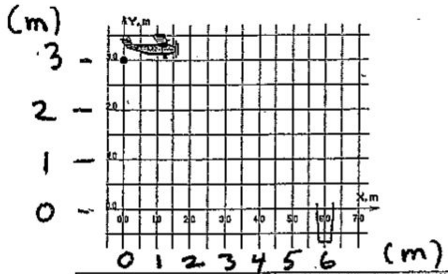



a) What is the horizontal velocity of the truck when it hits the floor

b) What is the vertical velocity of the truck when it hits the floor?

c) What is the impact speed of the truck when it hits the floor?

prob 3.7



In a toy airplane contest, a small plane travels at a constant elevation and at a constant 6.0 m/s speed. You are to decide the position where the plane should release supplies so that they land in a target basket. The gravitational constant is 10 $m/s^2$.

Make a sketch below to indicate all information known about the initial situation and the desired final situation.

Apply the x-component kinematics equations.

Apply the y-component kinematics equations.

Solve for the unknown.

Evaluate your solution in terms of magnitude, sign, and unit.

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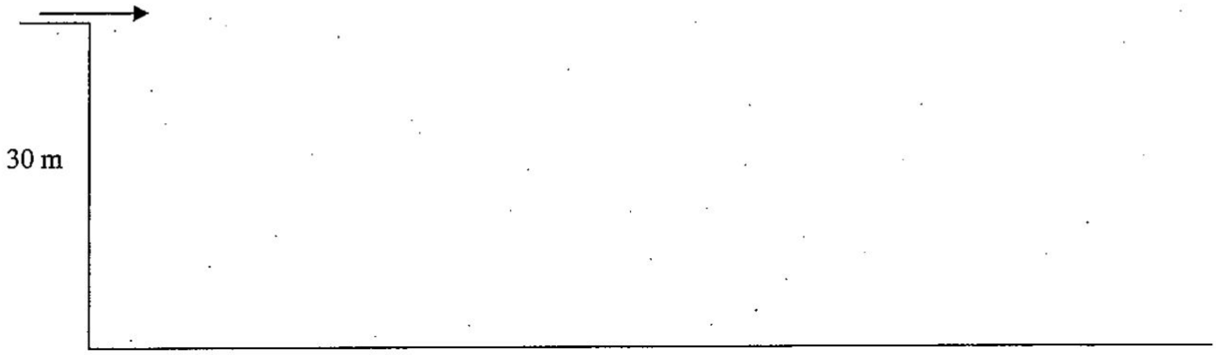
**PHY 111** **Projectile motion, initial velocity below the horizontal**

**1.** A projectile is thrown horizontally from the edge of a cliff 30 m above the ground with an initial velocity of 20 m/sec.




a) How many seconds will the projectile be in flight?

b) What forward distance does the projectile travel?

c) Write the equations of motions. Graph the motion to check your answer.

$x(t) =$

$y(t) =$

**2.** The goal now is to throw the projectile with the correct initial velocity so that it hits the ground 70 m away.

a) How many seconds will the projectile be in flight?

b) What should the initial velocity be?

c) Write the equations of motions. Graph the motion to check your answer.

$x(t) =$

$y(t) =$

**PHY 111** **Finding the launch angle and launch velocity**

An object is launched from the ground and returns to the ground. It is in the air a total time of 5 seconds and travels horizontal distance of 140 meters.

a) Use the total air time to determine the initial vertical velocity.

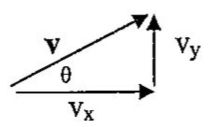
(Remember, 2.5 sec up and 2.5 sec down.)

$v_{oy} =$

b) Use the total air time and the forward distance traveled to determine the initial horizontal velocity.

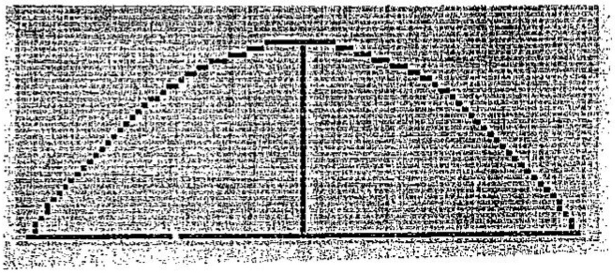
$v_{ox} =$

c) Determine the launch speed and launch angle. (Use the Pythagorean Theorem. Use a trig function to find the angle.)



**PHY 111** **Ball kicked over a wall**

A ball is initially on the ground 30 from a wall. The wall is 11.25 m high.



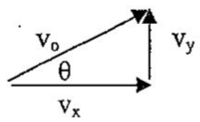
The ball is kicked so that it just barely makes it over the wall at the very top of its trajectory.

a) Use the given height of the wall to determine how many seconds the ball is in the flight?
**Remember to just ignore the x direction.**

b) Since you now know how many seconds the ball is in the air, what is the initial vertical velocity ($v_{oy}$) ?
**Remember to just ignore the x direction.**

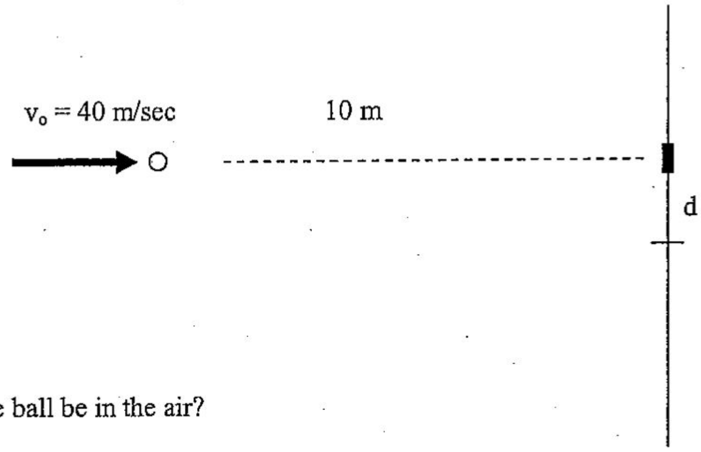
c) Since you know how many seconds the ball is in the air, what is the initial horizontal velocity ($v_{ox}$)?
**Remember to just ignore the y direction.**

d) Knowing $v_{oy}$ and $v_{oy}$ what was initial speed $v_o$ of the ball when it was kicked?
e) At what initial angle $\theta$ is the ball kicked?



**PHY 111 Missing the target**

A baseball pitcher throws a ball at a target (marked by ▮) directly ahead in a perfectly horizontal direction. (The target is located on a wall.) The target is 10 m away. Instead of going straight to the target, the ball curves downward and misses the target. The pitcher throws at a speed of 40 m/sec.




a) How many seconds will the ball be in the air?

b) By what distance d does the ball miss the target?

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**PHY 111 Projectile Motion with an unknown gravitational constant**

**1.** On a planet where the gravitational constant is unknown, a ball is launched with an initial speed of 12 m/sec from the ground and returns to the ground 1.2 sec after it is launched. The angle of launch is 58.3°. What is the gravitational constant *g* on this planet?

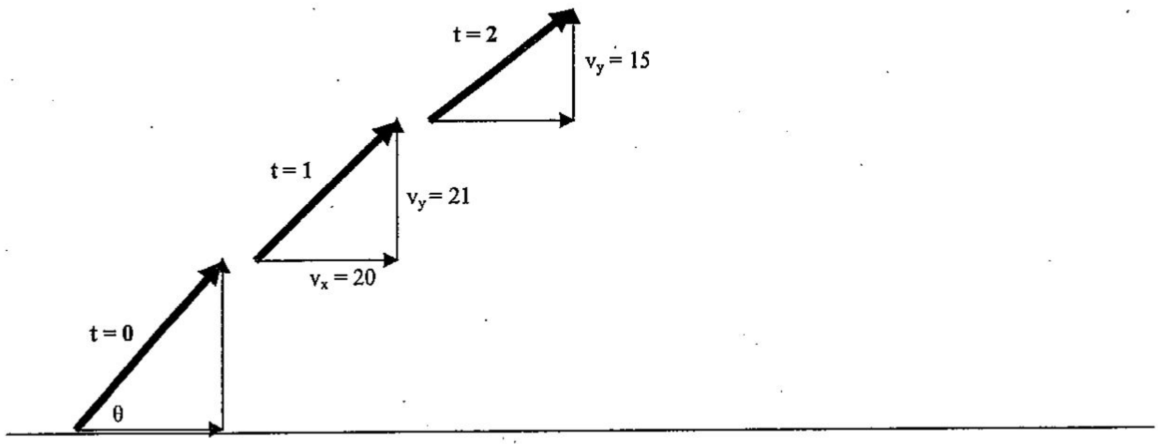
**2.** Knowing the gravitational constant on this planet, calculate the horizontal distance the ball will travel if it is launched at an angle of 58.3° with an initial velocity of 8 m/sec.

**PHY 111** **Projectile motion on a planet with unknown *g***

An object is launched from the ground and returns to the ground on a planet where g is unknown.

1 second after launch, the vertical velocity $v_y$ is 21 m/sec and the horizontal velocity $v_x$ is 20 m/sec.

2 seconds after launch, the vertical velocity $v_y$ is 15 m/sec.




1. What is the value of g on the planet?

2. What is the value of $v_x$ at t = 2 seconds?

3. What are the values of $v_x$ and of $v_y$ at t = 0 seconds?

4. What are the initial launch velocity and the initial launch angle?

5. How long will the object be in flight (up and down)?

6. What is the forward distance the object will travel while in flight?