Experiment III - 2-D Kinematics

You need to accurately predict the landing spot of a launched projectile.

To load the ball, put the ball into the mouth of the launcher and push down until the launcher clicks **<u>once</u>**. Pull the string on the launcher to launch the ball. Try not to have fun doing this.

Notes:

- If the launcher clicks a second time, then you will get a different launch speed. You need a consistent launch speed.
- While the odds of getting hit in the eye are small, the consequences are potentially significant. Be careful, wear goggles, and be <u>certain</u> that everyone in your group knows when you are about to fire the ball ("fore" or "fire in the hole").
- Neglect drag in all calculations and assume that the launch speed is independent of launch angle. (Of course, the launch *velocity* does depend on angle because velocity is a vector.)
- The initial position of the ball is not its position when the spring is compressed; the initial position is its position when the drive shaft is fully extended, marked on the side of the launcher.
- **<u>Measure the ball in a consistent manner</u>**. If for the landing ball you use the tabletop, which is the bottom of the ball, then you need to use the bottom of the ball at all positions.
- Do not test the experiment at your given launch angle without your TA present. Doing so may result in not getting credit for the graded activity.

Your instructor will tell you what launch angle to select for the range experiment. *Our launch angle for the experiment is* ___32___°.

Activity 1 **Determine the launch speed**. Orient your launcher so that it launches the ball straight up. Launch the ball and measure its peak height using a meter stick. One effective way to do this is to take a video using a smartphone (not provided), and then view the video in slow motion. Make sure the person who does the measurement has their eyes/camera near the peak height rather than viewing the meter stick at an angle.

48cm → 0.48 m

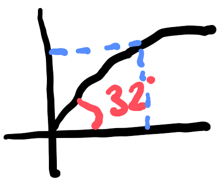
$v_1^2 = v_0^2 + 2ax$

$v_0 = \sqrt{-2ax}$

$v_0 = \sqrt{9.408} = 3.067\,m/s$

Check that you have a consistent launch speed by doing this multiple times.

Activity 2 **Graded Activity:** [5% for full credit; 15% for half credit] **Determine the horizontal distance for your launch.** Construct a target at the calculated landing point. Place a sheet of paper on the table with a line perpendicular to the direction of travel of the ball. If your calculation is accurate, the ball will land on this line. Use a small mass to hold the paper in place. Place a sheet of carbon paper, ink side down, on top of the target paper.



When you are ready to launch your ball, wait for your instructor. <u>Do not launch your ball without your instructor's assistance</u>.

$V_{ox} = V_o \cos\theta$

$V_o = 3.067 \text{ m/s}$

$\theta = 32^\circ$

$V_{ox} = 3.067 \cos 32 = 2.6 \text{ m/s}$

$V_{oy} = 3.067 \sin 32 = 1.63 \text{ m/s}$

$V_1 = V_{oy} + at$

$0 = 1.63 - 9.8t$

$t_1 = \frac{1.63}{9.8} = 0.166\text{ s}$

$y = \left(\frac{V_{1y} + V_{oy}}{2}\right)t = \left(\frac{0 + 1.63}{2}\right)0.166$

$y = 0.136\text{ m}$

$y + \text{tableheight} = .425\text{ m}$
$(.29\text{ m})$

$y = V_1 t + \frac{1}{2}at$

$.425 = \frac{1}{2}(9.8)t \rightarrow t_2 = \sqrt{\frac{.425}{4.9}} = 0.294\text{ s}$

$t = t_1 + t_2 = .166 + .294 = .46\text{ s}$

$\Delta x = V_{ox} * t$

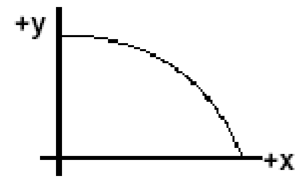
$\Delta x = 2.6 * 0.46$

$\boxed{\Delta x = 1.196\text{ m}}$

Instructor Initials: ______ Date: 9/7/22

2-D Kinematics

(1) A baseball is hit horizontally with an initial velocity v_o at time $t_o = 0$ and follows the parabolic arc shown at right.



1.1) Which graph below best represents its horizontal position (x) versus time graph? Explain your reasoning.

a - x constant increase

1.2) Which graph best represents the horizontal velocity (v_x) versus time graph?

h

1.3) Which graph best represents the horizontal acceleration (a_x) versus time graph?

g

1.4) Which graph best represents the vertical position (y) versus time graph?

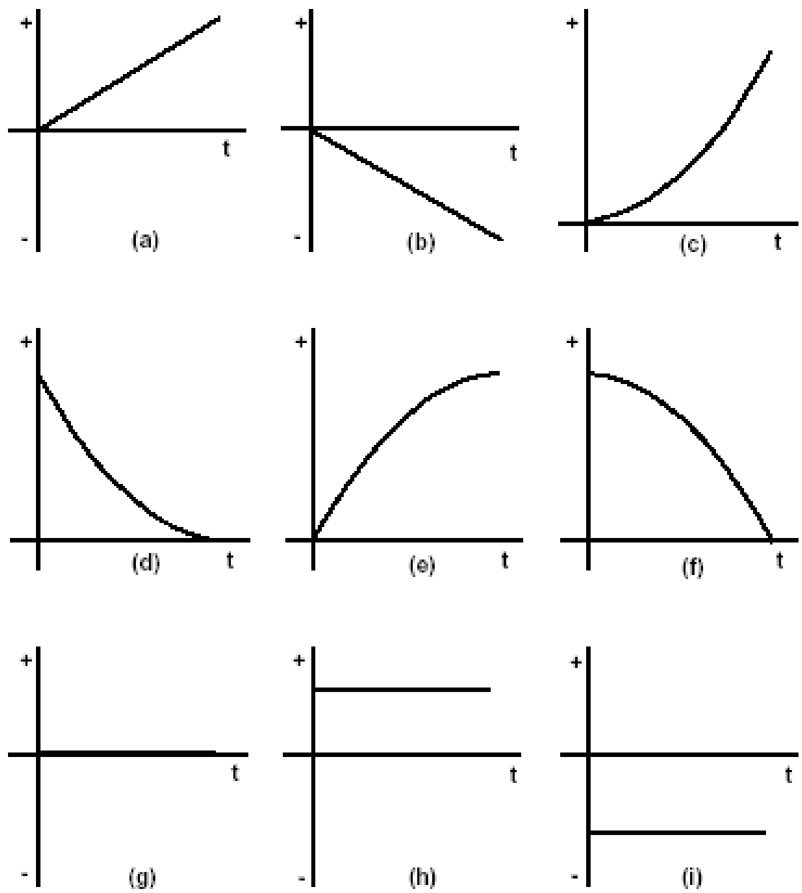
f

1.5) Which graph best represents the vertical velocity (v_y) versus time graph?

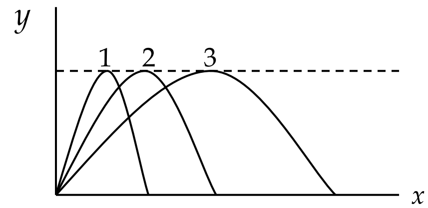
b

1.6) Which graph best represents the vertical acceleration (a_y) versus time graph?

i



(2) The figure shows three paths for a football kicked from ground level. Going from smallest to largest, rank the paths according to:



a) time of flight b) v_{ix} c) v_{iy} d) v_i

a) 1=2=3 b) 3>2>1

c) 1=2=3 d) 3>2>1

(3) A ball is shot from the ground into the air. At a height of 7.5 m, its velocity is $\vec{v} = 5.4 \text{ m/s } \hat{i} + 12 \text{ m/s } \hat{j}$, with x pointing horizontal and $+y$ upwards.

You are welcome to, and may be required to, use whiteboards or blackboards in your lab room for the group work.

a) What is the ball's speed when it reaches a height of 42 m?

N/A- Doesn't reach that height

b) To what maximum height does the ball rise?

14.847 m

c) At what angle was the ball launched?

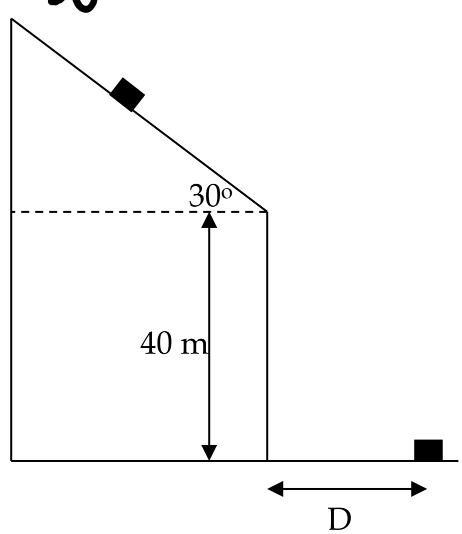
65.77°

(4) Particle #1 starts at the origin at rest but undergoes constant acceleration. Particle #2 starts at $\vec{r} = -100 \text{ m } \hat{j}$ moving with constant velocity: $\vec{v} = 8.0 \text{ m/s } \hat{i}$. They collide after 20 s.

a) What was particle #1's acceleration? 0.943 m/s²

b) In what direction was particle #1 moving just after it got underway? When it collided? 302° OR -58°

(5) A box slides down an oddly shaped hill, as shown, landing a distance, D, away. Its speed when it slid off the hill was 12 m/s. Find D.



D = 24 m