Physics 101H

General Physics 1 – Honors

Lecture 7 – 9/10/23

1D and 2D motion

Welcome!

I am Tangereen

Pronouns: they/them/their

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Problem sets

Problem Set 1 is due by the **start of class** on **Wednesday 14 September**

Remember

- There are two components – online and handwritten
- Chris will **drop the lowest grade** on your weekly Problem Sets

MAKING SURE YOUR WORK IS LEGIBLE IS *YOUR* RESPONSIBILITY

Summary

Topics

Last week

- Vectors
- Kinematics in 1D
- Kinematics in 2D
- Projectile motion

This week

- 2D motion
- Circular motion
- Forces

Today: practice problems

Announcements

Wednesday: **Problem set 1 due**
Problem set 2 assigned

Range Equation

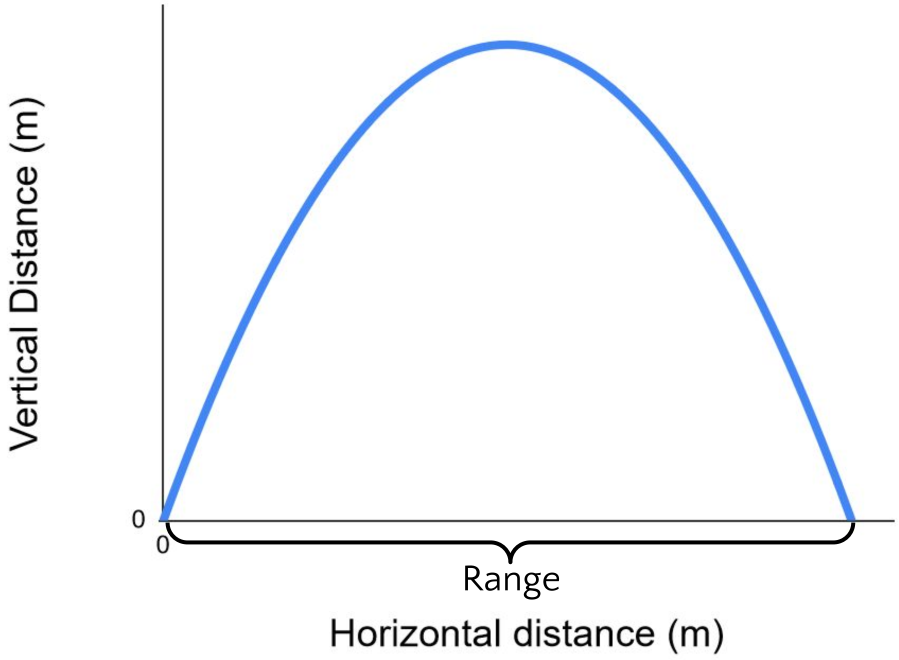
$$\vec{a} = -g\hat{y}$$

$$v_x(t) = v_{x,0}$$

$$x(t) = v_{x,0}t + x_0$$

$$v_y(t) = -gt + v_{y,0}$$

$$y(t) = -\frac{1}{2}gt^2 + v_{y,0}t + y_0$$



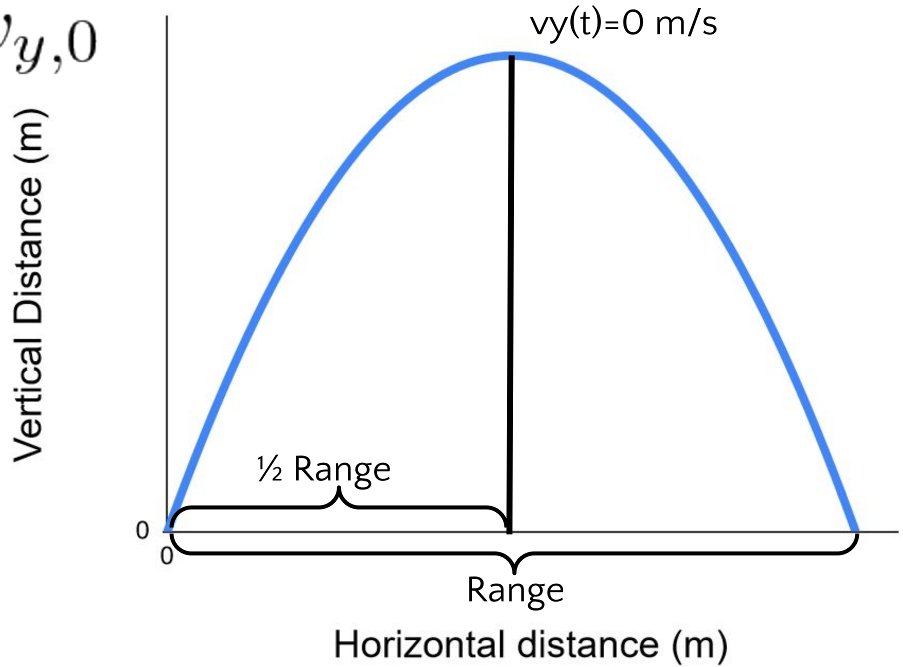
Range Equation

$$v_y(t_{1/2}) = 0 = -gt_{1/2} + v_{y,0}$$

$$\Rightarrow t_{1/2} = \frac{v_{y,0}}{g}$$

$$\Delta x = v_{x,0}(2t_{1/2})$$

$$\Delta x = \frac{2v_{x,0}v_{y,0}}{g}$$



Range Equation

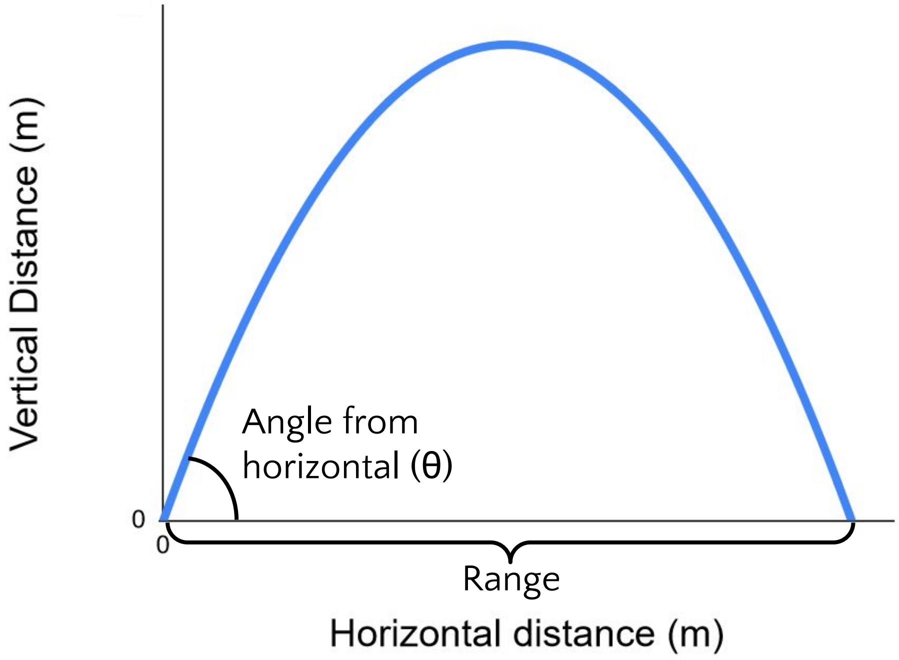
$$v_{x,0} = \left|\vec{v}_0\right| \cos(\theta)$$

$$v_{y,0} = \left|\vec{v}_0\right| \sin(\theta)$$

$$2\sin(\theta)\cos(\theta) = \sin(2\theta)$$

$$\Delta x = \frac{2 v_{x,0} v_{y,0}}{g}$$

$$\Delta x = \frac{\left|\vec{v}_0\right|^2 \sin(2\theta)}{g}$$



Group Work

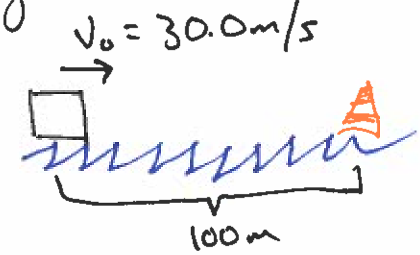
- Plan
  - 20 minutes: Work in groups on example problems
  - 10 minutes: Neatly write up solution
  - ?? minutes: Look at other groups' solutions
- Goals
  - Work with others
  - Communicate process in writing
  - Ask and get answers to questions as they come up
  - Consider the grader's perspective

- Have tables
- Look at it yourself before talking together
- Only got to work on one problem, maybe not the one you learned from
- When you look at others, see question without answer first
- Random is fun!

Physics 101 - Honors

"Lecture" 7 9/11/23

☆ A speed boat moving at 30.0 m/s approaches a no-wake buoy 100m ahead. The pilot slows the boat with a constant acceleration of $-3.5\,m/s^2$. How long does it take the boat to reach the buoy? What is the speed of the boat when it gets there?



The distance the boat is from the buoy during its constant deceleration is given by the kinematic equation

$$x(t) = \tfrac{1}{2}at^2 + V_0 t + x_0 .$$

Using a coordinate system where $x_0 = 0\,m$ and the known values of $V_0 = 30.0\,m/s$ and $a = -3.5\,m/s^2$, the time is given by

$$100\ m = \tfrac{1}{2}\cdot(-3.5\,m/s^2)\,t^2 + (30.0\,m/s)\,t$$

$$0 = -1.75\,\tfrac{m}{s^2}\,t^2 + 30.0\,\tfrac{m}{s}\,t - 100\,m,$$

which is a quadratic equation in t with solutions given by the quadratic equation

$$t = \frac{-30.0 \pm \sqrt{(30)^2 - 4\cdot 1.75\cdot 100}}{-3.5} = 4.54s \text{ and } 12.6s$$

The first solution will happen first so it takes the boat

$$\boxed{t = 4.54s}$$

to slow down.

After this amount of time, the boat's speed is

$$v(t) = at + V_0 = -3.5\,\tfrac{m}{s^2}\cdot 4.54\,s + 30.0\,\tfrac{m}{s}$$

$$\boxed{v(t) = 14.1\,m/s.}$$

☆ The position of a particle as a function of time is given by $x(t) = \sin(t)$. Find the instantaneous velocity and acceleration as functions of time. Determine the average velocity and acceleration over the period $t=0$ to $t=2\pi$. Draw diagrams showing the instantaneous ~~and average veloci~~ velocity and acceleration as functions of time.

The velocity is the time derivative of the position, so

$$v(t) = \frac{d}{dt}x(t) = \frac{d}{dt}\sin(t) = \cos(t).$$

The acceleration is the derivative of velocity, so

$$a(t) = \frac{d}{dt}v(t) = \frac{d}{dt}\cos(t) = -\sin(t).$$

The average velocity from $t=0$ to $t=2\pi$ is

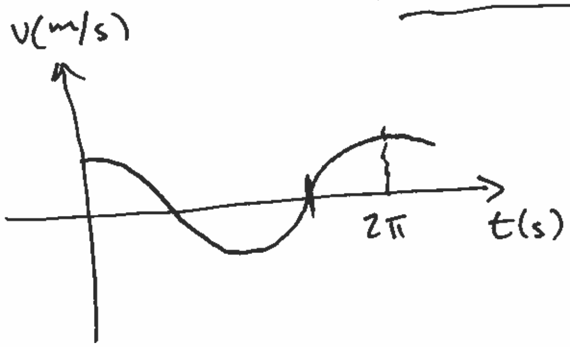
$$v_{ave} = \frac{x(2\pi) - x(0)}{2\pi} = \frac{\sin(2\pi) - \sin(0)}{2\pi} = \frac{0-0}{2\pi} = 0 \text{ m/s}$$

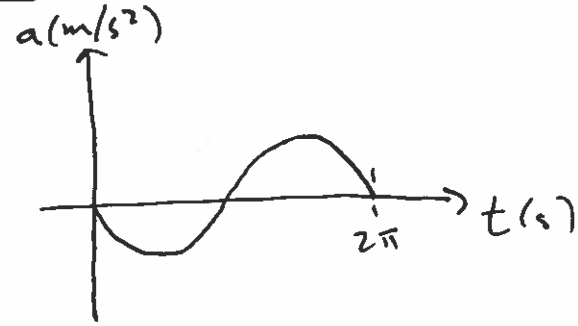
$$\boxed{v_{ave} = 0 \text{ m/s}}$$

and the average acceleration is

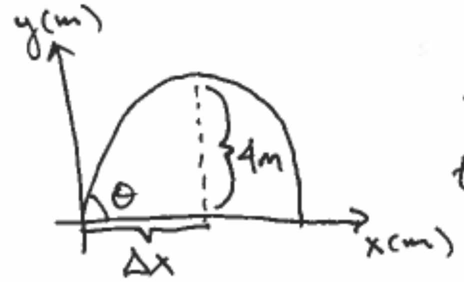
$$a_{ave} = \frac{v(2\pi) - v(0)}{2\pi} = \frac{\cos(2\pi) - \cos(0)}{2\pi} = \frac{1-1}{2\pi}$$

$$\boxed{a_{ave} = 0 \text{ m/s}^2}$$





★ A mountain lion can jump to a vertical height of 4 m when leaving the ground at a 45° angle. At what speed does it need to leave the ground to make this jump? How far does it travel horizontally by the time it reaches this height?



At the top of its leap, the mountain lion's velocity is 0 m/s, so the time it take to reach that height is

$$0 = -gt + v_{y,0}$$

$$t = v_{y,0}/g.$$

Using a coordinate system where $y_0 = 0$, we can substitute this in for the equation for the y displacement

$$y(t) = -\tfrac{1}{2} g t^2 + v_{y,0} t$$

$$y(t) = -\tfrac{1}{2} g \left(\frac{v_{y,0}}{g}\right)^2 + v_{y,0} \frac{v_{y,0}}{g}$$

$$y(t) = -\frac{1}{2} \frac{v_{y,0}^2}{g} + \frac{v_{y,0}^2}{g}$$

$$y(t) = \frac{1}{2} \frac{v_{y,0}^2}{g}.$$

Then

$$v_{y,0}^2 = 2y(t)g \quad \text{or} \quad v_{y,0} = \sqrt{2y(t)g}.$$

Using $y(t) = 4\,m$ and $g = 9.8\,m/s^2$

$$v_{y,0} = 8.9\ m/s.$$

Since the lion left at a 45° angle

$$v_{y,0} = |\vec{v}_0| \sin(45°)$$

so the initial speed needs to be

$$|\vec{v}_0| = \frac{8.9\,m/s}{\sin(45°)} = (8.9\,m/s)(\sqrt{2})$$

$$|\vec{v}_0| = 12.6\,m/s.$$

Using the Range equation, the lion has travelled

$$\Delta x = \tfrac{1}{2} R = \frac{|v_0|^2 \sin(2\theta)}{2g} = \frac{(6.3\,m/s)^2 \sin(90°)}{2 \cdot 9.8\,m/s^2}$$

$$\boxed{\Delta x = 8.1\,m}$$