Classical Mechanics
Lecture 2

Today's Concepts:

a) Vectors

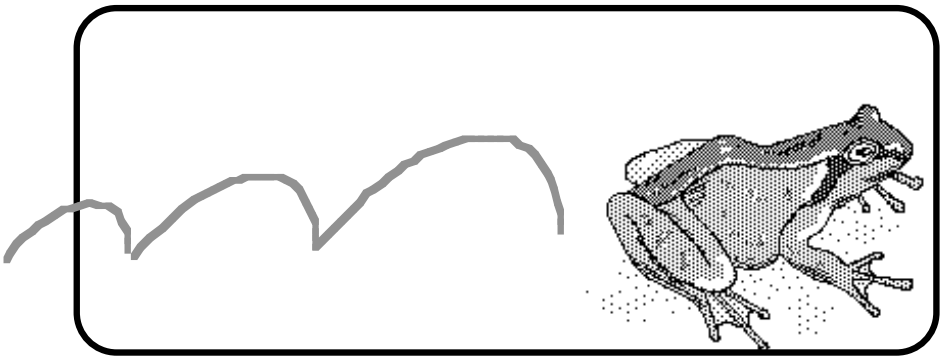
b) Projectile motion

c) Reference frames

Name _____ Date (YY/MM/DD) _____/_____/_____

SFU e-mail_____@sfu.ca Section_____ Group_____

UNIT 6: GRAVITY AND PROJECTILE MOTION

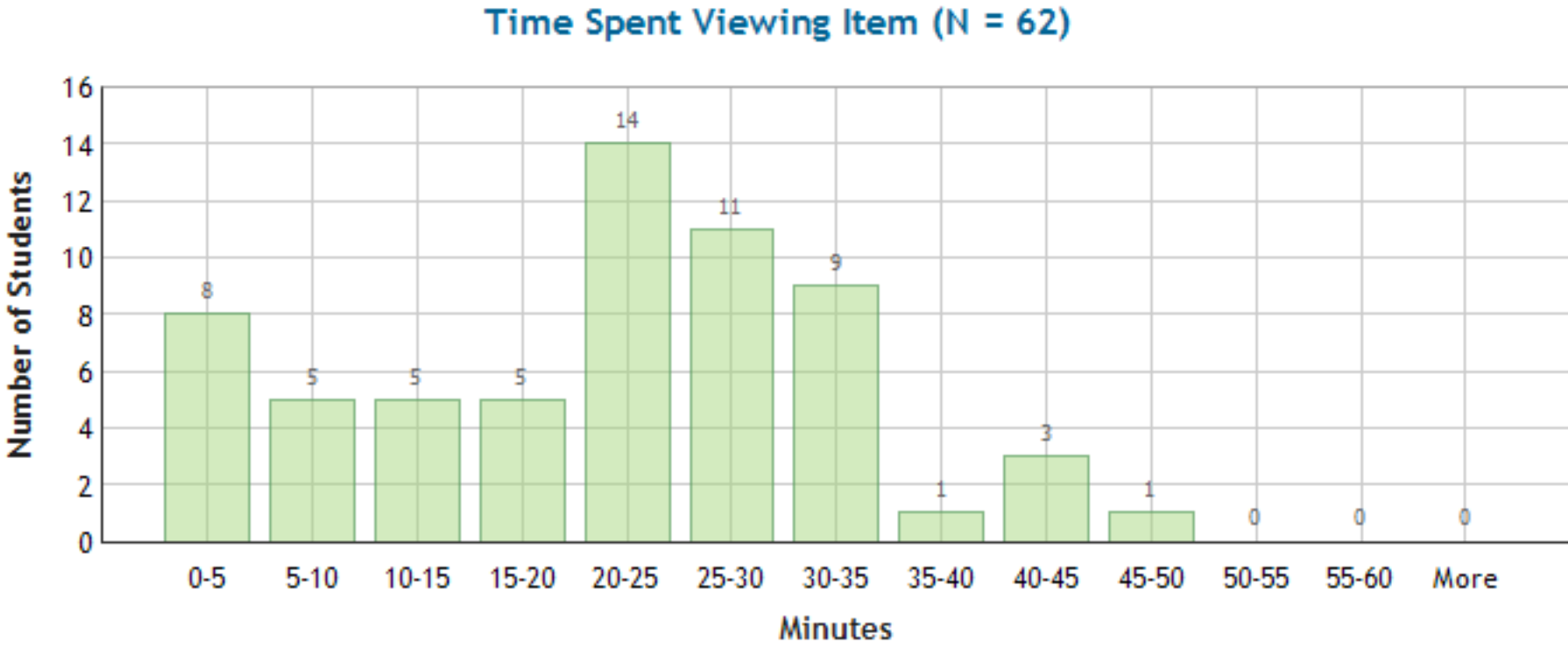


Science is a game... with reality... In the presentation of a scientific problem, the other player is the good Lord. He has... devised the rules of the game – but they are not completely known, half of them are left for you to discover or deduce... the uncertainty is how many of the rules God himself has permanently ordained, and how many apparently are caused by your own mental inertia, while the solution generally becomes possible only through freedom from its limitations. This is perhaps the most exciting thing in the game. For here you strive against the imaginary boundary between yourself and the Godhead – a boundary that perhaps does not exist.

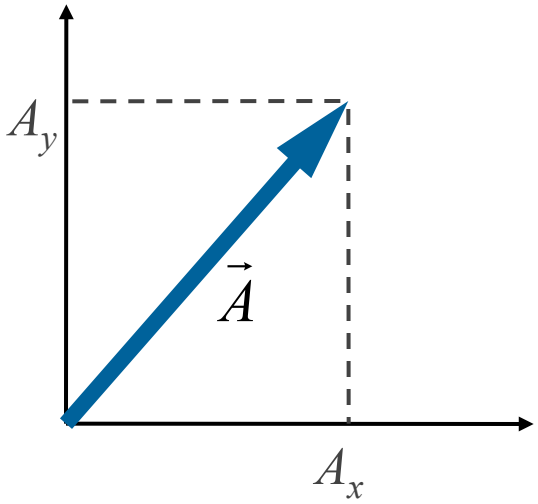
Erwin Schrödinger

OBJECTIVES


smartPhysics
mats@illinois.edu | account | log out
Instructor Links
Unit: Vectors and 2-D Kinematics
After this date:
Before this date:


Time Spent Viewing Item (N = 62)
Number of Students
16
14
12
10
8
6
4
2
0
8
5
5
5
14
11
9
1
3
1
0
0
0
0-5
5-10
10-15
15-20
20-25
25-30
30-35
35-40
40-45
45-50
50-55
55-60
More
Minutes

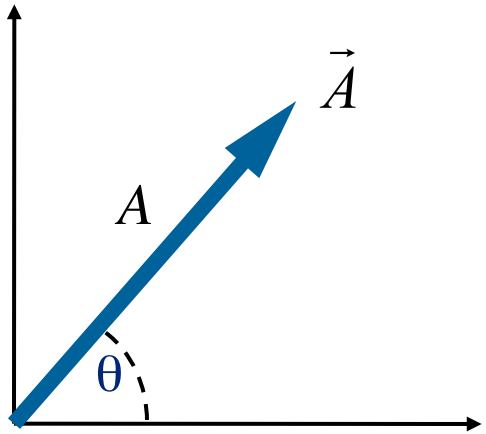
Vectors



Think of a vector as an arrow.
(An object having both magnitude and direction)

The object is the same no matter how we chose to describe it

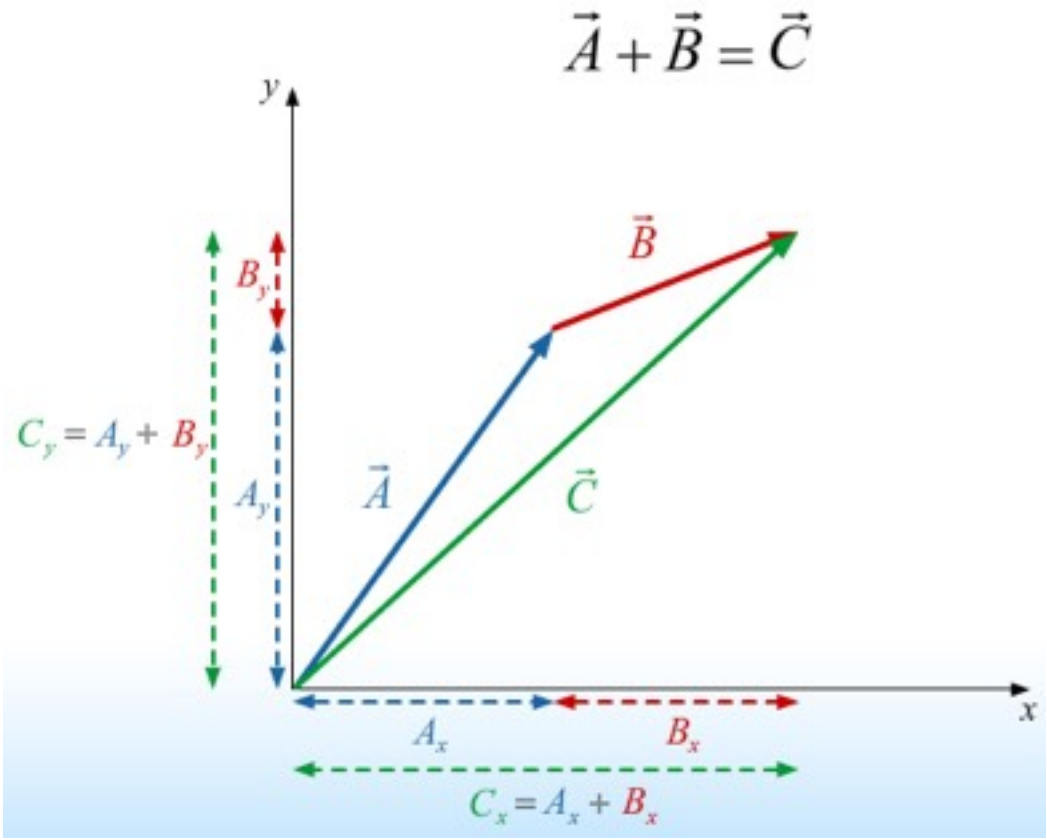
Vectors



Think of a vector as an arrow.
(An object having both magnitude and direction)

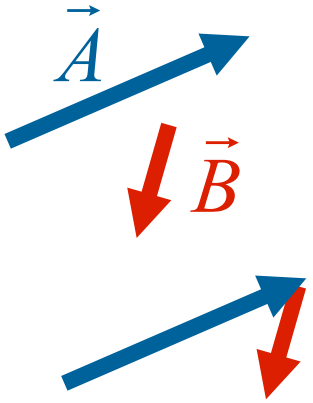
The object is the same no matter how we chose to describe it

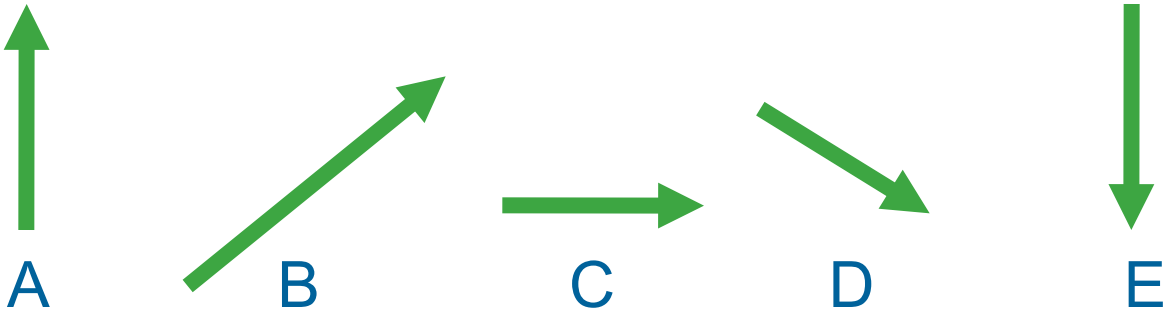
Vector Addition



Clicker Question

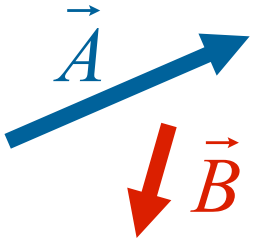
Vectors $\vec{A}$ and $\vec{B}$ are shown to the right.
Which of the following best describes $\vec{A} + \vec{B}$

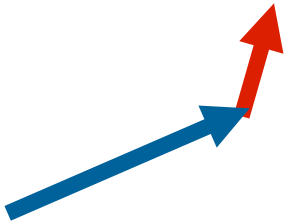


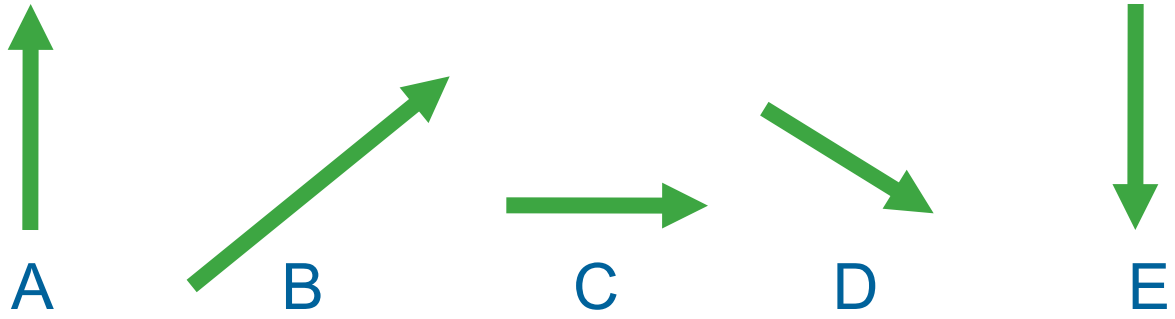


Clicker Question

Vectors $\vec{A}$ and $\vec{B}$ are shown to the right.
Which of the following best describes $\vec{A} - \vec{B}$

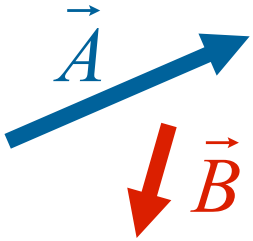


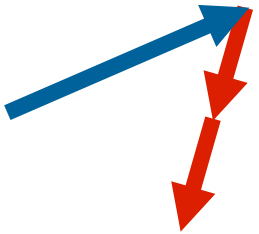


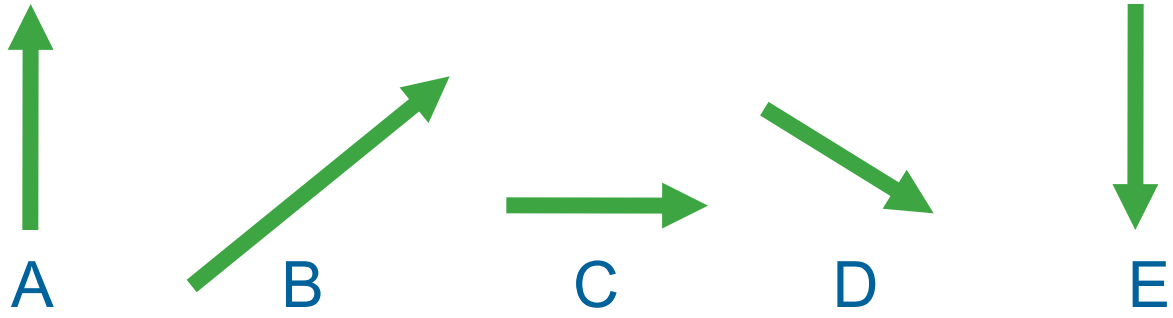


Clicker Question

Vectors $\vec{A}$ and $\vec{B}$ are shown to the right.
Which of the following best describes $\vec{A} + 2\vec{B}$

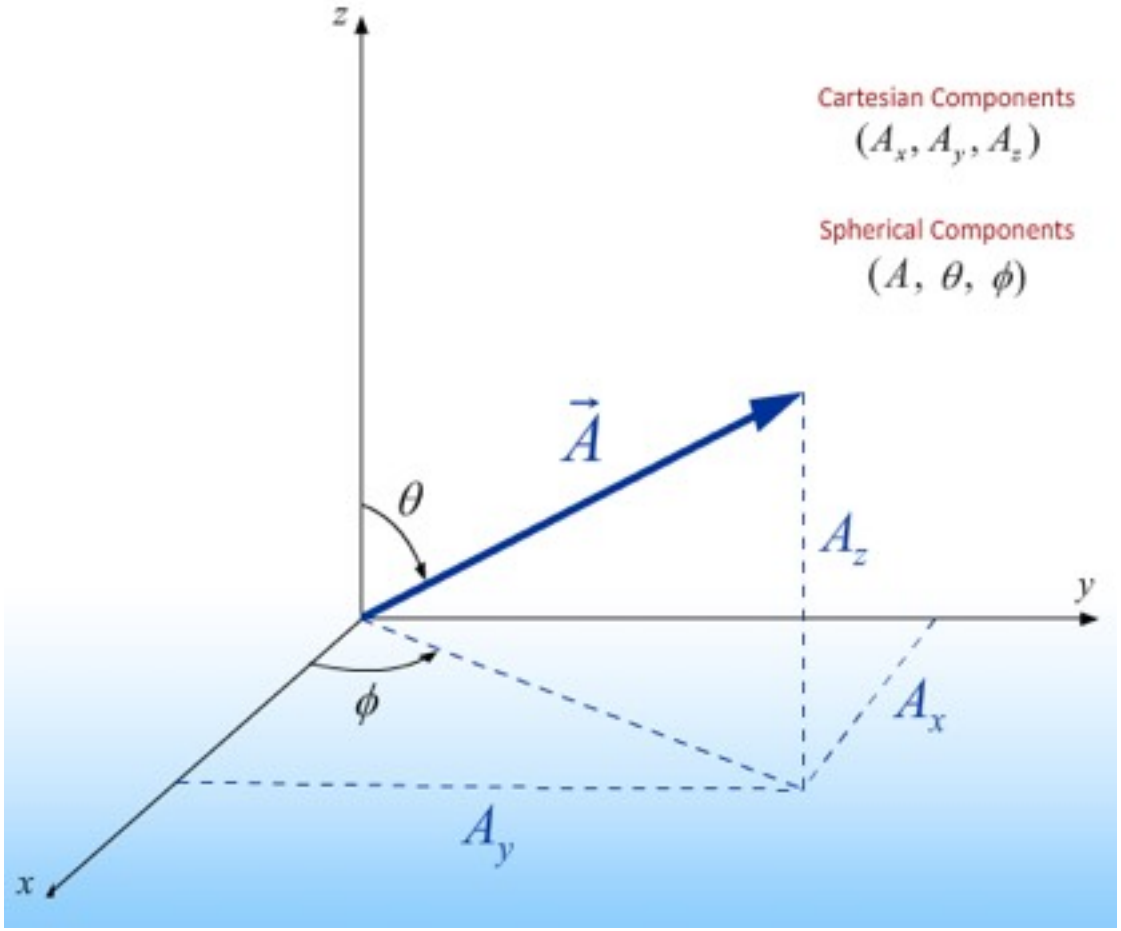




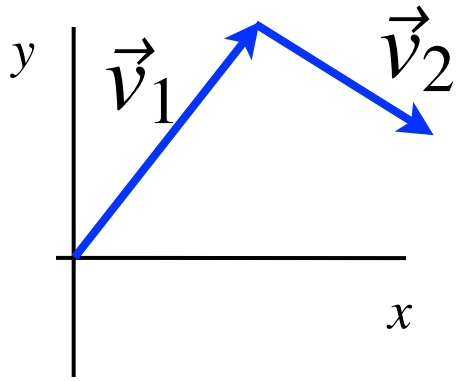


Vectors in 3D

A vector can be defined in 2 or 3 (or even more) dimensions:

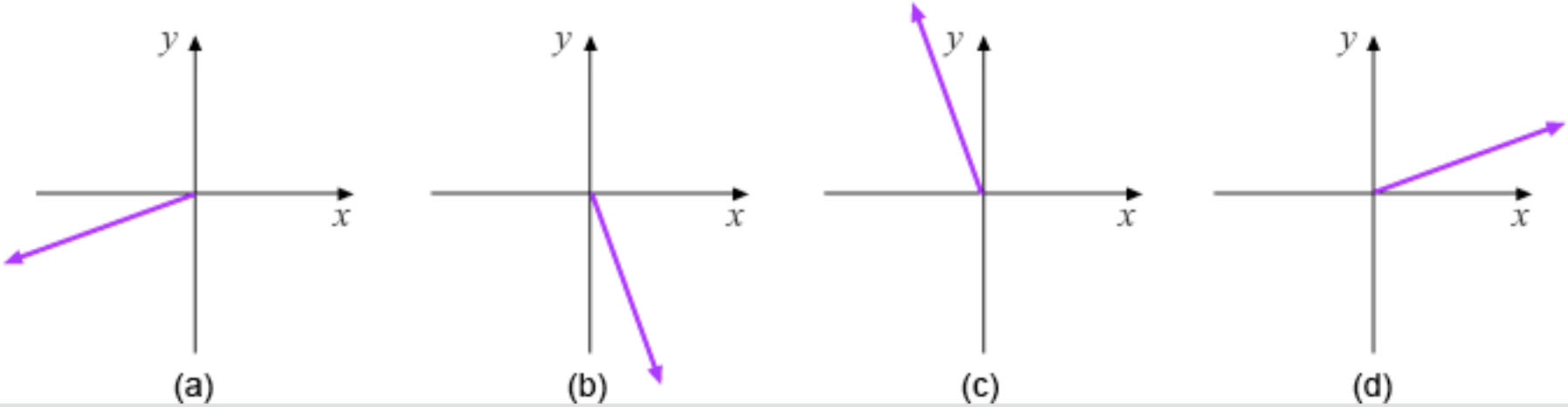


In the graph shown to the right, $\boldsymbol{v}_1$ is the velocity vector for a particle in two-dimensional motion at time t = 0, while $\boldsymbol{v}_2$



is the velocity vector for that particle at time t = 1 s.

Which of the following graphs represent a_{avg}, the average acceleration vector of the particle over the time interval from t = 0



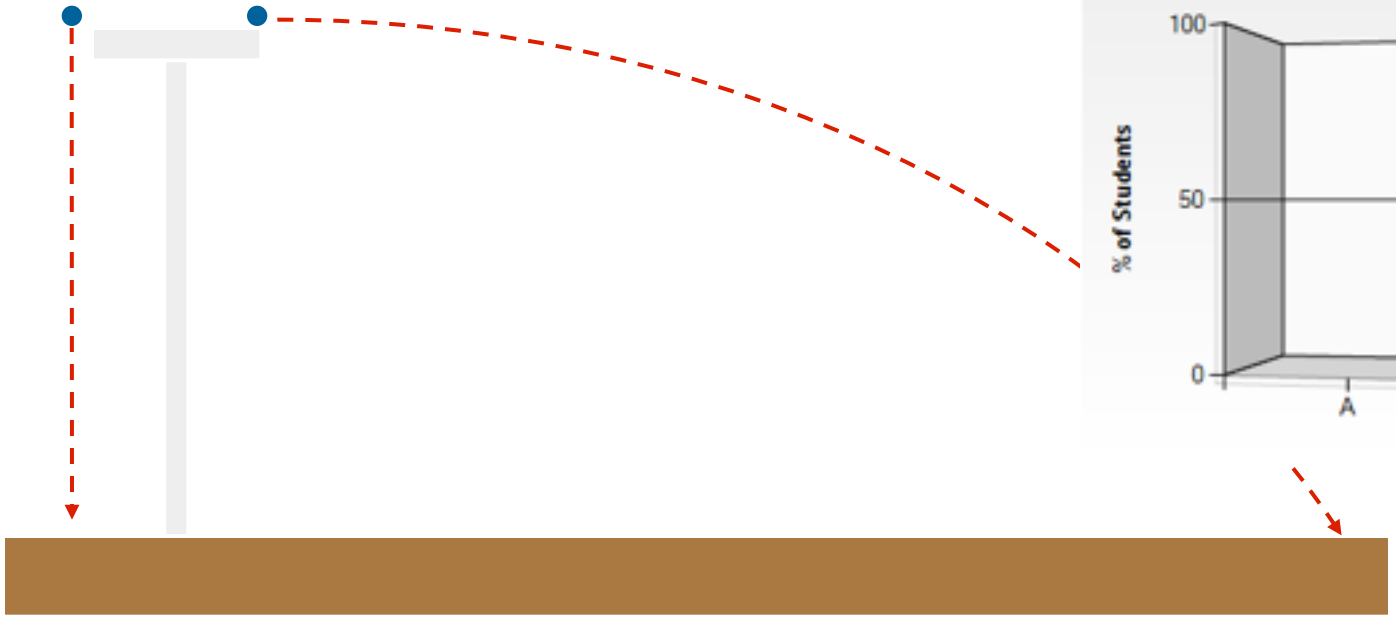
Kinematics in 3D

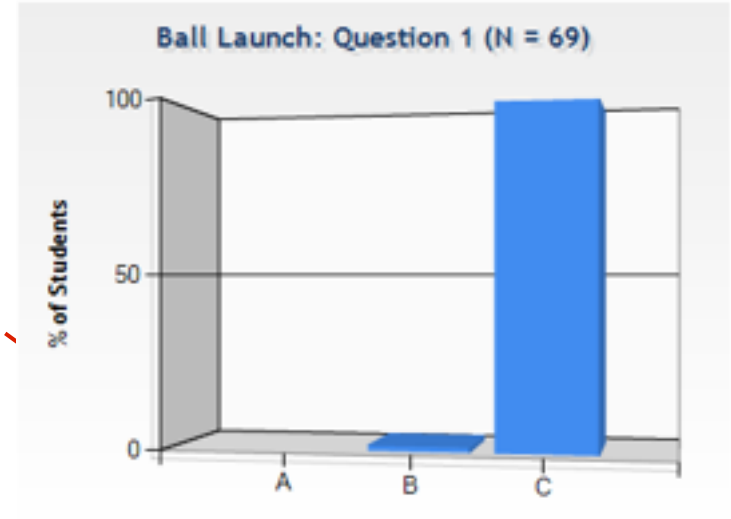
Kinematic Equations with Constant Acceleration

x-component	y-component	z-component
$a_x = \text{constant}$	$a_y = \text{constant}$	$a_z = \text{constant}$
$v_x = v_{o_x} + a_x t$	$v_y = v_{o_y} + a_y t$	$v_z = v_{o_z} + a_z t$
$x = x_o + v_{o_x} t + \frac{1}{2} a_x t^2$	$y = y_o + v_{o_y} t + \frac{1}{2} a_y t^2$	$z = z_o + v_{o_z} t + \frac{1}{2} a_z t^2$

Checkpoint 1

A physics demo launches one marble horizontally while at the same instant dropping a second marble straight down. Which one hits the ground first?





A) The launched marble hits first.

B) The dropped marble hits first.

C) They both hit at the same time.

Projectile Motion

Horizontal

$$a_x = 0$$

$$v_x = v_{o_x}$$

$$x = x_o + v_{o_x} t$$

Vertical

$$a_y = -g$$

$$v_y = v_{o_y} - gt$$

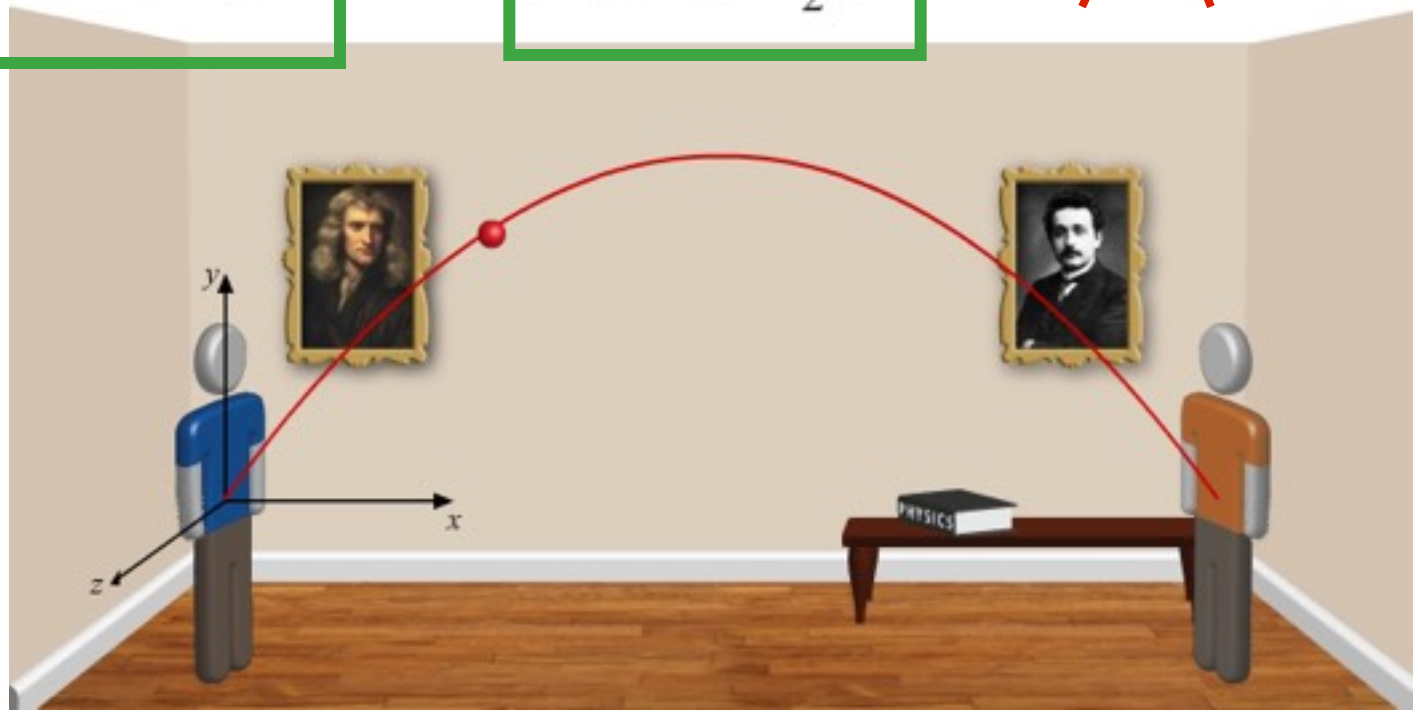
$$y = y_o + v_{o_y} t - \frac{1}{2} g t^2$$

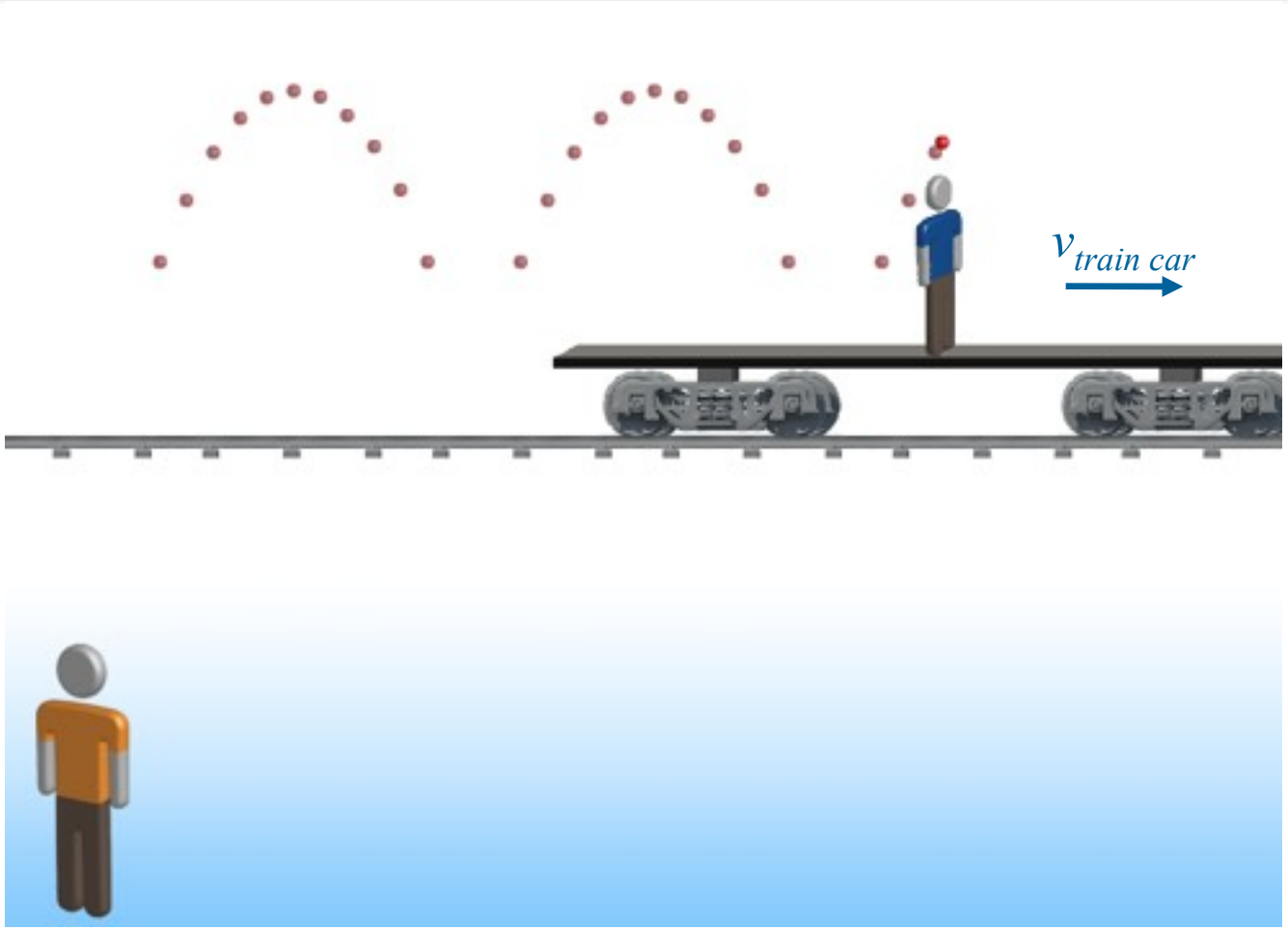
Boring

$$a_z = 0$$

$$v_z = 0$$

$$z = z_o$$

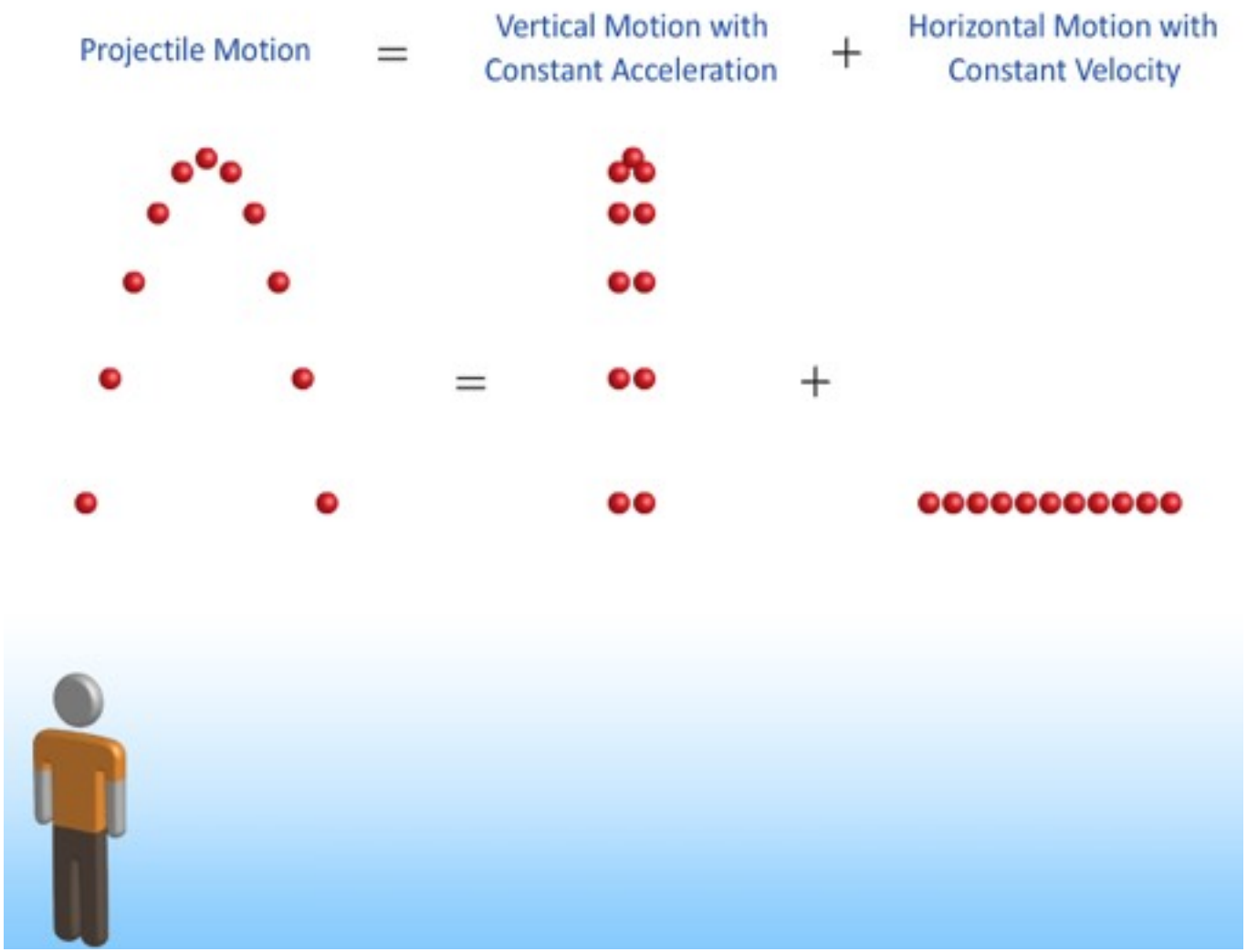




Time spent in the air depends on the maximum height

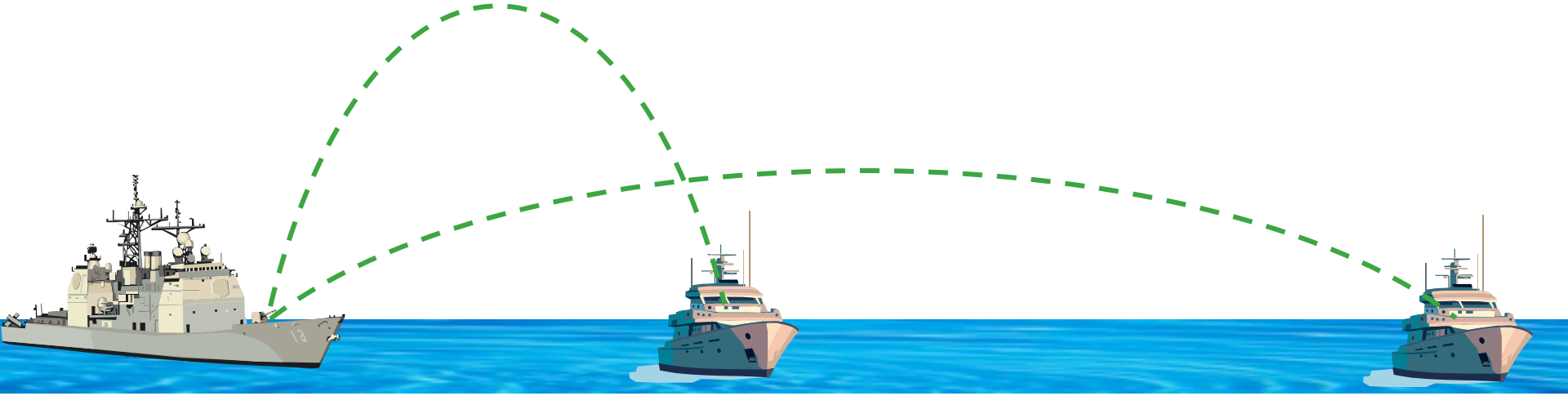
Maximum height depends on the initial vertical velocity

Projectile Motion & Frames of Reference



Checkpoint 2

A destroyer simultaneously fires two shells with the same initial speed at two different enemy ships. The shells follow the trajectories shown. Which ship gets hit first.



A) Enemy 1

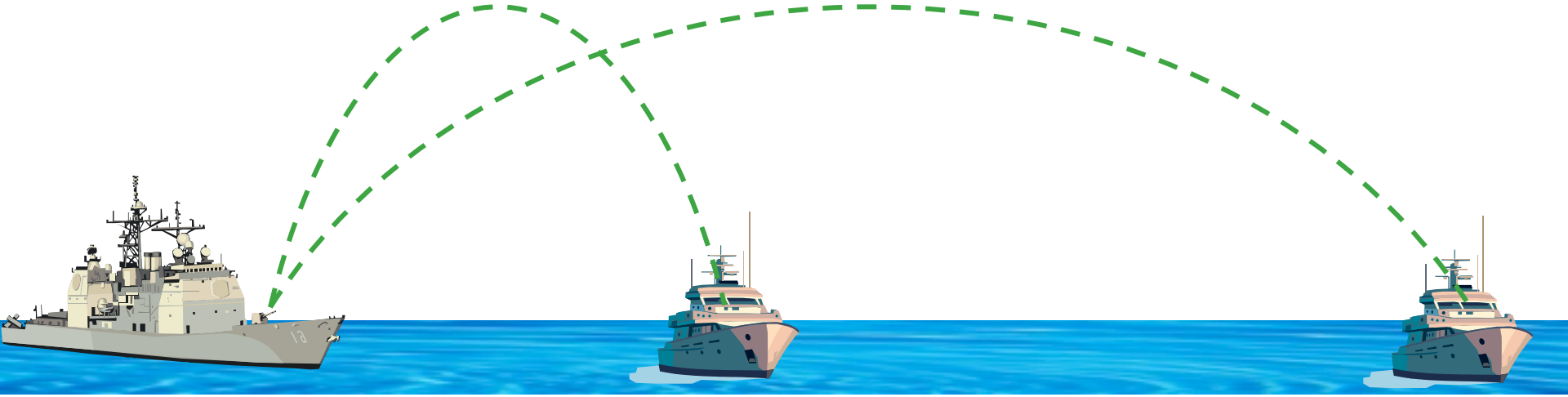
B) Enemy 2

C) They are both hit at the same time

65% of you got this one right…let's try again

Checkpoint 3

A destroyer fires two shells with different initial speeds at two different enemy ships. The shells follow the trajectories shown. Which enemy ship gets hit first?



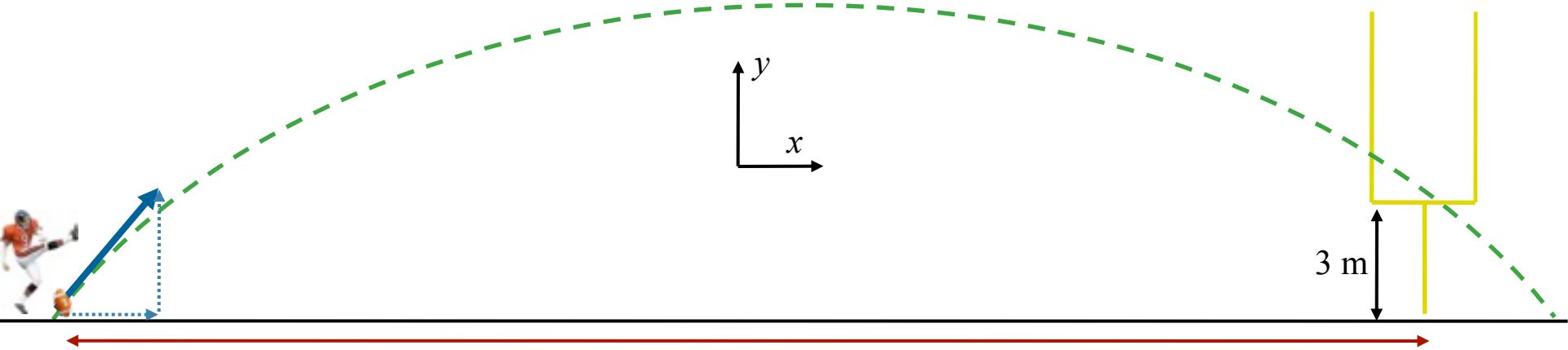
Destroyer Enemy 1 Enemy 2

A) Enemy 1
B) Enemy 2
C) They are both hit at the same time

78% of you got this one right…let's try again

Field Goal Example

A field goal kicker can kick the ball 30 m/s at an angle of 30 degrees w.r.t. the ground. If the crossbar of the goal post is 3m off the ground, from how far away can he kick a field goal?



y-direction

$v_{oy} = v_o \sin(30^o) = 15$ m/s

$y = y_o + v_{oy}t + \frac{1}{2} at^2$

3 m $= 0$ m $+ (15$ m/s$)\, t - \frac{1}{2} (9.8$ m/s$^2)\, t^2$

$t = 2.8$ s or $t = 0.22$ s.

x-direction

$v_{ox} = v_o \cos(30^o) = 26$ m/s

$D = x_o + v_{ox}\, t + \frac{1}{2} at^2$

$= 0$ m $+ (26$ m/s$)(2.8$ s$) + 0$ m/s$^2\, (2.8$ s $)^2$

$= 72.8$ m

Video of 70-yard Field Goal

1) If you toss a ball up into the air, which of the following tables would accurately describe its velocity and acceleration.

A)

	Going up	At the top	Going down
Velocity	+	0	–
Acceleration	+	0	–

B)

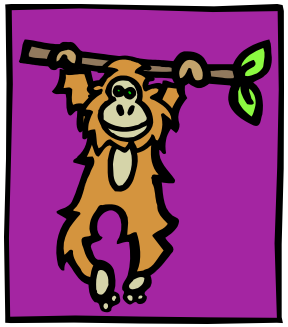
	Going up	At the top	Going down
Velocity	+	0	–
Acceleration	–	–	–

C)

	Going up	At the top	Going down
Velocity	+	0	–
Acceleration	–	0	+

Monkey Troubles

You are a vet trying to shoot a tranquilizer dart into a monkey hanging from a branch in a distant tree. You know that the monkey is very nervous, and will let go of the branch and start to fall as soon as your gun goes off. In order to hit the monkey with the dart, where should you point the gun before shooting?

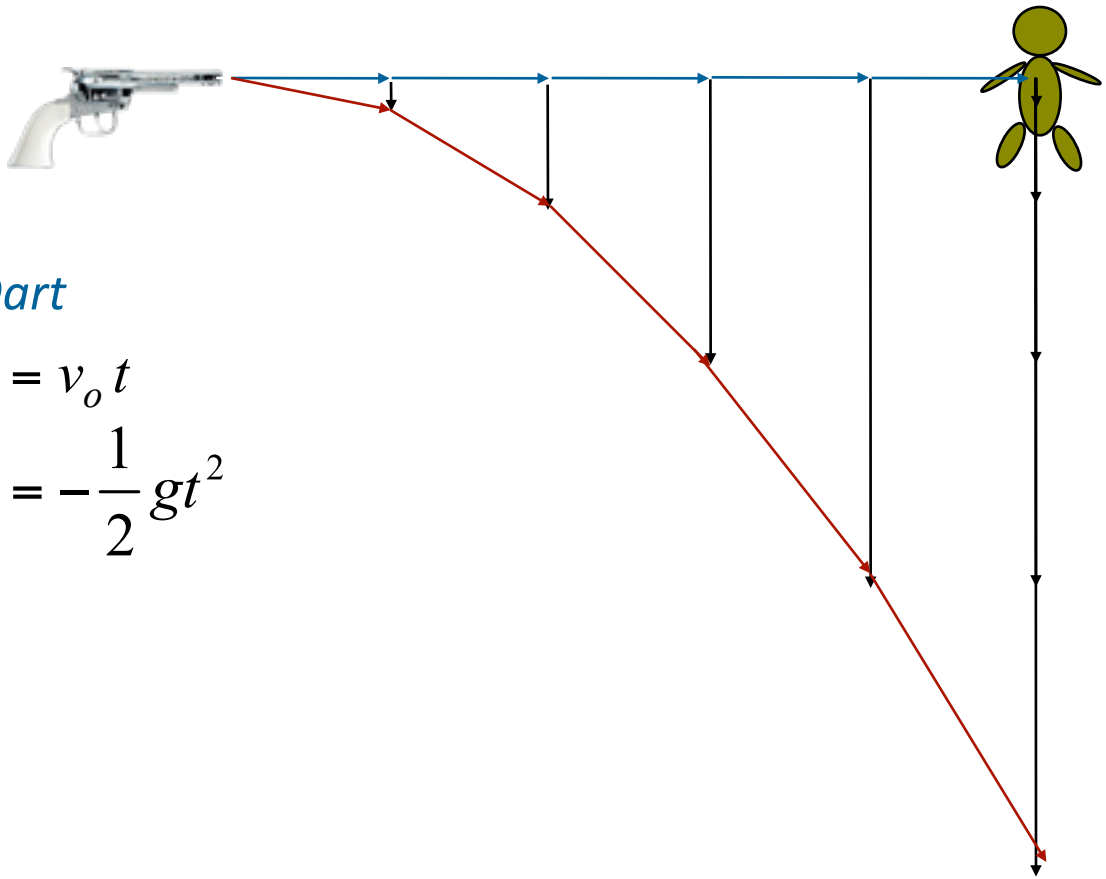


A) Right at the monkey

B) Below the monkey

C) Above the monkey

Shooting the Monkey…



Dart

$$x = v_o t$$

$$y = -\frac{1}{2} g t^2$$

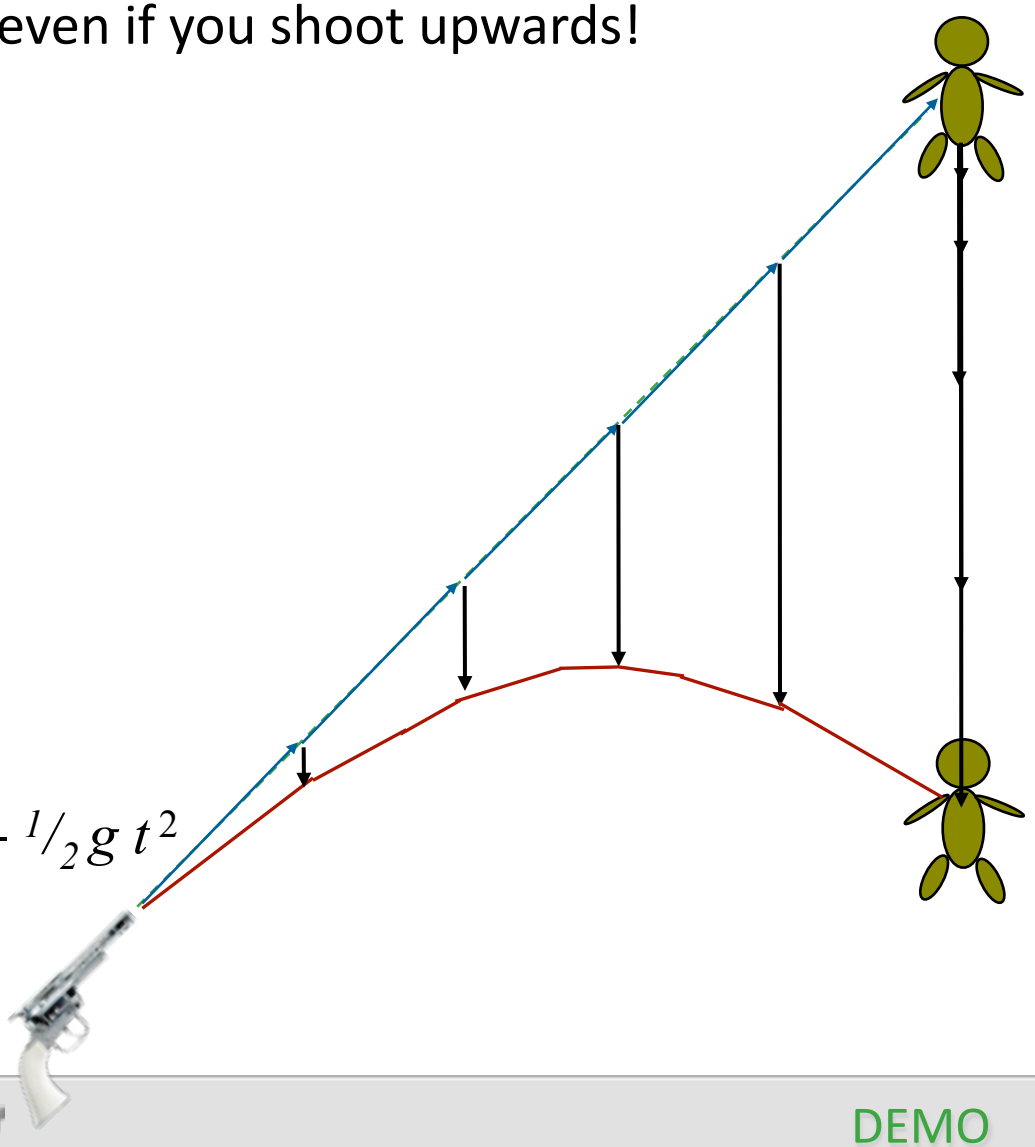
Monkey

$$x = x_o$$

$$y = -\frac{1}{2} g t^2$$

Shooting the Monkey…

Still works even if you shoot upwards!



$y = y_o - {}^1/_2 g\, t^2$

$y = v_{oy}\, t - {}^1/_2 g\, t^2$

Dart hits the monkey

DEMO

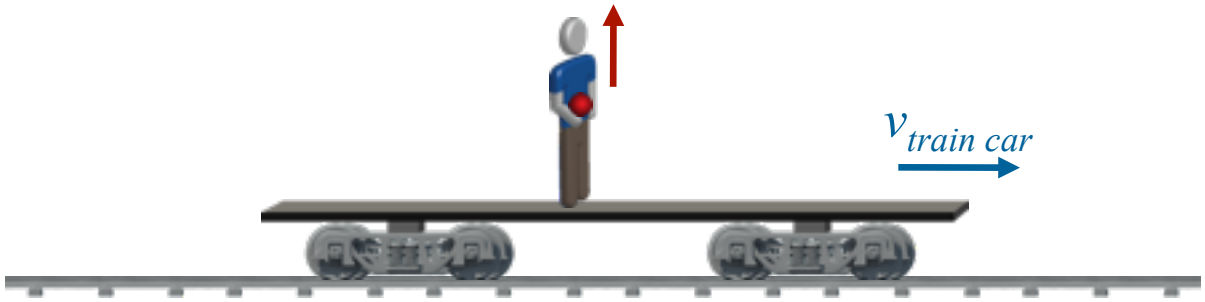
Train Demo Clicker Question

A flatbed railroad car is moving along a track at constant velocity.
A passenger at the center of the car throws a ball straight up.
Neglecting air resistance, where will the ball land?

A) Forward of the center of the car

B) At the center of the car ← correct

C) Backward of the center of the car



Ball and car start with same x position and x velocity,
Since $a = 0$ they always have same x position.

Demo - train