DEVIL PHYSICS
THE BADDEST CLASS ON CAMPUS

AP PHYSICS

Kinematics Is The Study of _____ ?

LSN 2-7: FALLING OBJECTS

Questions From Reading Activity?

- Anyone still not know how to do a Frayer diagram?

Big Idea(s):

- Big Idea 3: The interactions of an object with other objects can be described by forces.
- Big Idea 4: Interactions between systems can result in changes in those systems.

Enduring Understanding(s):

- 3.A: All forces share certain common characteristics when considered by observers in inertial reference frames.
- 4.A: The acceleration of the center of mass of a system is related to the net force exerted on the system, where

$$\vec{a} = \frac{\sum \vec{F}}{m}$$

Essential Knowledge(s):

- 3.A.1: An observer in a particular reference frame can describe the motion of an object using such quantities as position, displacement, distance, velocity, speed, and acceleration.
  - Displacement, velocity, and acceleration are all vector quantities.
  - Displacement is change in position. Velocity is the rate of change of position with time. Acceleration is the rate of change of velocity with time. Changes in each property are expressed by subtracting initial values from final values.
  - A choice of reference frame determines the direction and the magnitude of each of these quantities.

Essential Knowledge(s):

- 4.A.1: The linear motion of a system can be described by the displacement, velocity, and acceleration of its center of mass.

Essential Knowledge(s):

- 4.A.2: The acceleration is equal to the rate of change of velocity with time, and velocity is equal to the rate of change of position with time.
  - The acceleration of the center of mass of a system is directly proportional to the net force exerted on it by all objects interacting with the system and inversely proportional to the mass of the system.
  - Force and acceleration are both vectors, with acceleration in the same direction as the net force.

Learning Objective(s):

- (3.A.1.1): The student is able to express the motion of an object using narrative, mathematical, and graphical representations.
- (3.A.1.2): The student is able to design an experimental investigation of the motion of an object.

Learning Objective(s):

- (3.A.1.3): The student is able to analyze experimental data describing the motion of an object and is able to express the results of the analysis using narrative, mathematical, and graphical representations.

Learning Objective(s):

- (4.A.2.1): The student is able to make predictions about the motion of a system based on the fact that acceleration is equal to the change in velocity per unit time, and velocity is equal to the change in position per unit time.

Learning Objective(s):

- (4.A.2.3): The student is able to create mathematical models and analyze graphical relationships for acceleration, velocity, and position of the center of mass of a system and use them to calculate properties of the motion of the center of mass of a system.

Video: Force of Gravity

Let’s Experiment (i.e. drop stuff)

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- What did we learn?
  - Things fall at the same rate = gravitational acceleration is constant
  - The acceleration is approximately equal to 9.81 m/s^2

Galileo

- At a given location on the Earth and in the absence of air resistance, all objects fall with the same constant acceleration.
- This is the acceleration due to gravity, g.
- $g \approx 9.80\ m/s^2$ or $32\ ft/s^2$
- The acceleration due to gravity is always toward the center of the earth.

Gravity Varies

Location	Elevation	g
New York	0	9.803
San Francisco	100	9.800
Denver	1650	9.796
Pike's Peak	4300	9.789
Equator	0	9.780
North Pole	0	9.832

Gravity Varies

- Why does gravity vary?

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$$F = G\frac{M_1 m_2}{r^2}$$

Gravity Varies

- Why does gravity vary?

$$F = G\frac{M_1 m_2}{r^2}$$

$$F = G\frac{M_1 m_2}{r^2}$$

$$F = ma$$

$$m_2 a = G\frac{M_1 m_2}{r^2}$$

$$a = G\frac{M_1}{r^2}$$

So What Does This All Mean?

(i.e., Why should I care?)

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- All of the equations we developed for horizontal motion can be used for vertical motion
  - Substitute g = 9.8**o** m/s² for a
  - Change ***x*** to ***y*** to represent vertical displacement
  - You now have to decide which direction is positive (up or down) and which is negative
  - Make sure that your value for g (positive or negative) matches the direction

So What Does This All Mean?

(i.e., Why should I care?)

Horizontal Equations

$$v = v_0 + at$$

$$x = x_0 + v_0 t + \tfrac{1}{2} a t^2$$

$$v^2 = v_0^2 + 2a(x - x_0)$$

$$\bar{v} = \frac{v + v_0}{2}$$

Vertical Equations

$$v = v_0 + gt$$

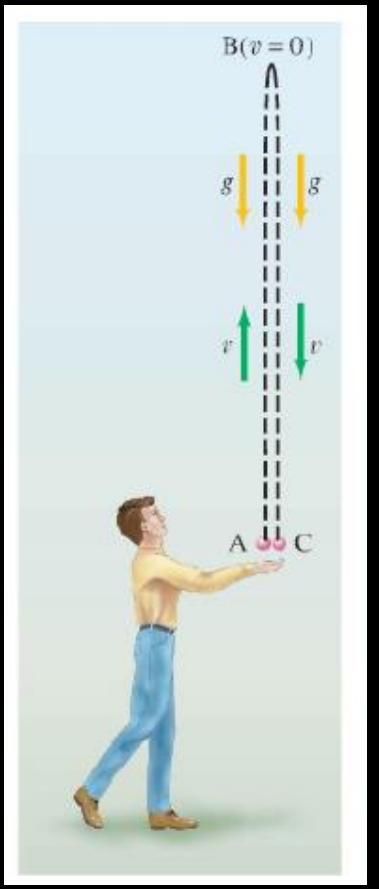
$$y = y_0 + v_0 t + \tfrac{1}{2} g t^2$$

$$v^2 = v_0^2 + 2g(y - y_0)$$

$$\bar{v} = \frac{v + v_0}{2}$$

Let's Try Some Problems

- A ball is thrown up into the air at 25.0 m/s.
  - How long before it stops?



Let's Try Some Problems

- A ball is thrown up into the air at 25.0 m/s.
  - How long before it stops?
    - *2.55s*
  - What will be its speed when it returns?

$$v = v_0 + gt$$

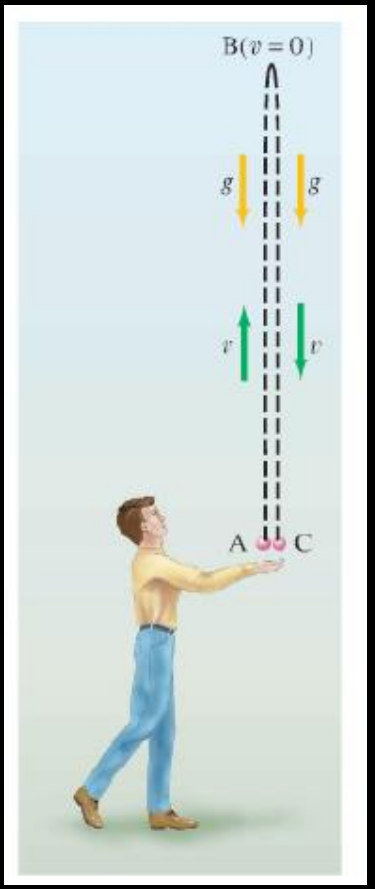
$$v = 0$$

$$0 = v_0 + gt$$

$$-gt = v_0$$

$$t = \frac{v_0}{-g}$$

$$t = \frac{25.0}{-(-9.81)} = 2.55s$$



Let's Try Some Problems

- A ball is thrown up into the air at 25.0 m/s.
  - How long before it stops?
    - *2.55s*
  - What will be its speed when it returns?
    - -25 m/s
  - How long does it take to reach 8m high?

$$v = v_0 + gt$$

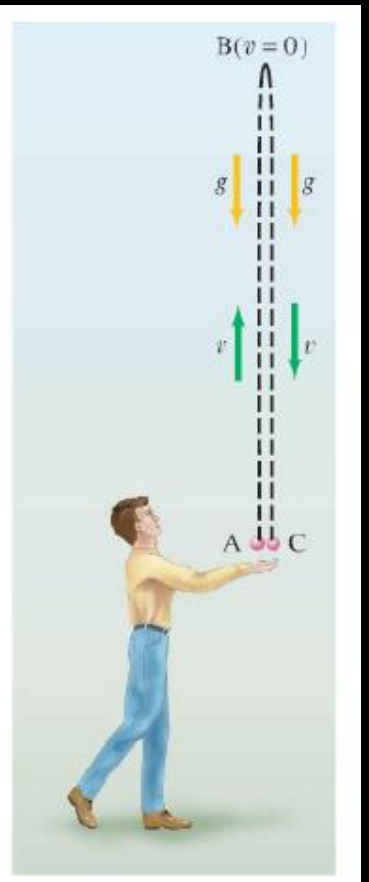
$$v_0 = 25.0 m/s$$

$$t = 2x2.55 = 5.10s$$

$$v = v_0 + gt$$

$$v = 25.0 + (-9.81)(5.10)$$

$$v = 25.0 - 50.0 = -25.0$$



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- A ball is thrown up into the air at 25.0 m/s.
  - How long before it stops?
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  - How long does it take to reach 8m high?

$$y_0 = 0$$

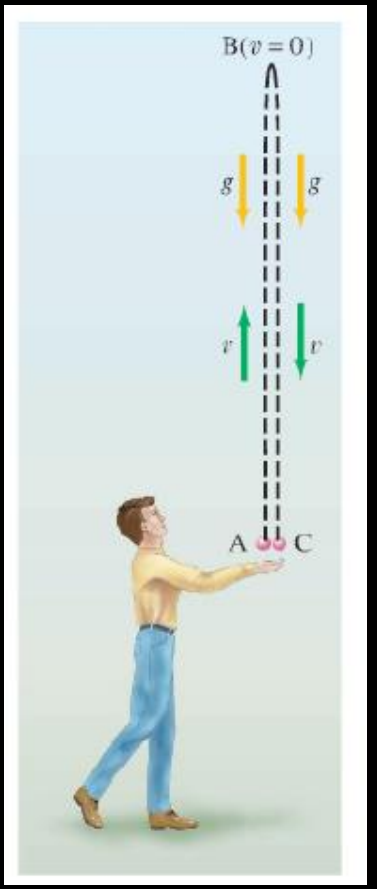
$$y = 8m$$

$$y = y_0 + v_0 t + 1/2\, g t^2$$

$$8 = 25t + 1/2\,(-9.81)t^2$$

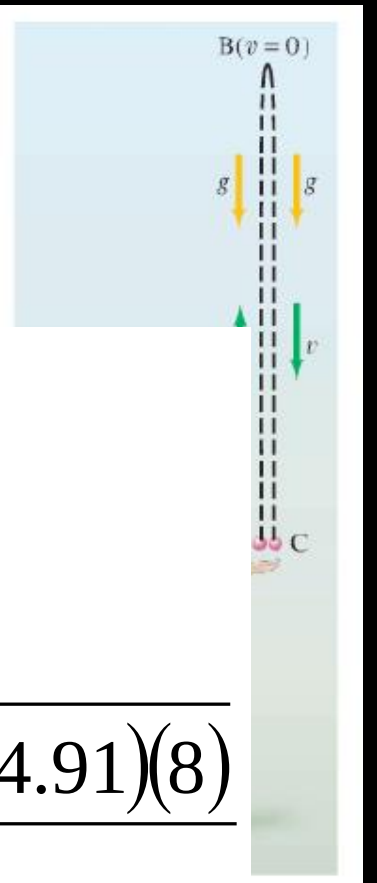
$$8 = 25t - 4.91t^2$$

$$4.91t^2 - 25t + 8 = 0$$



Let's Try Some Problems

- A ball is thrown up into the air at 25.0 m/s.
  - How long before it stops?
    - *2.55s*
  - What will be its speed when it returns?
    - -25 m/s
  - How long does it take to reach 8m high?
    - Which one?



$$4.91t^2 - 25t + 8 = 0$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

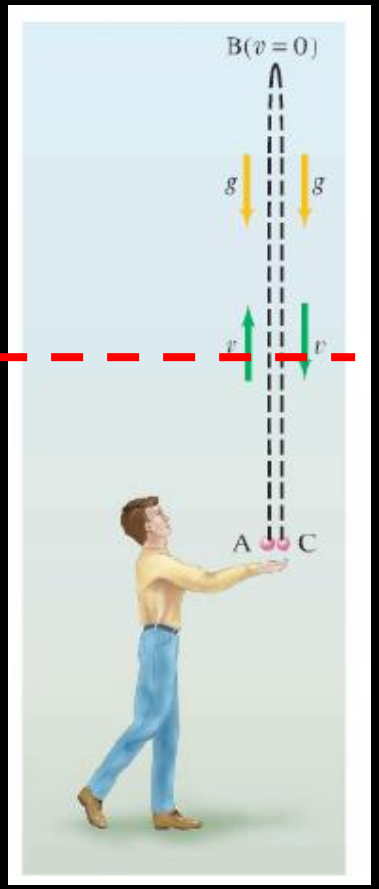
$$t = \frac{25 \pm \sqrt{(-25)^2 - 4(4.91)(8)}}{2(4.91)}$$

$$t = \frac{25 \pm \sqrt{625 - 317}}{9.81}$$

$$t = \frac{25 \pm 17.5}{9.81} = 4.33s, 0.76s$$

Let's Try Some Problems

- A ball is thrown up into the air at 25.0 m/s.
  - How long before it stops?
    - *2.55s*
  - What will be its speed when it returns?
    - -25 m/s
  - How long does it take to reach 8m high?
    - Both, one going up and one coming down



$$t = 4.33s, 0.76s$$

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QUESTIONS?

Homework

#33-41

New penalty for not completing homework assignments