DEVIL PHYSICS

THE BADDEST CLASS ON CAMPUS

AP PHYSICS

2-4: ACCELERATION
2-5: MOTION AT CONSTANT ACCELERATION
2-6: SOLVING PROBLEMS

Questions From Reading Activity?

Big Idea

- Interactions between systems can result in changes in those systems.

Enduring Understanding

- 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

- 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

- 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 Objectives:

- (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 Objectives:

- (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: Velocity, Position, and Acceleration

this video is a dirty little review of basic physics topics. these videos are not meant to be stand-alone learning tools, but complementary aids to class lectures and a good textbook. enjoy.

Movie Spoiler

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

$$v = v_0 + at$$

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

$$v^2 = v_0^{\,2} + 2a\left(x - x_0\right)$$

~~Movie~~ Test Spoiler

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

$$v = v_0 + at$$

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

$$v^2 = v_0^{\,2} + 2a(x - x_0)$$

$$v_x = v_{x0} + a_x t$$

$$x = x_0 + v_{x0} t + \frac{1}{2} a_x t^2$$

$$v_x^{\,2} = v_{x0}^{\,2} + 2a_x(x - x_0)$$

Average Acceleration

- Average acceleration is the change in velocity per unit time
- It is the rate of change of velocity

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1}$$

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1}$$

Average Acceleration

- It I'm going 25 m/s and 10 seconds later I'm going 35 m/s,
  - My velocity increased 1 m/s every second
  - The rate of change was 1 m/s per second
  - My acceleration was 1 m/s²

$$\frac{m/s}{s} = \frac{m}{s^2}$$

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1}$$

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1}$$

Average Acceleration

- Velocity tells us how fast the position changes
- Acceleration tells us how fast the velocity changes

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1}$$

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1}$$

Average Acceleration

- *What does it mean when acceleration is negative?*

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1}$$

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1}$$

Average Acceleration

- *What does it mean when acceleration is negative?*
- *No, you aren't going backwards.*

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1}$$

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1}$$

Average Acceleration

- *What does it mean when acceleration is negative?*
- *The velocity is decreasing – also called deceleration.*

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1}$$

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1}$$

Average Acceleration

- Units for velocity are m/s
- Units for acceleration are:
  - Meters per second per second
  - (m/s)/s
  - m/s^2

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{m}{s}$$

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{m/s}{s}$$

$$\bar{a} = \frac{m}{s^2}$$

Air Track Exercise

- Calculate average velocity between two points
- Calculate velocity at each point
  - *Where did the average velocity occur?*
- Calculate average acceleration

Instantaneous Acceleration

- Acceleration at any given instant

$$\bar{a} = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t}$$

- What does it mean when the average and instantaneous acceleration are the same?

Instantaneous Acceleration

- What does it mean when the average and instantaneous acceleration are the same?

$$\bar{a} = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t}$$

- The acceleration is ***constant***

Instantaneous Acceleration

- What does it mean when the average and instantaneous acceleration are the same?

- The acceleration is ***constant***

$$\bar{a} = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t}$$

We will assume constant acceleration (a) for most of the work we do

Motion at Constant Acceleration

- Assume that our initial time (t_o) is zero

$$\bar{v} \equiv \frac{x - x_0}{t - t_0} \equiv \frac{x - x_0}{t}$$

$$a \equiv \frac{v - v_0}{t - t_0} \equiv \frac{v - v_0}{t}$$

Motion at Constant Acceleration

- Determine velocity after a given time period

$$a = \frac{v - v_0}{t}$$

$$at = v - v_0$$

$$at + v_0 = v$$

$$v = v_0 + at$$

Motion at Constant Acceleration

- Determine velocity after a given time period
- *You are moving at 30 m/s and you accelerate at 5 m/s² [(5m/s)/s] for 2 seconds. How fast will you then be going?*

$$a = \frac{v - v_0}{t}$$

$$at = v - v_0$$

$$at + v_0 = v$$

$$v = v_0 + at$$

Motion at Constant Acceleration

- Determine velocity after a given time period
- *You are moving at 30 m/s and you accelerate at 5 m/s² [(5m/s)/s] for 2 seconds. How fast will you then be going?*
- ***40 m/s***

$$a = \frac{v - v_0}{t}$$

$$at = v - v_0$$

$$at + v_0 = v$$

$$v = v_0 + at$$

$$v = 30m/s + \left(\frac{5m}{s^2}\right)(2s)$$

$$v = \frac{30m}{s} + \frac{10m}{s} = 40m/s$$

Motion at Constant Acceleration

- Determine velocity after a given time period

- What are the units for ***at***?

$$a = \frac{v - v_0}{t}$$

$$at = v - v_0$$

$$at + v_0 = v$$

$$v = v_0 + at$$

Motion at Constant Acceleration

- Determine velocity after a given time period

- What are the units for ***at***?

$$\frac{m}{s^2} x \frac{s}{1} = \frac{m}{s}$$

$$a = \frac{v - v_0}{t}$$

$$at = v - v_0$$

$$at + v_0 = v$$

$$v = v_0 + at$$

Motion at Constant Acceleration

- Determine the position of an object after a given period of time

$$\bar{v} = \frac{x - x_0}{t}$$

$$\bar{v}t = x - x_0$$

$$\bar{v}t + x_0 = x$$

$$x = x_0 + \bar{v}t$$

Motion at Constant Acceleration

- Determine the position of an object after a given period of time
- At ***constant*** velocity

$$x = x_0 + vt$$

$$\bar{v} = \frac{x - x_0}{t}$$

$$\bar{v}t = x - x_0$$

$$\bar{v}t + x_0 = x$$

$$x = x_0 + \bar{v}t$$

Motion at Constant Acceleration

- Determine velocity after a given time period

- What are the units for ***vt***?

$$\bar{v} = \frac{x - x_0}{t}$$

$$\bar{v}t = x - x_0$$

$$\bar{v}t + x_0 = x$$

$$x = x_0 + \bar{v}t$$

Motion at Constant Acceleration

- Determine velocity after a given time period

- What are the units for ***vt***?

$$\frac{m}{s} x \frac{s}{1} = \frac{m}{1}$$

$$\bar{v} = \frac{x - x_0}{t}$$

$$\bar{v}t = x - x_0$$

$$\bar{v}t + x_0 = x$$

$$x = x_0 + \bar{v}t$$

Motion at Constant Acceleration

- If, and only if, the ***acceleration is constant***, the average velocity will occur at half of the distance and half of the time
- Therefore, it will be an average of initial and final velocities

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

Motion at Constant Acceleration

- Let's substitute this into the last equation

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

$$x = x_0 + \bar{v}t$$

$$x = x_0 + \frac{v + v_0}{2}t$$

Motion at Constant Acceleration

- Now let's try a little more trickeration by substituting the velocity equation into the displacement equation

$$x = x_0 + \frac{v + v_0}{2} t$$

$$v = v_0 + at$$

$$x = x_0 + \frac{v_0 + at + v_0}{2} t$$

$$x = x_0 + \frac{2v_0}{2} t + \frac{at}{2} t$$

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

Motion at Constant Acceleration

- And now, for the Grande Finale . . .
  - Solve the velocity equation for time, *t*
  - Substitute this value for time into the distance equation

$$v = v_0 + at$$

$$v - v_0 = at$$

$$\frac{v - v_0}{a} = t$$

$$x = x_0 + \frac{v + v_0}{2} t$$

$$x = x_0 + \frac{v + v_0}{2} \frac{v - v_0}{a}$$

Motion at Constant Acceleration

- Using FOIL or difference of two squares

$$x = x_0 + \frac{v + v_0}{2}\frac{v - v_0}{a}$$

$$x = x_0 + \frac{v^2 - {v_0}^2}{2a}$$

Motion at Constant Acceleration

- Now solve for v^2

$$x = x_0 + \frac{v^2 - {v_0}^2}{2a}$$

$$x - x_0 = + \frac{v^2 - {v_0}^2}{2a}$$

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

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

Motion at *Constant Acceleration*

Summary

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

$$v = v_0 + at$$

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

$$v^2 = v_0^{\,2} + 2a(x - x_0)$$

Motion at *Constant Acceleration* Summary

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

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Problem Solving Process

Problem Solving Process

My Embellishment

Problem Solving Process

1. Read the problem (the whole problem) carefully.
   - What does it tell you?
   - What is implied?

Problem Solving Process

2. Draw a diagram.
   - A picture is worth a thousand words – it really is.
   - What is your reference point?
   - Where are you going to put your coordinate axes?
   - How are objects moving in relation to each other?

Problem Solving Process

3. Write down the *givens* – then write down the ***knowns*** – then write what you need to find.
   - Include the units
   - Convert to compatible units before you ever start problem solving

Problem Solving Process

4. Think about it.
   - What principles apply?
   - What am I really looking for?

Problem Solving Process

5. Decide which equation to use.
   - It must contain ***what you know*** (givens and knowns) and ***what you are looking for***.
   - If it doesn't have what you need, you may need to solve a different equation first to give you the value you need for your primary equation.

Problem Solving Process

6. Carry out the calculation.
   - **Solve for the variable you are looking for algebraically first.**
   - Then plug in numbers to get an answer.

Problem Solving Process

7. Does it make sense?
   - Is your answer reasonable.

Problem Solving Process

8. Check your units.
   - Did all of your units cancel out correctly?
   - Are the units for your answer appropriate for what you are looking for?

LET'S TRY IT:
PICK A HOMEWORK PROBLEM

SUMMARY REVIEW: DID YOU GET IT

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Learning Objectives:

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Big Idea

- Interactions between systems can result in changes in those systems.

QUESTIONS?

Homework

Normal Students: #16-19, 21-28

Mensa Students: #16-28, skip #20

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