Physics 200 (Stapleton) Name: Key

1-D Kinematics Notes, Part 1

Kinematics: The study of motion without considering its causes.

Scalar: A quantity with magnitude but no direction.

Vector: A quantity with magnitude and direction. Numerically, may be positive or negative, depending on the chosen reference frame. Usually, signs follow the same conventions as an x/y grid… upward = positive, downward = negative, rightward = positive, leftward = negative.

Δ = Delta = "change in". If x changes from 3m to 1m, then Δx = -2m.

Preview of Kinematics Formulas to Come

$$x = x_0 + \overline{v}\,t$$

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

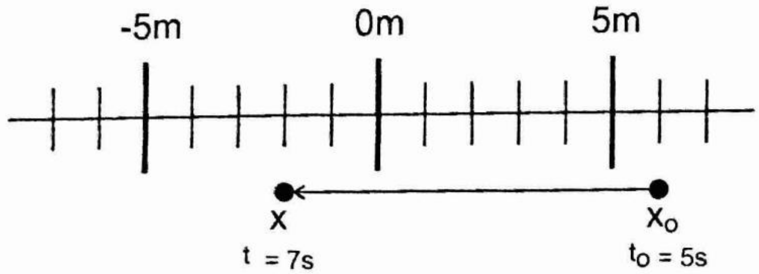
$$v = v_0 + at$$

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

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

	Symbol	**Meaning** (what it's *supposed to* mean)	**Vector or Scalar?**	**Common Units**	**How to estimate or convert**
Position	x (or y, depending on axis of motion)	Current distance (in a positive or negative direction) from some chosen point of origin.	S	Meters (m)	1 long step 0.305m ≈ 1foot
Displacement (often called "distance.")	Δx (or Δy) *Sometimes = d*	Final position minus original position(e.g. $x-x_0$); "Change in position"	V	Meters (m)	1 long step 0.305m ≈ 1foot
Distance	d	How far something has traveled from its original position, disregarding direction. Distance is not negative.	S	Meters (m)	1 long step 0.305m ≈ 1foot
Distance traveled	d	Sum of all of the distances traveled on a trip. Distance traveled is what is recorded by a car's odometer.	S	Meters (m)	1 long step 0.305m ≈ 1foot
Time	t	?	S	Seconds (s)	1s = "one mississippi"
Speed	**v** *(even though v is technically velocity)*	How fast something is moving. A ratio of distance traveled to travel time.	S	Meters per second (m/s)	1m/s ≈ 2.234mph ≈ 1 long step per second
Velocity	**v**	Speed and direction. Speed that may be positive or negative.	V	Meters per second (m/s)	1m/s ≈ 2.234mph 4.5m/s = 6min/mile pace

Practice: At t=5s, an object leaves position x_o and travels to position x.



Position: x_o = 6m x = -2m

Displacement: $X - X_o = -2m - 6m = -8m = \Delta X$

Final Distance From Origin: 2m

Distance Traveled: 8m

Average Velocity: $\bar{V} = \frac{\Delta X}{\Delta t} = \frac{-8m}{(7s-5s)} = \frac{-8m}{2s} = -4m/s$

Average Speed: $\overline{speed} = |\bar{V}| = |-4m/s| = 4m/s$

***Average* Velocity** (symbol =): when we measure velocity, *average velocity* is what we will actually measure. This is the average speed of an object as it travels through a given distance. The object may speed up or slow down over that distance, but the average velocity that we calculate will not show this.

Instantaneous Velocity: the velocity of an object at a single point in time

"Initial velocity" symbol = V_o

Final velocity symbol = V

If I have a velocity of 3 m/s, what does that mean?

I travel a distance of 3m (in a positive direction) each second.

Explain how to walk with a velocity of 1m/s.

Take one long step every second.

Average Velocity Formula (Hint: the units provide the formula) — $\frac{m}{s}$ ← distance / ← time

$\bar{V} = \frac{\Delta X}{\Delta t}$ ← displacement / ← elapsed time

Two Ways to Graph The Same Event

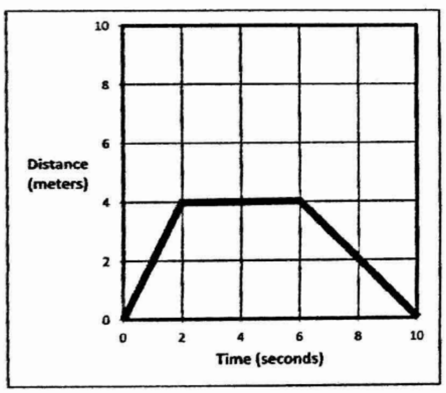
Position vs. time graph (below, left) [also called "distance vs. time"]:

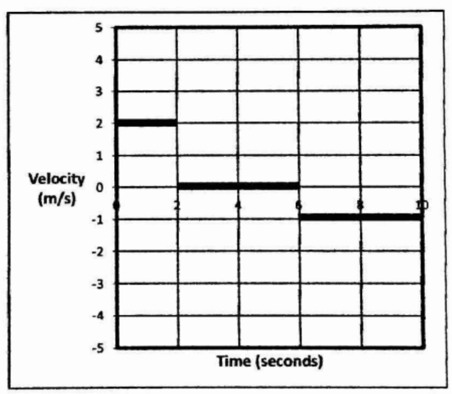
1. For the first 2 seconds, Chuck walked steadily away from a motion sensor. During that time, he traveled 4m "forward."
2. For the next 4 seconds (from t=2 to t=6), Chuck stood still at the 4m distance mark.
3. During the last 4 seconds (t=6 through t=10), Chuck walked steadily back toward the sensor. During those two seconds, Chuck traveled 2m "backward."

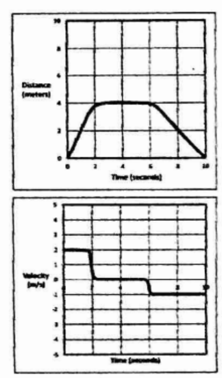
Velocity vs. time graph:

1. During the first segment, Chuck traveled 4m forward (+4m) over a time of 2s. His average velocity for that interval is therefore 4m/2s = 2m/s. The velocity vs. time graph shows a constant velocity of 2m/s for the first two seconds.
2. During the second segment of data (2s to 6s), Chuck stood still (0m distance) over a time of 4s. His average velocity for that interval was therefore 0m/4s = 0m/s. The velocity vs. time graph shows a constant velocity of 0m/s for the second segment of data.
3. During the 3rd segment (6s to 10s), Chuck moves 4m backward (-4m). His average velocity for that interval is therefore -4m/4s = -1m/s. The velocity vs. time graph shows a constant velocity of -1m/s for the second segment of data (6s through 10s).

The small graphs, below, are actually more realistic than the large graphs. Why?







Velocity Practice: The graph on the right shows the movement of an object in front of a motion sensor. Determine the velocity of the moving object for lettered each segment, and use your calculations to fill out a velocity vs. time graph for the object (bottom of page).

1. Fill in the correct information for segment **A**, in the graph on the right.

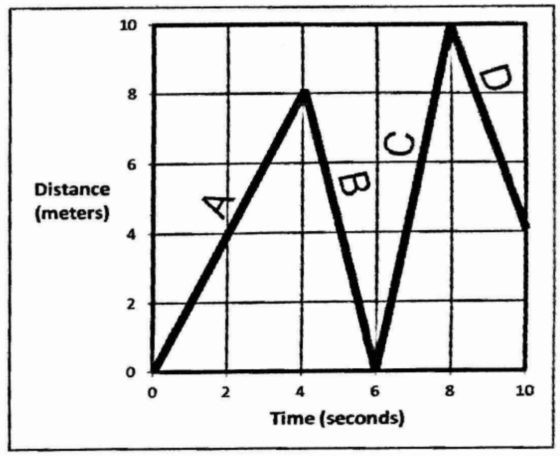
   Displacement = 8m

   Δt = 4s

   $\bar{v}$ $v_{average}$ = 2m/s (8m / 4s)

   Distance traveled = 8m

   Position at end of segment = 8m



2. Fill in the correct information for segment **B**.

   Displacement = −8m

   Δt = 2s

   $v_{average}$ = −4m/s (−8m / 2s)

   Distance traveled = 8m

   Position at end of segment = 0

3. Fill in the correct information for the entire trip (segments **A-D**).

   Displacement = 4m

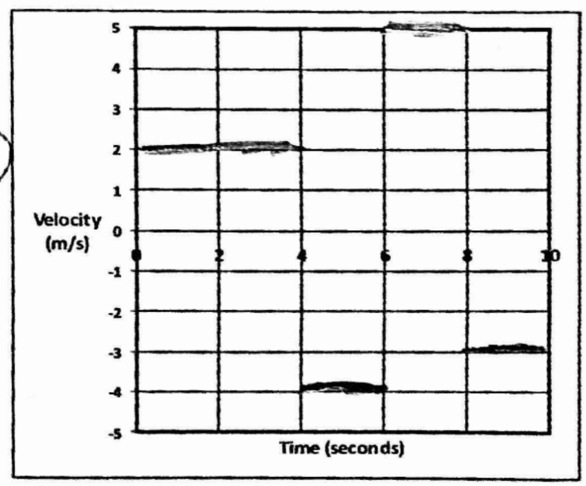
   Δt = 10s

   $v_{average}$ = 0.4m/s (4m / 10s)

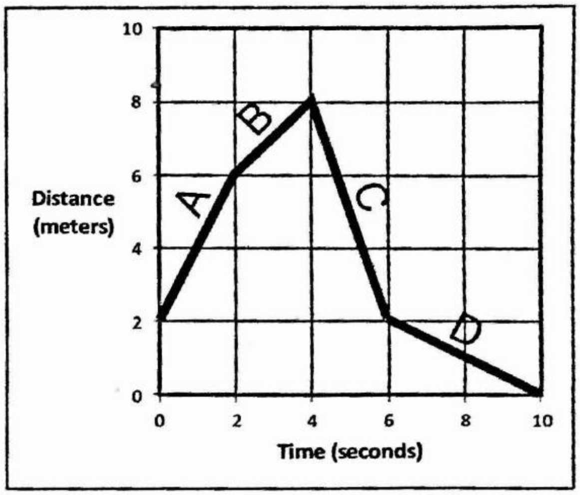
   Distance traveled = 32m (8+8+10+6)

   Position at end of segment = 4m

4. Use the distance vs. time graph above to fill in the velocity vs. time graph on the right.



5. Fill in the correct information for segment **A**, in the graph on the right.



Displacement = 4m (6m−2m)

Δt = 2s

$v_{average}$ = 2m/s (4m/2s)

Distance traveled = 4m

Position at end of segment = 6m

6. Fill in the correct information for segment **D**.

Displacement = 2m

Δt = 2s

$v_{average}$ = 1m/s (2m/2s)

Distance traveled = 2m

Position at end of segment = 8m

7. Fill in the correct information for the entire trip (segments **A-D**).

Displacement = −2m (0-2)

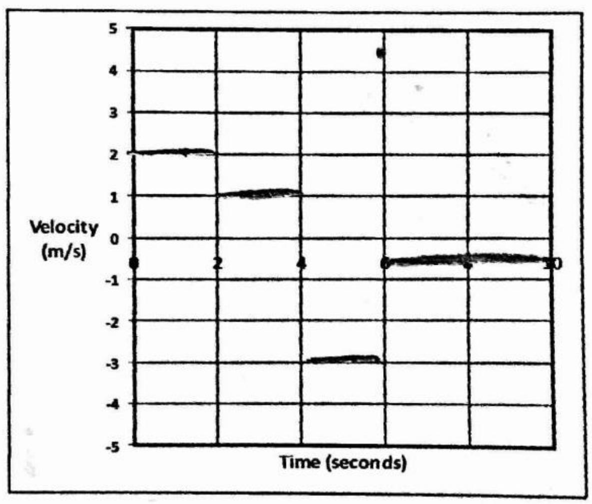
Δt = 10s

$v_{average}$ = −0.2 m/s (−2m/10s)

Distance traveled = 14m (4+2+6+2)

Position at end of segment = 0m

8. Use the distance vs. time graph above to fill in the velocity vs. time graph on the right.



Motion Matching Activity Questions:

On a motion sensor graph of position vs. time…

1. What does a positive (upward) slope tell you about the object's motion?

   The Motion is away from the sensor

2. What does a negative slope indicate?

   Motion toward the sensor

3. What does the steepness of a slope tell you about the object's motion?

   Speed (steeper = faster)

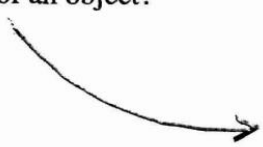
4. What does a constant (straight line) slope indicate?

   Constant speed (no acceleration)

5. What might a smoothly curving line indicate?

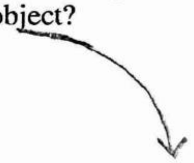
   Acceleration (either positive or negative)

6. Sketch a negative slope that is becoming less steep. What does this curve indicate about the motion of an object?

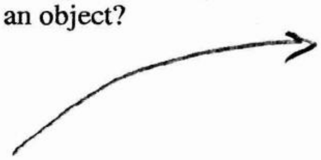
   The object is moving toward the sensor, and it is slowing down (decelerating)

7. Sketch a negative slope that is getting steeper What does this curve indicate about the motion of an object?

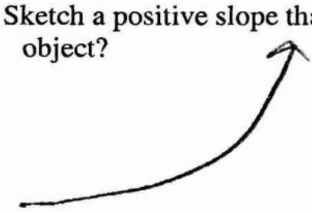
   Moving toward the sensor, accelerating

8. Sketch a positive slope that is becoming less steep. What does this curve indicate about the motion of an object?

   Moving away, decelerating

9. Sketch a positive slope that is getting steeper What does this curve indicate about the motion of an object?

   Moving away, accelerating

Physics 200 **Name:** Key
Notes: Acceleration

Velocity tells you how something's position changes during one second.

Acceleration tells you how something's velocity changes during one second.

Is acceleration a vector or scalar quantity?

Not just magnitude, but also direction, so I got rid of the word "much."

Acceleration can happen in two fundamentally different ways:

1) Changing Speed
2) Changing Direction

or both

Negative acceleration is also called deceleration

Common metric units for acceleration are: m/s^2

Sometimes I use m/s/s

The Analogous Relationship between Velocity and Acceleration:

If Pam has a *velocity* of +6m/s, that means she travels 6m for every second that ticks by. Another way to say this is that, **for each passing second, Pam adds 6m to her position.**

Analogously, if Pam's *acceleration* is +6m/s/s, this means… with each passing second, 6m/s is added to her velocity.

Velocity adds meters **each second.**

Acceleration adds meters per second **each second.**

Velocity is the slope of a position **vs** time **graph.**

Velocity is the slope of a velocity **vs** time **graph.**

The acceleration formula:

Velocity describes a change in position over a time interval. Acceleration describes a change in velocity over a time interval.

$$a_{average} = \bar{a} = \frac{\Delta v}{\Delta t}$$

(Δv ← m/s; Δt ← s)

Acceleration Formula Practice Problems:

1. Suppose your velocity is 2m/s. One second later, your velocity is 6m/s. What is your average acceleration over this time period?

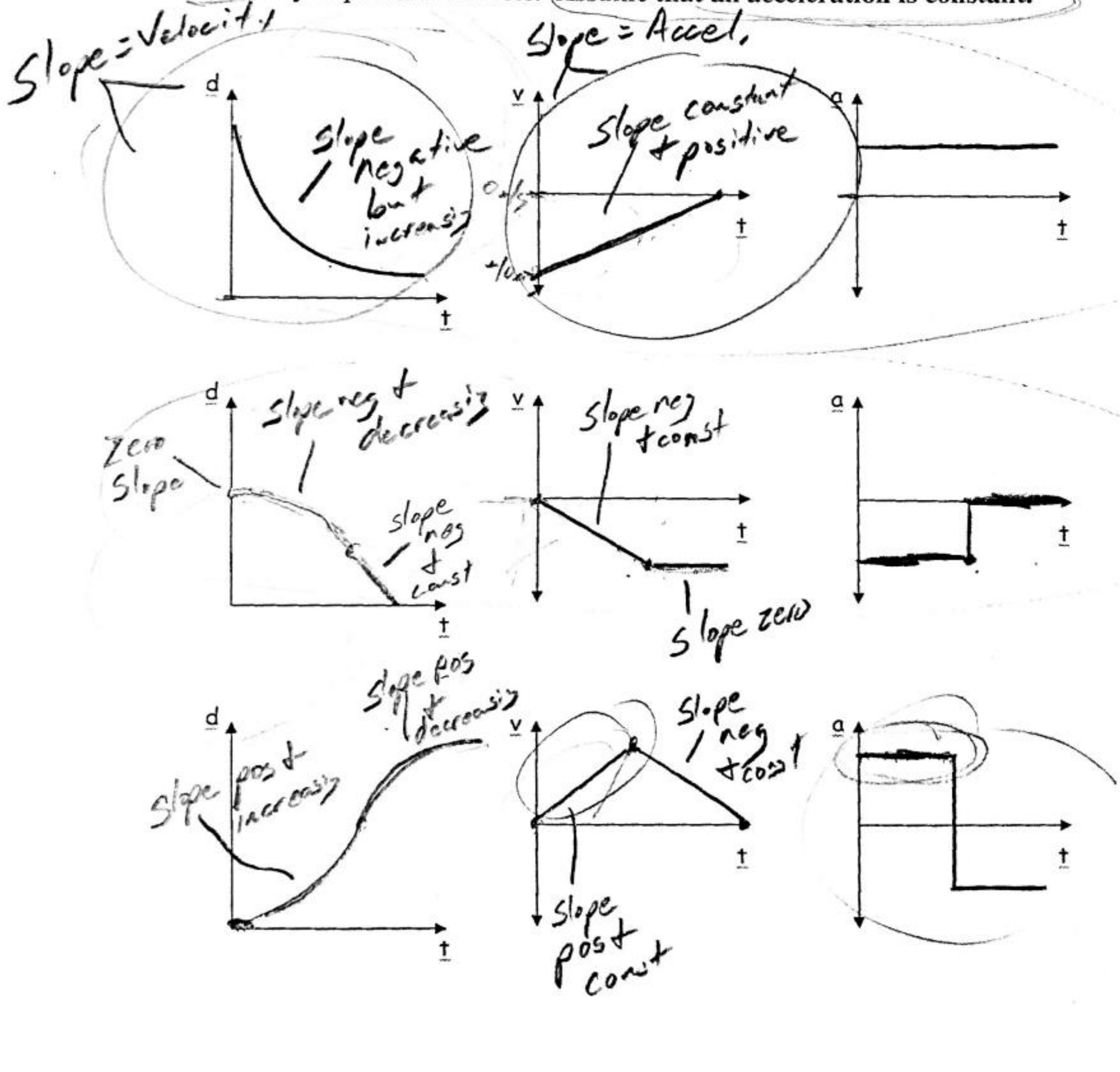
$$\bar{a} = \frac{\Delta V}{\Delta t} = \frac{4 m/s}{1 s} = 4 m/s^2$$

2. When your watch reads 8:01:32 AM, your velocity is 6m/s. At 8:01:40 AM (on the same day), your velocity is 2m/s. What is your average acceleration over this time period?

$$\bar{a} = \frac{\Delta V}{\Delta t} = \frac{-4 m/s}{8 s} = -0.5 m/s^2$$

Motion Graphs:

Each row of graphs below comprises a position vs. time graph, a velocity vs. time graph, and an acceleration vs. time graph. Every graph in a row conveys the same motion. For each row, use the one completed graph to fill in the incomplete graphs with reasonable curves. Some rows will have a wider variety of possible answers. **Assume that all acceleration is constant.**



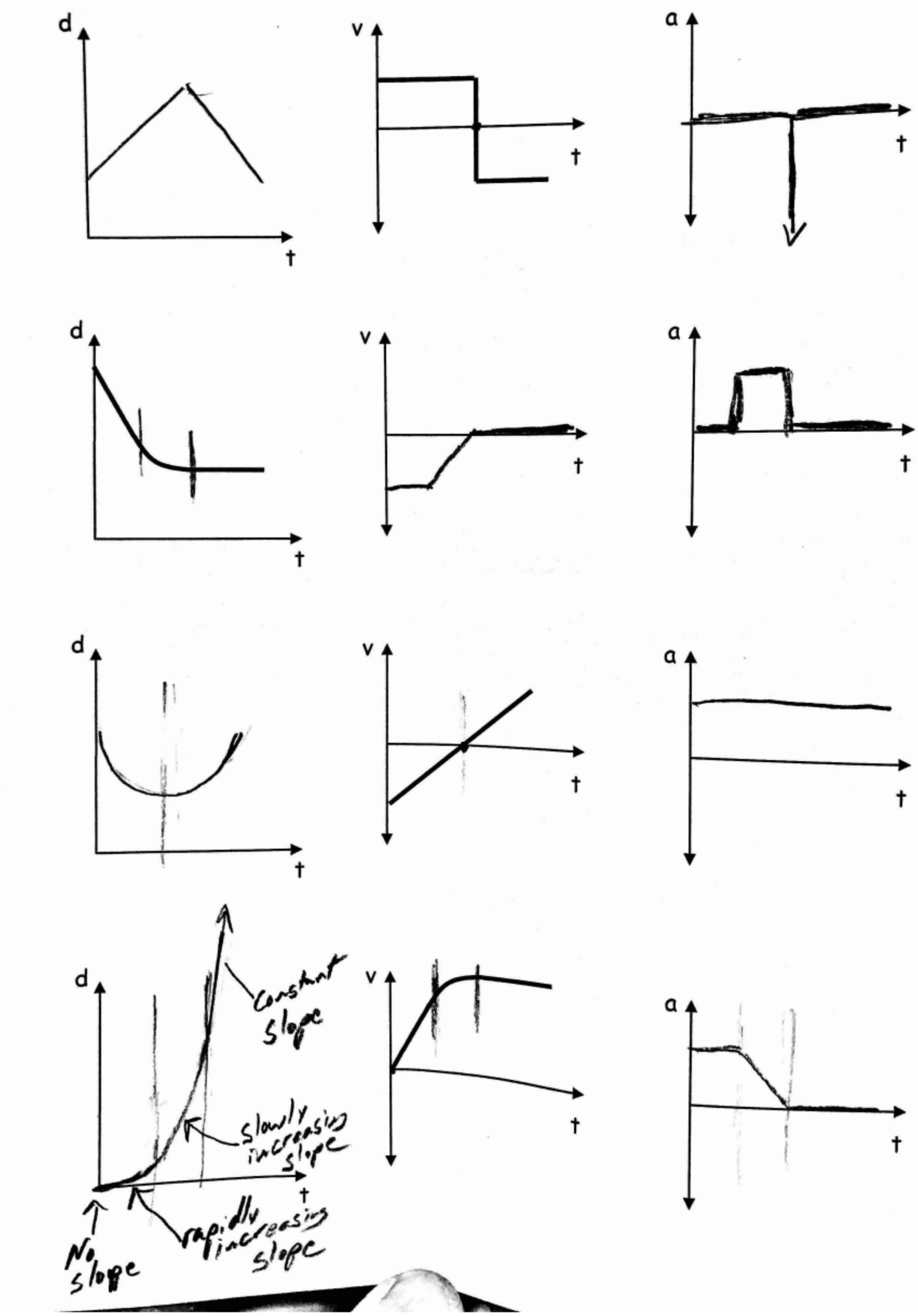
Essex High School
Physics 200

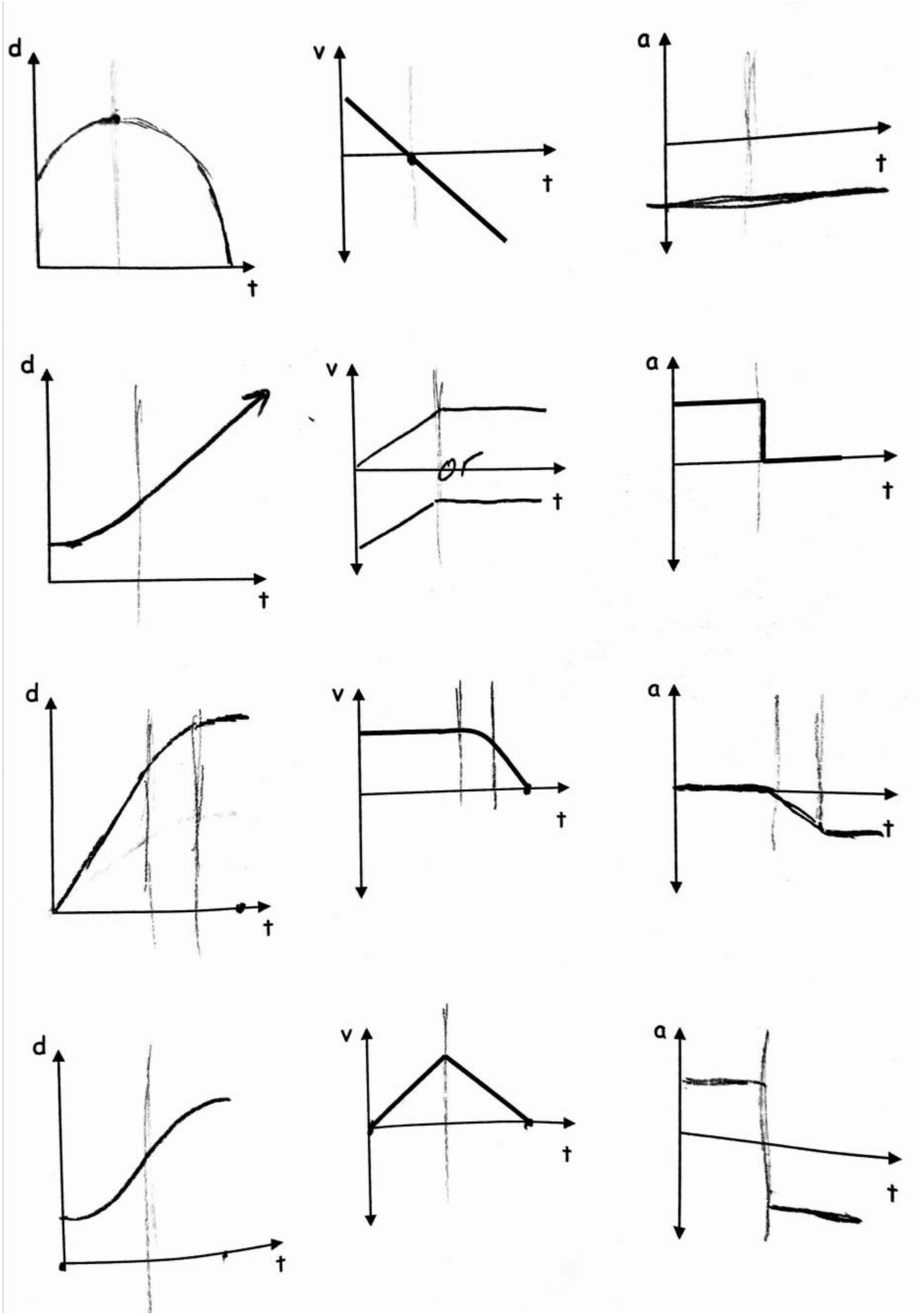
Name Key

Graph Comparisons

Graph Analysis (20 pts)

Using the information provided in one graph, complete the other 2.

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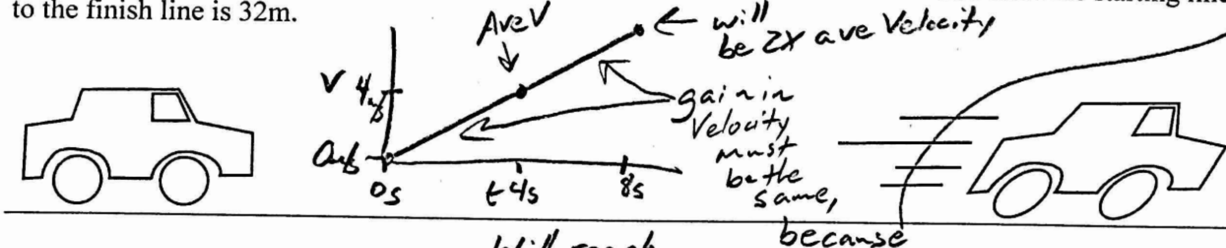
Physics 200
Notes: Intro to Kinematics Formulas

Name: Key

Deriving a formula for constant acceleration of an object starting from rest:

Suppose the car below moves with **constant acceleration** after starting from rest at the starting line. The car travels from the starting line to the finish line in a time of 8s. The distance from the starting line to the finish line is 32m.



Will reach $\bar{V}$ at t=4s
$\bar{V}$ = 4m/s

x_0 = 0m
t_0 = 0s
v_0 = 0m/s

x = 32m
t = 8s
v = 8m/s

$\bar{v}= \frac{\Delta x}{\Delta t} = \frac{32m}{8s} = 4m/s$

More generally, $\bar{V} = \frac{V+V_0}{2}$

v = $2\bar{V} = 2(4m/s) = 8m/s$

Δv = $V - V_0 = 8m/s - 0m/s = 8m/s$

Δt = $t - t_0 = 8s$

$\bar{a} = \frac{\Delta V}{\Delta t} = \frac{8m/s}{8s} = 1s$

Solving for a algebraically, using only symbols, we get…

$$\bar{a} = \frac{\Delta V}{\Delta t} = \frac{V}{\Delta t} = \frac{2\bar{V}}{\Delta t} = \frac{2\left(\frac{\Delta x}{\Delta t}\right)}{\Delta t} = \frac{2\Delta x}{\Delta t^2}$$

The formula we just derived for acceleration can be rearranged to give a version of the first displacement formula, on the right. What is the difference between the formula we derived and the formula on the right?

$a = \frac{2\Delta x}{t^2} \Rightarrow \frac{at^2}{2} = \Delta x$

The box on the right contains a more complete set of kinematics formulas for zero or constant acceleration. If you're curious about their derivations, many of the derivations can be found in the online textbook.

Those formulas will not always look like the ones on the right. Some symbols may be different, and some may be left out. For example:

$V_2 = V_0^2 + 2a\Delta x$

$\Delta x = \bar{v} t$

$V = V_0 + at$

Formulas for zero or Constant Acceleration

$$\bar{v} = \frac{\Delta x}{\Delta t} \quad \bar{v} = \frac{v_{x0} + v_x}{2}$$

$$\bar{a} = \frac{\Delta v}{\Delta t}$$

$$\Delta x = v_{x0}t + \frac{1}{2}at^2$$

$$\Delta x = \frac{1}{2}\left(v_{x0} + v_x\right)t$$

$$v_x = v_{x0} + at$$

$$v_x^2 = v_{x0}^2 + 2a(x - x_0)$$

By convention, rightward and upward directions are positive, and

leftward and downward directions are negative.

Practice With Motion Equations:

The G.U.E.S.S. method…

- Steps: Identify what is **G**iven. Identify the **U**nknown(s). Find an ***E**quation that incorporates the givens and the unknown. ****S**ubstitute givens into the equation. **S**olve.
- *Sometimes you will need more than one equation
- **It will sometimes save time and confusion if you solve for the unknown algebraically before substituting givens into the equation.

Example 1. What is the displacement of a car that starts from rest and accelerates at $6 m/s^2$ for 7 seconds?

$\Delta x = ?$, V_0, a, Δt

$\Delta x = V_0 t + \frac{1}{2}at^2 = \frac{1}{2}(6 m/s^2)(7 s)^2$

$V_0 = 0 m/s$, $a = 6 m/s^2$, $t = 7 s$

$= 147 m$

Example 2. A nut is falling at a rate of -5m/s. If gravity accelerates the nut at a rate of 9.8m/s² for 6 additional seconds, what will be the velocity of the nut after those 6 seconds?

V_0 a Δt $V = ?$

$V = V_0 + at$ ← 6s; $V_0 = -5m/s$; $a = -9.8m/s^2$

$V = -5m/s + (-9.8m/s^2)(6s)$

$V = -63.8m/s$

1. A grouse takes off from the 8 yard line of a football field and travels to the 40 yard line over a time of 8 seconds. What is its average velocity?

x_0 x Δt $\bar{V} = ?$

$$\bar{V} = \frac{\Delta x}{\Delta t} = \frac{x - x_0}{\Delta t} = \frac{40y - 8y}{8s} = \frac{32 yard}{8s} = 4 \frac{yard}{s}$$

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2. A car accelerates from 30mph to 50mph over a time of 4 seconds. What is the car's average velocity during this time period? (Assume constant acceleration)

V_0 V t — Not necessary

$$\bar{V} = \frac{V_0 + V}{2} = \frac{30mph + 50mph}{2} = \frac{80mph}{2} = 40mph$$

3. You drop a rock off of a very high bridge. Starting from rest, the rock accelerates at a rate of -9.8m/s². You see a splash 8 seconds after you release the rock. What is the rock's velocity when it hits the water?

$V_0 = 0m/s$ a t V

$V = V_0 + at$

$V = 0m/s + 8s(-9.8m/s^2) = -78.4m/s$

4. Starting from rest, a car accelerates at 7m/s² for 10 seconds. What is the car's displacement during this time?

$V_0 = 0$ a t Δx

$\Delta x = V_0 t + \frac{1}{2}at^2$

$= 0t + \frac{1}{2}(7m/s^2)(10s)^2 = 350m$

5. A runner's velocity at 12:34:33 PM is 4m/s. At time 12:34:38 PM the runner's velocity is 2m/s. What is the runner's average acceleration over this time period?

t_0, V_0, t, V, Δt, $a = ?$

$$\bar{a} = \frac{\Delta V}{\Delta t} = \frac{V - V_0}{t - t_0} = \frac{-2m/s}{5s} = -0.4m/s^2$$

6. A child traveling at a rate of 15m/s along a zip line. After slowing down at a constant rate over a distance of 40m, the child comes to a stop.

V_0, Δx, $V = 0$

a. What is the child's average acceleration over this 40m?

$a = ?$

$$V^2 = V_0^2 + 2a\Delta x$$

$$0^2 m/s = (15m/s)^2 + 2a(40m)$$

$$0 = 225m^2/s^2 + 80m(a)$$

$$-225m^2/s^2 = 80m(a)$$

$$\frac{-225m^2/s^2}{80m} = a = -2.81m/s^2$$

b. How many seconds does it take for the child to travel this 40m distance?

$\Delta t = ?$

$$V = V_0 + at$$

$$0m/s = 15m/s + (-2.81m/s^2)t$$

$$t = 5.34s$$

7. (*requires multiple formulas) A driver sees a turtle in the road and hits the brakes. It takes him 3 seconds and a distance of 20m to slow to ~~a complete stop~~. What was the driver's rate of acceleration during this three second time period? 4m/s

Δx, Δt, V, $a = ?$

$$a = \frac{\Delta V}{\Delta t} = \frac{V - V_0}{3s} = \frac{4m/s - V_0}{3s} \Rightarrow a = \frac{4m/s - 9.33m/s}{3s}$$

$$a = -1.78m/s^2$$

3 formulas

$$\bar{V} = \frac{\Delta x}{\Delta t} \text{ and } \bar{V} = \frac{V + V_0}{2}$$

$$\text{so } \frac{\Delta x}{\Delta t} = \frac{V + V_0}{2}$$

$$\frac{20m}{3s} = \frac{4m/s + V_0}{2}$$

$$V_0 = 9.33m/s$$

Physics 200 Name: *Key*

1-D Kinematics: Free-fall (mostly), plus Areas Under Curves

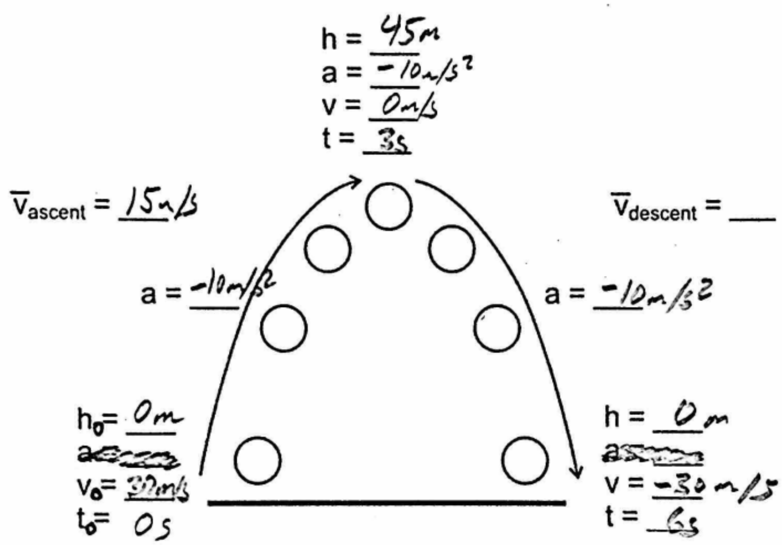
Free-fall: The state of being acted upon by only the force of gravity [Note that an upward-moving object may be in free-fall.]

g: the absolute value of free-fall acceleration near the Earth's surface.

Free-fall acceleration: -9.8m/s^2 or $-g$

The diagram below is intended to represent an object that is launched <u>vertically upward</u> in the absence of air resistance (i.e. in free-fall). The diagram appears to show the ball moving sideways, but it isn't moving sideways. The apparent sideways motion is unavoidable if we're going to separate upward-moving objects from the downward-moving objects (as we need to do for clarity).

1. Fill in one of the blanks in the diagram with a made-up value. Based on that value, fill in the rest. Estimate by using $g=10\text{m/s}^2$



Free-Fall Hint #1: Free-falling objects that go up and then come down have symmetric flights. The trip up is the same as the trip down, only backward. It is often easier to analyze the fall rather than the ascent, because we know the initial velocity of the fall is __0__.

Example 1: A ball is launched directly upward from ground level (in the absence of air resistance). It stays in the air for 10 seconds. What height did it reach at its highest point?

Consider the Fall...

$V_0 = 0\text{m/s}$

$\Delta t = 5\text{s}$

$a = -9.8\text{m/s}$

$\Delta x = V_0 t + \frac{1}{2} a t^2$

$\Delta x = 0(5\text{s}) + \frac{1}{2}(-9.8\text{m/s}^2)(5\text{s})^2$

$\Delta x = -122.5\text{m}$

Fell 122.5m, so max height was 122.5m

Helpful Hint #2: Draw a diagram.

Helpful Hint #3: If you're having trouble getting started, list all of the usual variables and fill in the ones you know.

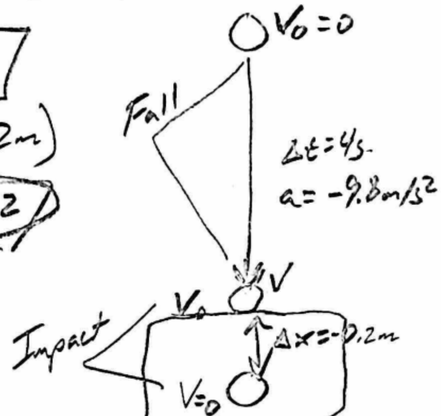
Example 2: A ball is released, from rest, above a couch. After free-falling for 4 seconds, the ball contacts the couch cushion and then travels another 0.2m downward before coming to a stop. What is the ball's acceleration while it was being stopped by the couch cushion?

Fall
$V_0 = 0 m/s$
$V = ?$
$a = -9.8 m/s^2$
$\Delta x = ?$
$\Delta t = 4 s$

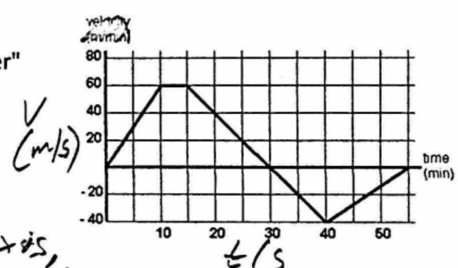
Impact
$V_0 = ?$
$V = 0 m/s$
$a = ?$
$\Delta x = -0.2 m$
$\Delta t = ?$

$V = V_0 + at$
$V = 0 m/s + (-9.8 m/s^2)(4s) = -39.2 m/s$

$V^2 = V_0^2 + 2a\Delta x$
$0^2 = (-39.2 m/s)^2 + 2a(-0.2 m)$
$a = 3{,}842 m/s^2$



Areas "Under" curves:

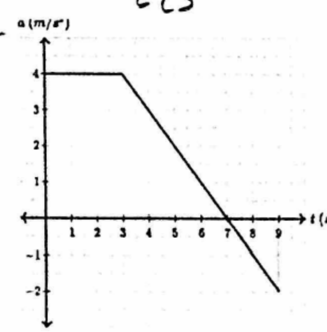


1. What kinematic information can we get by calculating the area "under" the curve of a velocity vs. time graph?

area = $V(\Delta t) = \Delta x$ or $\frac{m}{s}(s) = m$
Displacement

2. Why did I put quotation marks around "under?"

When the curve is below the x axis, we find the area above it and make it negative.

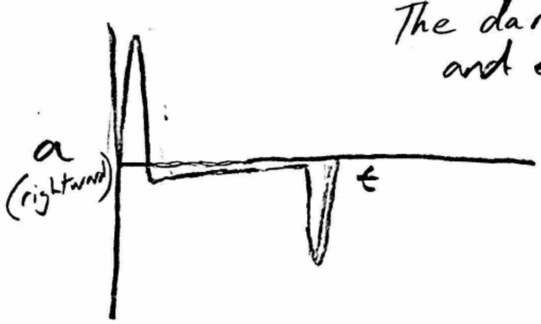


3. What does the area under the curve of an acceleration vs. time graph tell us?

area = $a(\Delta t) = \Delta V$ ← Change in Velocity

4. Suppose we graph the acceleration of a sticky Nerf dart that is shot across the room, sticking to the opposite wall. How can #2, above, help us draw that graph more correctly? Try it, and we will see.

The dart starts and ends motionless ($V_0 = V = 0 m/s$)
So, overall $\Delta V = 0$,
So the total area "under" the curve is zero...
So the positive and negative areas must be equal.



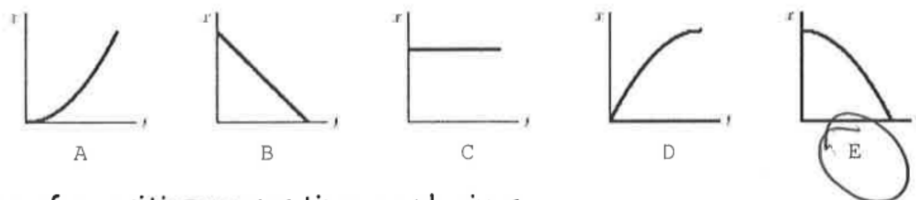
NAME: Key

MC 21 Prob 35

Chapter 1 & 2 Test 2015-2016

I. MULTIPLE CHOICE: Select the one best answer for each question. Where g is used, assume it equals 10 m/s^2 and neglect air resistance for falling/moving objects.

1. Which of the following five position versus time graphs represents the motion of an object moving with an increasingly negative velocity?



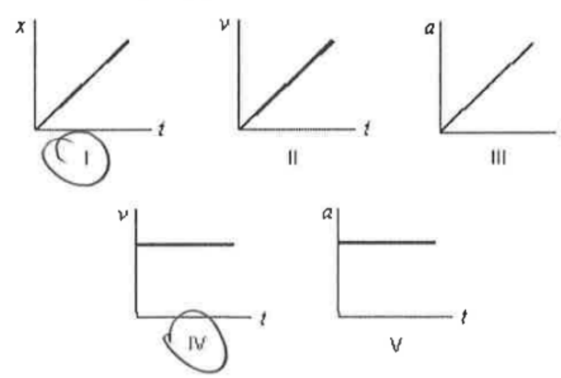
2. The slope of a position versus time graph gives
   A) position. B) velocity. C) acceleration. D) displacement.

3. Which one of the following situations is impossible?
   A) A body having a positive velocity and a negative acceleration
   B) A body having a negative velocity and a negative acceleration
   C) A body having zero velocity and positive acceleration
   D) A body having constant acceleration and positive velocity
   E) A body having constant velocity and positive acceleration

4. A particle moves on the x axis. When its velocity is positive and increasing:
   A) its acceleration must be positive
   B) its acceleration must be negative
   C) its acceleration must be zero
   D) it must be slowing down
   E) none of the above must be true

5. The slope of a velocity versus time graph gives
   A) position. B) velocity. C) acceleration. D) displacement.

6. Consider the following five graphs (note the axes carefully!). Which of these represent(s) motion at constant velocity?
   A) IV only
   B) IV and V only
   C) I, II, and III only
   D) I and II only
   E) I and IV only



7. A particle moves along the x axis from x_0 to x. Of the following values of the initial and final coordinates, which results in the displacement with the largest magnitude?

   A) $x_0 = -4$ m, $x = 2$ m
   B) $x_0 = -4$ m, $x = 4$ m
   C) $x_0 = 4$ m, $x = -2$ m
   D) $x_0 = 4$ m, $x = 6$ m
   E) $x_0 = -4$ m, $x = -8$ m

Questions 8-11

A car starts from Burlington, goes 60 km in a straight line to Montpelier, immediately turns around, and returns to Burlington. The time for this round trip is 2 hours.

8. What is the average speed for this round trip?
   A) 0 B) 30 km/hr C) 60 km/hr D) 120 km/hr

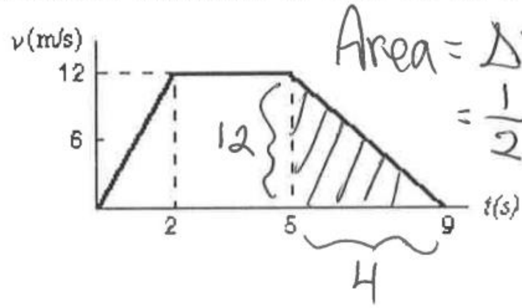
9. What is the average velocity for this round trip?
   A) 0 B) 30 km/hr C) 60 km/hr D) 120 km/hr

10. What is the distance traveled on this round trip?
    A) 0 B) 30 km C) 60 km D) 120 km

11. What is the displacement for this round trip?
    A) 0 B) 30 km C) 60 km D) 120 km

12. A car starts from rest and goes down a slope with a constant acceleration of 5 m/s^2. After 6 seconds the car reaches the bottom of the hill. Its speed at the bottom of the hill is: $v = v_0 + at \Rightarrow v = 0 + (5\ \frac{m}{s^2})(6s) = 30\ \frac{m}{s}$
    A) 5 m/s B) 12 m/s C) 25 m/s D) 30 m/s E) 180 m/s

13. The graph represents the straight line motion of a car. How far does the car travel between t = 5 seconds and t = 9 seconds?
    A) 4 m
    B) 12 m
    C) 24 m
    D) 36 m
    E) 60 m



Area $= \Delta x = \frac{1}{2}(4)(12) = 24$ m

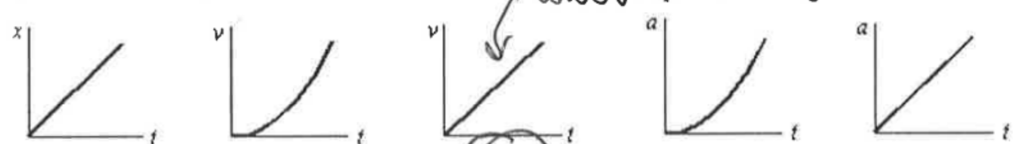
14. A ball is tossed straight up. Upward is taken to be the positive direction. The acceleration due to gravity of the ball is:
    - A) positive during both ascent and descent
    - B) negative during both ascent and descent
    - C) negative during ascent and positive during descent
    - D) positive during ascent and negative during descent
    - E) none of the above

15. The area under a curve in an acceleration versus time graph gives
    A) change in acceleration. B) change in velocity. C) displacement. D) position.

16. A freely falling body has a constant acceleration of 10 m/s^2. This means that:
    - A) the speed of the body increases by 10 m/s during each second
    - B) the body falls 10 m during each second
    - C) the body falls 10 m during the first second
    - D) the acceleration of the body increases by 10 m/s^2 during each second
    - E) the acceleration of the body decreases by 10 m/s^2 during each second

17. An object is thrown straight up from ground level with a speed of 50 m/s. What is its upward speed above ground level 3.0 seconds later? Assume $g = 10\ m/s^2$.
    A) 0 m/s B) 50 m/s C) 40 m/s D) 30 m/s E) 20 m/s

18. A stone is dropped from a cliff. The graph (carefully note the axes) that best represents its speed while it falls is:



A B C D E

19. Suppose that an object travels from one point in space to another. Make a comparison between the displacement and the distance traveled. (Note: The path is not necessarily a direct straight-line path.)
    - A) The displacement is either greater than or equal to the distance traveled.
    - B) The displacement is always equal to the distance traveled.
    - C) The displacement is either less than or equal to the distance traveled.
    - D) The displacement can be either greater than, smaller than, or equal to the distance traveled.

20. The area under a curve in a velocity versus time graph gives
    A) acceleration. B) velocity. C) position D) displacement..

21. Suppose a ball is thrown straight up. Make a statement about the velocity and the acceleration when the ball reaches the highest point.

A) Both its velocity and its acceleration are zero.
B) Its velocity is zero and its acceleration is not zero.
C) Its velocity is not zero and its acceleration is zero.
D) Neither its velocity nor its acceleration is zero.

Chapter 1-2 Test
2015-2016

(1) $95.1 \frac{km}{h} \left(\frac{1000\,m}{1\,km}\right)\left(\frac{1\,h}{3600\,s}\right) = \boxed{26.4 \frac{m}{s}}$

(2) $v = \frac{\Delta x}{\Delta t} = \frac{2\pi r}{T} = \frac{2\pi(2.28\times10^{8}\,km)}{687\,d\left(\frac{24\,h}{1\,d}\right)}$

$= \boxed{8.69\times10^{4}\,\frac{km}{h}}$

(3) $v = \frac{\Delta x}{\Delta t} \Rightarrow \Delta t = \frac{\Delta x}{v} = \frac{18.4\,m}{0.800\times3.00\times10^{8}\frac{m}{s}}$

$= \boxed{7.67\times10^{-8}\,s}$

(4) $a = \frac{\Delta v}{\Delta t} = \frac{v - v_0}{t} = \frac{15.0 - 24.0\frac{m}{s}}{3.0\,s} = -3.00\frac{m}{s^2}$

$x - x_0 = v_0 t + \frac{1}{2}at^2 = \left(24.0\frac{m}{s}\right)(3.00\,s) + \frac{1}{2}\left(-3.00\frac{m}{s^2}\right)(3.00\,s)^2$

$= \boxed{58.5\,m}$

(5) $v = v_0 + at = 12.0\frac{m}{s} + \left(2.80\frac{m}{s^2}\right)(6.00s)$

$$= \boxed{28.8\frac{m}{s}}$$

(6) Equation

$v = v_0 + at \Rightarrow t = \frac{v - v_0}{a}$

$t = \frac{-60.0\frac{m}{s} - 60.0\frac{m}{s}}{-9.80\frac{m}{s^2}} = \boxed{12.2s}$ Time up

Time up = Time down

Table

t	v
0	60 m/s
1	50
2	40
3	30
4	20
5	10
6	0

Approx

(7) $v^2 = v_{0y}^2 + 2a(y - y_0)$ (with $v_{0y} = 0$, $a = g$)

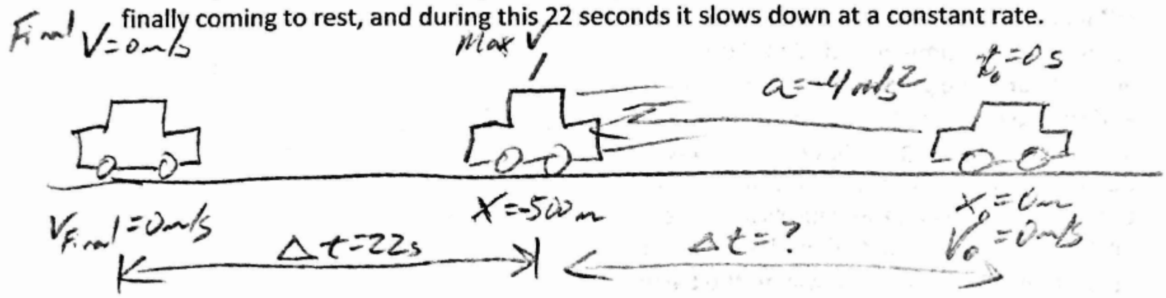
$\Rightarrow v = \sqrt{2g(y - y_0)} = \sqrt{2\left(9.80\frac{m}{s^2}\right)(6.00m)}$

$$= \boxed{10.8\frac{m}{s}}$$

Physics 200
Chapter 2: Extended Kinematics Problems Practice

Name: Key

1. A car accelerates from rest at a constant rate of $-4 m/s^2$. After accelerating at this rate for a distance of 500m, the car turns off its engine and begins to coast. The car coasts for 22 seconds before finally coming to rest, and during this 22 seconds it slows down at a constant rate.



a. What was the car's maximum speed during this event?

$v^2 = v_0^2 + 2a\Delta x$

$v^2 = 0 + 2(-4 m/s^2)(-500 m)$ ⇒ $v^2 = 4{,}000 \frac{m^2}{s^2}$

$v = -63.2 m/s$ ⇒ speed = 63.2 m/s

b. What was the car's velocity when it reached its maximum speed?

$-63.2 m/s$

c. At what time did the car reach that velocity?

$v = v_0 + at$

$-63.2 m/s = 0 + -4 m/s^2 (t)$

$t = 15.8 s$

d. What was the car's acceleration during its coasting period?

$v = v_0 + at$

$0 m/s = -63.2 m/s + a(22 s)$ ⇒ $63.2 m/s = a(22 s)$

$a = 2.87 m/s^2$

e. How far did the car travel after its motor turned off?

$\Delta x = v_0 t + \frac{1}{2}at^2 = -63.2 m/s(22 s) + \frac{1}{2}(2.87 m/s^2)(22 s)^2$

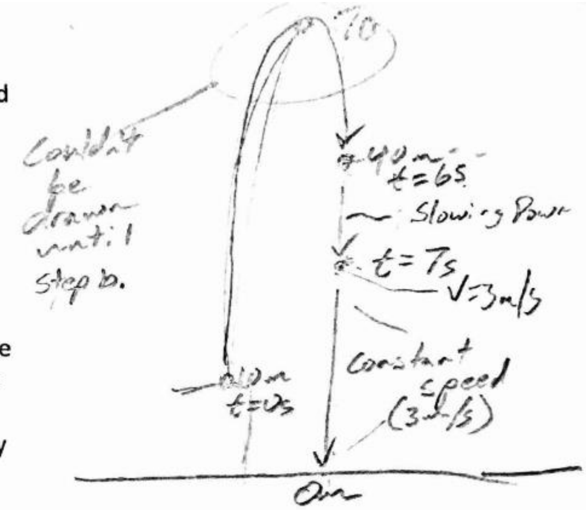
$\Delta x = -1390 m + 695 m = -695 m$

f. What was the car's total displacement?

$-500 m + -695 m = -1195 m$

accel. period   decel. period

2. A plastic action figure is launched vertically upward from a point 10m above the ground [At t = 0s, the height of the action figure is 10m above the ground]. From t=0s to t=6s, the action figure travels solely under the influence of gravity. Air resistance can be ignored for this time period. At t=6s, the action figure's height is 40m. Between t=6s and t=7s, a parachute pops out of the figure and deploys, causing the figure's speed to decrease at a constant rate for that 6s to 7s time period. At t=7s, the figure's speed is 3m/s. From t=7seconds onward, the action figure floats the rest of the way to the Earth (height = 0m) at a constant speed of 3m/s.



a. What was the action figure's initial velocity?

$\Delta x = V_0 t + \frac{1}{2} a t^2$

$30m = V_0(6s) + \frac{1}{2}(-9.8m/s^2)(6s)^2$

$30m = V_0(6s) - 176.4m \Rightarrow 206m = V_0(6)$

$V_0 = 34.3m/s$

b. What was the action figure's velocity at t=6s?

$V = V_0 + at = 34.3m/s + (-9.8m/s^2)(6s)$

$V = 34.3m/s - 58.8m/s = -24.5m/s$

c. What was the action figure's average acceleration between t=6s and t=7s?

$V = V_0 + at$

$-3m/s = -24.5m/s + a(1s) \Rightarrow 21.5m/s = a(1s)$

$a = 21.5m/s^2$

d. What was the action figure's displacement between t=6s and t=7s?

One way $\rightarrow \Delta x = V_0 t + \frac{1}{2} a t^2$

$\Delta x = -24.5m/s(1s) + \frac{1}{2}(21.5m/s^2)(1s)^2$

$\Delta x = -24.5m + 10.75m = -13.75m$

Another way $\rightarrow \bar{V} = \frac{V + V_0}{2} = \frac{-3m/s + (-24.5m/s)}{2}$

$\bar{V} = -13.75m/s$

$\bar{V} = \frac{\Delta x}{\Delta t} \Rightarrow -13.75m/s = \frac{\Delta x}{1s} \Rightarrow \Delta x = -13.75m$

e. What was the action figure's elevation at t=7s?

$40m - 13.75m = 26.25m$

f. How long did the entire trip last?

Final 26.25m traveled @ 3m/s

$\bar{V} = \frac{\Delta x}{\Delta t}$ $-3m/s = \frac{-26.25m}{\Delta t} \Rightarrow \Delta t = 8.75s$

total $t = 7s + 8.75s = 15.75s$

g. **What was the action figure's average speed?

Ave speed = total Dist. / total time. Need to know max height.

$V^2 = V_0^2 + 2a\Delta x \Rightarrow (0m/s)^2 = (34.3m/s)^2 + 2(-9.8m/s^2)(\Delta x)$

(V: at top; V_0: initial; a: $-g$)

$\Delta x = 60.0m$ = max height

Total distance = 60m up, 70m down $\Rightarrow$ 130m total

Ave speed $= \frac{130m}{15.75s}$ (total t) $= 8.25m/s$

Name Key

Ch. 2 Kinematics in 1-D Assessment

Essex High School
Physics 200

Formulas and info:

$$\Delta x = v_0 t + \frac{1}{2}at^2$$

$$v = v_0 + at$$

$$v^2 = v_0^2 + 2a\Delta x$$

1mile = 5280 feet

ft = 0.305m

Part I:

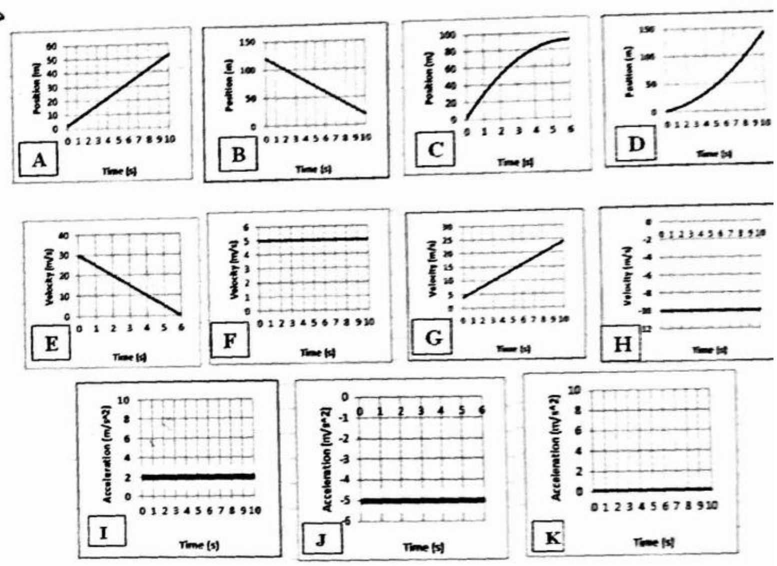
1) Describe an example of motion that has negative velocity and positive acceleration.

Someone is walking to the left and slowing down.

2) Describe an example of motion that has zero velocity and negative acceleration.

A motionless object is just beginning to move leftward (or downward)

3) Three parts:

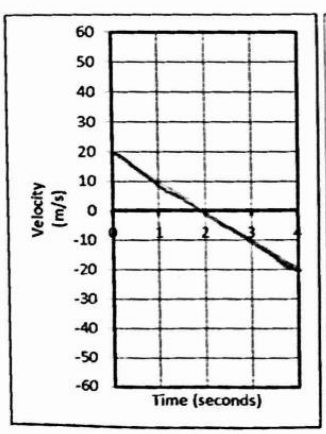


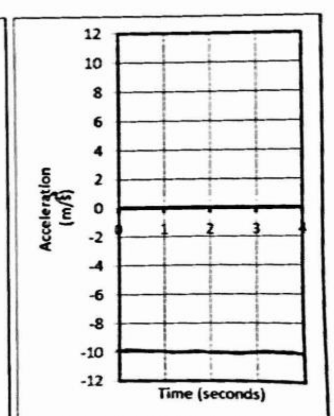
E i. Which **velocity** graph shows the same motion depicted in **position** graph **C**?

D ii. Which **position** graph shows the same motion depicted in **acceleration** graph **I**?

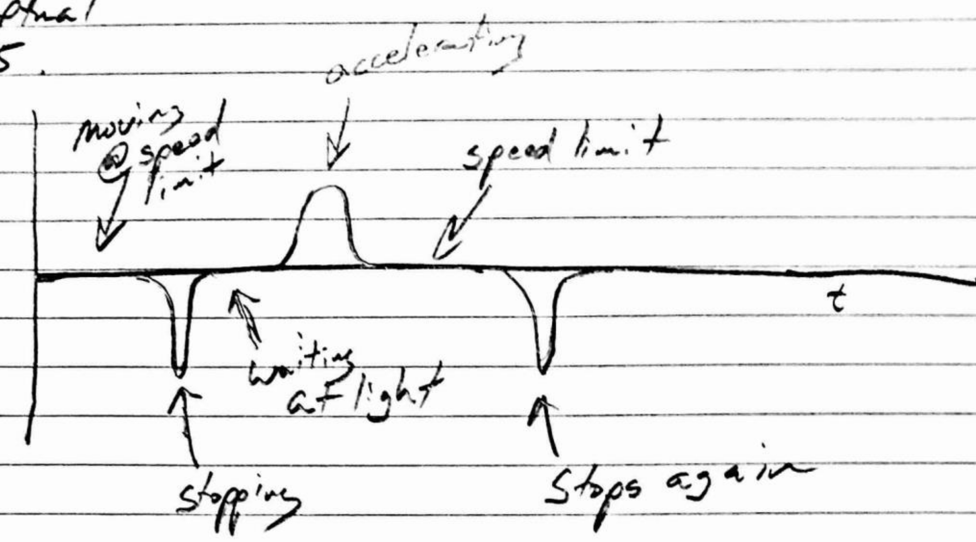
B iii. Which **position** graph shows the same motion depicted in **velocity** graph **H**?

4) (2pts) Suppose an object is launched directly upward in the absence of air resistance (i.e. freefall). The object goes up and comes down, remaining in the air for 4 seconds. On the graphs to the right, sketch the object's velocity, and acceleration at each point in the 4 second trip. ~~For simplicity, assume use g = 10m/s²~~





Conceptual #5.



(or useful diagram)

Problems [4 points Each = Useful Equation (1/2 point) + Givens with symbols and units (1/2 point) + Work – Givens substituted into equations and solved (1/2 point) + Correct units for answer (1/2 point) + Correct answer (1 point).]

1. Video analysis of a car shows that it is able to start from rest and reach a speed of 6.00 m/s over a distance of 6m meters. Calculate the car's acceleration.

$V_0 = 0\,m/s \quad V = 6.00\,m/s \quad \Delta x = 6\,m$

$V^2 = V_0^2 + 2a\Delta x$

$(6\,m/s)^2 = 0 + 2a(6\,m)$

$a = 3\,m/s^2$

2. A car is traveling at a constant rate of ~~20m/s~~ 60m/s. At some point, the car begins to undergo constant acceleration of $4 m/s^2$. If this acceleration lasts for 5 seconds, what distance does the car travel during the acceleration period?

$V_0 = 60\,m/s$

$a = 4\,m/s^2$

$\Delta t = 5\,s$

$\Delta x = V_0 t + \frac{1}{2} a t^2$

$\Delta x = 60\,m/s(5\,s) + \frac{1}{2}(4\,m/s^2)(5\,s)^2$

$\Delta x = 300\,m + 50\,m$

$\Delta x = 350\,m$

3. A pumpkin is dropped from the top of a tall building. If the pumpkin freefalls to ground level in a time of 2.5 seconds, what is its ~~speed in miles per hour~~ velocity when it hits the ground?

$V_0 = 0\,m/s$

$\Delta t = 2.5\,s$

$a = -9.8\,m/s^2$

$V = V_0 + at$

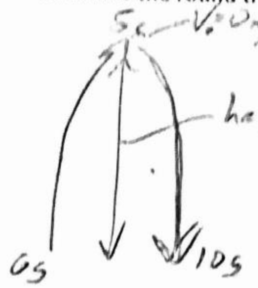
$V = 0\,m/s + (-9.8\,m/s^2)(2.5\,s)$

$V = -24.5\,m/s$

4. In the absence of air resistance (freefall), a soccer ball is kicked straight up in the air and then returns directly to Earth. If the soccer ball makes the round trip in 10 seconds, how high does the ball go?

$\Delta t_{total} = 10\,s$

$a = -9.8\,m/s^2$



height = Δx for trip ... downward

Δt for trip down = 5s

Consider the fall...

$\Delta x = V_0 t + \frac{1}{2} a t^2$

$\Delta x = 0 + \frac{1}{2}(-9.8\,m/s^2)(5\,s)^2$

$\Delta x = -123\,m$ — ball goes up 123 m

5. Starting from rest, a bear accelerates at a constant rate of 2m/s² until it reaches it's top speed of

Problem #5.

$$\left(\frac{1\ class}{10\ seconds}\right)\left(\frac{24\ students}{1\ class}\right)\left(\frac{9\ kg}{1\ student}\right)\left(\frac{1000\ g}{kg}\right)\left(\frac{3600\ s}{1\ hour}\right) = 7.78 \times 10^7\ g/hour$$

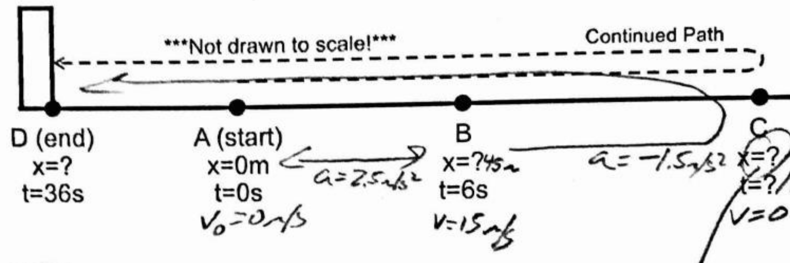
Physics 200
Chapter 2 Test (2 points each)

Extended Problem (12pts)

Name: ______________

A student is stuck on a one-dimensional line in the X dimension. She can move left and right, but not up, down, back, or forth. Starting from rest at point A (x=0m, t=0s), she accelerates to the right at a rate of $2.5 m/s^2$ until she reaches point B a time of 6 seconds. At t=6s, (as she passes point B) her acceleration instantly changes to $-1.5 m/s^2$ (leftward acceleration). She continues traveling with this same $-1.5 m/s^2$ acceleration until she reaches point D 30 seconds later (at t=36s). After leaving point B, and before reaching point D, she reverses direction at point C. At point D she crashes into an immovable wall and stops.

Acceleration between **points A and B = $2.5 m/s^2$**
Acceleration between **points B and D = $-1.5 m/s^2$**



$x = 45m$
$+ 75m$
$= 120m$

(a) What is her **velocity** at point B?

$V = V_0 + at$
$= 0 m/s + 2.5 m/s(6s) = 15 m/s$

(b) What is the **distance** of point B from the origin (Point A, x=0m)?

$\Delta x = V_0 t + \frac{1}{2} a t^2$
$= 0 + \frac{1}{2}(2.5 m/s)(6s)^2$
$= 45m$

(c) How much ~~time~~ elapses as she travels from point B to point C?

$V_0 = 15 m/s$
$V = 0 m/s$
$a = -1.5 m/s^2$

$V = V_0 + at$
$0 m/s = 15 m/s + (-1.5 m/s^2) t$
$\Delta t = 10s$

(d) What is the **distance** between points B and C?

$\Delta t = 10s$ between B+C

$\Delta x = V_0 t + \frac{1}{2} a t^2$
$= 15 m/s(10s) + \frac{1}{2}(-1.5 m/s^2)(10s)^2$
$= 150m - 75m = 75m$

(e) What is her **velocity** when she reaches point D (before she stops, while she is still moving)?

Consider C to D $\Rightarrow V_0 = 0 m/s$ $a = -1.5 m/s^2$ $t_0 = 16s$ $t = 36s$ $\Delta t = 20s$

$V = V_0 + at \Rightarrow V = 0 m/s + (-1.5 m/s^2)(20s)$
$V = -30 m/s$

(f) What is her total ***displacement*** (**not** distance traveled!) for the entire trip – through all points A-D?

$X_0 = 0m$ $X = ?$

$\Delta X_{A \to B} = 45$
$\Delta X_{B \to D} = -225$
$\Delta x_{total} = 45 - 225 = -180m$

Total Δx

(Consider $B \to D$: $X_0 = 45m$ $V_0 = 15 m/s$ $t_0 = 6s$
$t = 36s$ $\Delta t = 30s$ $a = -1.5 m/s^2$

$\Delta x = V_0 t + \frac{1}{2} a t^2$
$= 15 m/s(30s) + \frac{1}{2}(-1.5 m/s^2)(30s)^2 = -225m$

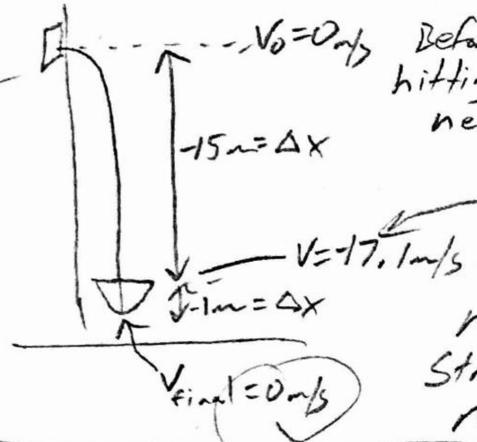
Physics 200

More Kinematics Problems

Name: ____________________

57. A person jumps from a fourth-story window 15.0 m above a firefighter's safety net. The survivor stretches the net 1.0 m before coming to rest. What was the average deceleration experienced by the survivor when she was slowed to rest by the net? (b) What would you do to make it "safer" (that is, to generate a smaller deceleration): would you stiffen or loosen the net? Explain.

Part A



Before hitting net $\Rightarrow$ $V^2 = V_0^2 + 2a\Delta x$

$V^2 = (0\,m/s)^2 + 2(-9.8\,m/s^2)(-15\,m)$

$V = -17.1\,m/s$

While stretching net $\Rightarrow$ $V^2 = V_0^2 + 2a\Delta x$ (V_0: before hitting net; Δx: net stretch)

$(0\,m/s)^2 = (-17.1\,m/s)^2 + 2(a)(-1\,m)$

$a = 147\,m/s^2$

Part B To decrease acceleration, loosen the net, so the acceleration distance increases.

58. The acceleration due to gravity on the Moon is about one-sixth what it is on Earth. If an object is thrown vertically upward on the Moon, how many times higher will it go than it would on Earth, assuming the same initial velocity?

The most concrete way to solve this is to make up a velocity and solve with -9.8 and $\frac{-9.8}{6}$.

Another way...
Consider the upward flight

$V^2 = V_0^2 + 2a\Delta x$

$0 = V_0^2 + 2a\Delta x$ (V at top of flight path)

$\Delta x = \frac{-V_0^2}{2a}$

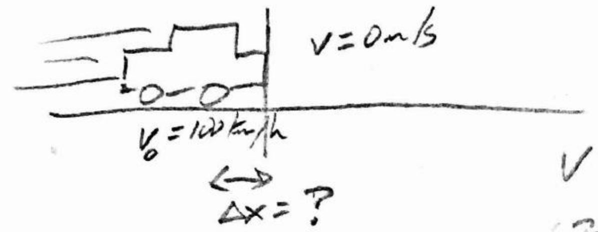
on Earth $\Delta x = \frac{-V_0^2}{2(-g)} = \frac{1}{2}\frac{V_0^2}{g}$

on the moon $\Delta x = \frac{-V_0^2}{2(-g/6)} = \frac{3V_0^2}{g}$

6X higher than

59. A person who is properly constrained by an over-the-shoulder seat belt has a good chance of surviving a car collision if the deceleration does not exceed about 30 "gs" $(1.0\,g = 9.8\,\text{m/s}^2)$. Assuming uniform deceleration of this value, calculate the distance over which the front end of the car must be designed to collapse if a crash brings the car to rest from 100 km/h.

$a = 30g = 30(9.8\,\text{m/s}^2) = 294\,\text{m/s}^2$



$a = -294\,\text{m/s}^2$

$v_0 = \left(\frac{100\,\text{km}}{\text{h}}\right)\left(\frac{1\,\text{hr}}{3600\,\text{s}}\right)\left(\frac{1000\,\text{m}}{1\,\text{km}}\right)$

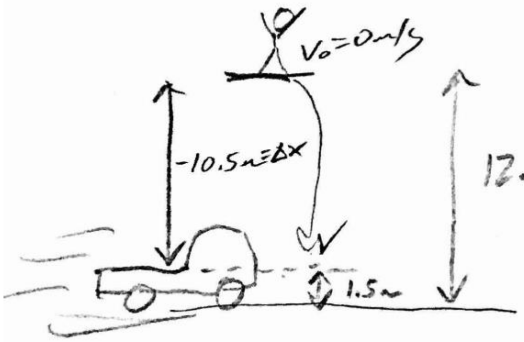
$v_0 = 27.8\,\text{m/s}$

$v^2 = v_0^2 + 2a\Delta x$

$0^2 = (27.8\,\text{m/s})^2 + 2(-294\,\text{m/s}^2)\Delta x$

$\Delta x = 1.31\,\text{m}$

60. Agent Bond is standing on a bridge, 12 m above the road below, and his pursuers are getting too close for comfort. He spots a flatbed truck approaching at 25 m/s, which he measures by knowing that the telephone poles the truck is passing are 25 m apart in this country. The bed of the truck is 1.5 m above the road, and Bond quickly calculates how many poles away the truck should be when he jumps down from the bridge onto the truck to make his getaway. How many poles is it?



Find fall time $\Rightarrow$ $\Delta x = v_0 t + \frac{1}{2}at^2$

$-10.5\,\text{m} = 0\,\text{m/s}\,t + \frac{1}{2}(-9.8\,\text{m/s}^2)t^2$

$-10.5\,\text{m} = -4.9\,\text{m/s}^2\,t^2$

$2.14\,\text{s}^2 = t^2$

$t = 1.46\,\text{s}$ (fall time)

Find Distance traveled by truck during fall

$\bar{v} = \frac{\Delta x}{\Delta t}$ $\quad 25\,\text{m/s} = \frac{\Delta x}{1.46\,\text{s}}$

$\Delta x = 36\,\text{m}$

convert to poles

$36\,\text{m}\left(\frac{1\,\text{pole}}{25\,\text{m}}\right) = 1.46\ \text{poles}$