Early E. C.:	**/ 1**
Total HW Points Unit 2:	**/ 18**
Total Lab Points Unit 2:	**/ 52**
Unit 2 Apps.:	**/ 5**
Late, Incomplete, No Work, No Units Fee?	Y / N

Unit 2 – One Dimensional Kinematics

Essential Fundamentals of Kinematics

1. Distance is total path length (a scalar); displacement is straight-line position change (a vector).
2. Initial position, velocity, and acceleration govern the final position of an object.
3. Velocity and acceleration are vector quantities: an object's direction and speed matter.
4. Free fall calculations of motion involve g – earth's local gravitational constant (-9.81 m/s^2).

Add More!

Link to Algebra

In Unit 2, the following equations will be used. Isolate the variables indicated to prepare for it.

AP Equations (solid boxes)

In-Class Equations (dashed boxes)

Average Speed Definition

$$\bar{s} = \frac{d}{\Delta t}$$

$d =$

$\Delta t =$

Velocity Definition

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

$\Delta x =$

$\Delta t =$

Velocity Equation

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

$v_{x0} =$

$a_x =$

$t =$

Acceleration Definition

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

$\Delta v =$

$\Delta t =$

Position Equation

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

$x_0 =$

$v_{x0} =$

$a_x =$

$t =$

Sandbag Equation

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

$v_x =$

$v_{x0} =$

$a_x =$

$\Delta x =$

Free Fall Kinematics

$$v = v_0 - gt$$

$t =$

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

$v_0 =$

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

$v_0 =$

Possible 2.1 Pts.:	5
Late, Incomplete, No work, No Units Fee:	- 1 - 2 - 3
Final Score:	**/ 5**

2.1 Problems – Distance and Motion
Section 2.1 – 2.2 of your book.

1. What is the magnitude of the displacement of a car that travels half a lap around a circular track with a radius of 150 m? How about when the car travels a full lap? What distance does the car cover in both of the previous cases?

2. a. A hospital nurse walks 30.0 m to a patient's room at the end of the hall in 35 seconds. She talks with the patient for 2.0 minutes, then walks back to the nursing station at the same rate. What is the nurse's average speed for the entire journey? What's her average velocity for the entire journey?

   b. Graphically show the nurse's entire journey in a labeled time vs. position graph.

For the next problem, the distance between two cities is 150 km. Metric/Imperial conversion: Resources P. 4.

3. a. If you drive the distance at the legal speed limit of 65 mi/h, how long would the trip take?

   b. Suppose on the return journey you pushed it up to 80 mi/h. How much time would you save?

Possible 2.2 Pts.: 4
Late, Incomplete, No work, No Units Fee: - 1 - 2 - 3
Final Score: / 4

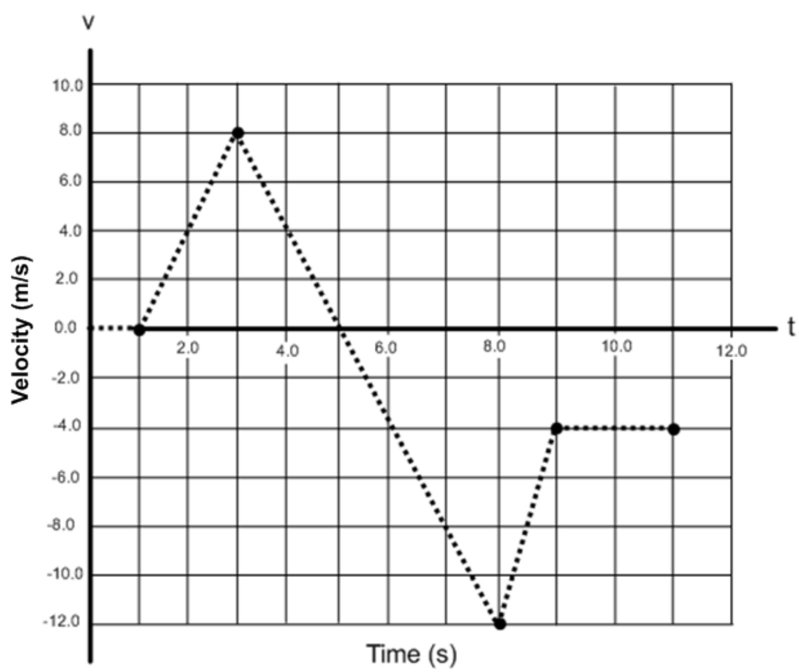
2.2 Problems – Acceleration
Section 2.3 of your book.

1. An automobile traveling at 4.17 m/s along a straight, level road accelerates to 18.1 m/s in 6.00 s. What is the magnitude of the auto's average acceleration in m/s^2?

2. If a sports car can accelerate at a rate of 7.2 m/s^2, how long does the car take to accelerate from 0 m/s to 27 m/s?

3. The following figure shows a plot of velocity vs. time for an object in linear motion.
   a. Compute the acceleration for each of the five phases of motion below, and report your values in a table.

   b. Describe the object's movement during the last time segment.



Possible 2.3 Pts.:	6
Late, Incomplete, No work, No Units Fee:	- 1 - 2 - 3
Final Score:	/ 6

2.3 Problems – One Dimensional Kinematics

Section 2.4 of your book.

Wizard Challenge Alert!

1. A. At a sports car rally, a car starting from rest accelerates uniformly at a rate of 9.0 m/s^2 over a straight line distance of 100.0 m. How long does the driver take to cover this distance?

   B. For the previous problem, the time to beat in this event is 4.5 s. What must the minimum acceleration be to beat this 4.5 second requirement?

2. A. A car traveling at 25 m/s needs to stop on a 35-m-long shoulder of the road. What is the required magnitude of minimum acceleration?

   B. For the previous problem, how much time will elapse before the car stops?

3. Two cars, A and B, starting from rest, accelerate away from a starting line for the same amount of time. Car A has half the magnitude of acceleration as Car B. How much farther will Car B have gone after this time? What percent of the Car B's speed will Car A have?

Possible 2.4 Pts.:	4
Late, Incomplete, No work, No Units Fee:	- 1 - 2 - 3
Final Score:	/ 4

2.4 Problems – Free Fall – Gravitational Force
Section 2.5 of your book.

1. A. A student drops a ball from the top of a tall building, and it takes 4.25 seconds to hit the ground. What was the ball's speed as it hit the ground?

   B. What is the height of the building in the previous problem?

2. Two towers have heights of 452 m, and 443 m. If objects were dropped from the top of each, what would be the difference in the time it takes the objects to reach the ground?

3. A juggler tosses a ball 2.5 m into the air. How much higher must the ball be tossed so as to spend twice as much time in the air?

AP Physics 1	Unit 2.1 Lab - Kinematics Graphing Excel Tutorial
Reminder: Update Table of Contents	Correction Credit: Half

Excel Tutorial Lab (2.1) Guide		
Table of Contents, Title/Date, Detailed Synopsis, Two Purposes		/ 2
Mission 1: Spreadsheets and Graphing	Spreadsheet with Boxed Data	/ 2
	Position Graph	/ 2
	Velocity Graph	/ 2
	Acceleration Graph	/ 2
	Labels on Graphs	/ 3
	All on One Page	/ 1
Question 1: Benefits of Computer Based Graphing		/ 2
Late Lab Fee:		- 3
Total:		/ 16

Overview:

Students will be given an Excel tutorial. By the time the tutorial is over, they should be able to produce simple x-y graphs and use basic spread sheet programming to compute values.

Resources page 15: There is an Excel Guide in the back of your Booklet – read it before the lab.

Mission 1: Spreadsheet Manipulation and Graphing

1. Open an Excel file and title it "Excel Tutorial by (your name)."
2. Several spaces down, make four columns in a row named time (s), position (m), velocity (m/s), and acceleration (m/s^2). See example below:

Time (s)	Position (m)	Velocity (m/s)	Acceleration (m/s^2)
0.00	0.00	0.00	0.00

3. For each column, make the first value zero.
4. For the second value of each column, I will guide you through inputting formulas:
   a. Time: add 0.25 seconds to each subsequent value
   b. Position: input the position equation
   c. Velocity: input the velocity equation
   d. Acceleration: copy the acceleration from the previous line. You will alter this later.
5. Copy formulas down until 5 seconds are shown.
6. Make three straight line x-y scatter graphs: position vs. time, velocity vs. time, acceleration vs. time by selecting appropriate data blocks and inserting a graph.
7. Re-size and move the graphs so they all fit on one page. Press Control Print, then escape, and you can see how they sit on your page.
8. Alter some of the acceleration data and see how it changes all three of your graphs. If you want to reset your acceleration back to the original values, type in zero again for the first value, input the 'equals previous line' equation, and copy the formula all the way down.
9. Tidying up. Put a box around your title and each data set, then make a thick box border around the entire data table. If it's necessary to shrink any rows, or merge cells, I'll show you how.
10. When you have made a graph that shows at least one segment of positive and one segment of negative acceleration, print the whole sheet and staple it into your Lab Notebook. Along with your pre-lab, this will serve as the gradable material. Points will be deducted if you print on more than one sheet. In future labs, you can cut up printouts and only include data tables and graphs, but for this lab, I want to see that you shrunk it appropriately.

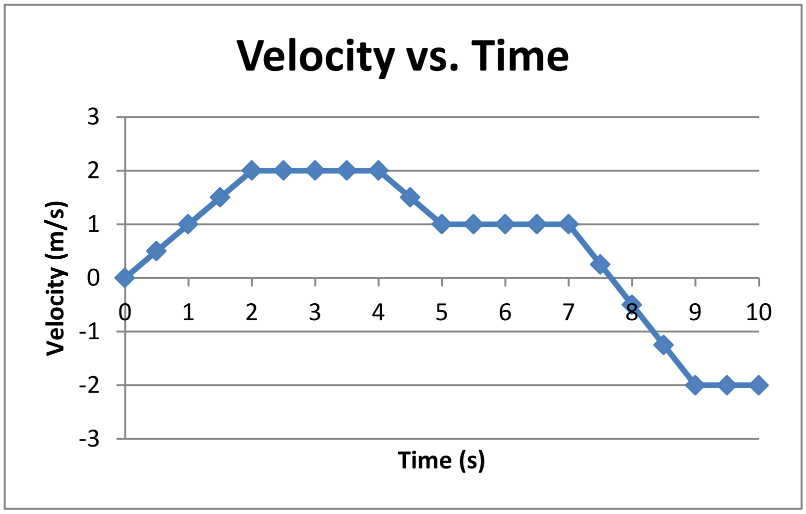
Question: Rephrase and answer in complete sentences for full credit.

1. Explain the benefits of using a spreadsheet/graphing program vs. doing it all by hand.

AP Physics 1	Unit 2.2 Lab - Kinematics - Velocity, Acceleration, Position
Reminder: Update Table of Contents	Correction Credit: Half

Overview:

Students interpret the following graph with partners, and respond to questions and directives entirely in their Lab Notebooks. While Excel is recommended for tables and graphs, it is not a requirement.



Kinematics Lab (2.2) Scoring Guide		
Table of Contents, Title/Date, Detailed Synopsis, Two Purposes		/ 2
Mission 1: Velocity vs. Time	Complete Description	/ 4
	Data Table	/ 2
Mission 2: Acc. vs. Time	Data Table	/ 2
	Graph	/ 2
Mission 3: Pos. vs. Time	Data Table	/ 2
	Graph	/ 2
Question 1: Significance of a horizontal slope in graphs.		/ 2
Late Lab Fee:		-4
Total:		**/ 18**

Mission 1: Velocity vs. Time

Use the graph to describe the movement of an object during a 10 second journey. Be thorough in your description, stating negative values (or direction indicators: forwards, backwards, etc.) when needed.

Produce a complete data table of time vs. velocity using data from the graph at ½ second intervals.

Mission 2: Acceleration vs. Time

Based on the information from the graph, and the data table you produced, make a data table and graph portraying acceleration vs. time for all ten seconds.

Mission 3: Position vs. Time

Make a position vs. time data table and graph for the first two phases of motion (from 0 to 4 seconds), using your velocity vs time and acceleration vs. time tables, using the position equation iteratively. Calculate every position at ½ second intervals.

Be careful that you use the correct number of seconds for each calculation. Because you are making a calculation every ½ of a second, time (t) should always equal 0.5 in your equation.

Questions: Rephrase and answer in complete sentences for full credit.

1. Consider three kinematics graphs: a) position vs time, b) velocity vs. time, and c) acceleration vs. time. Describe what a horizontal slope at y = + 1 means for each type of graph.

AP Physics 1	Unit 2.3 Lab - Determining g
Reminder: Update Table of Contents	Correction Credit: Half

Determining g Lab (2.3) Scoring Guide		
Table of Contents, Title/Date, Detailed Synopsis, Two Purposes		/ 2
Mission 1: Determining g	Data Table	/ 1
	Wall Height	/ 1
	Three Drop Times	/ 3
	Average Time	/ 1
	Average value of g	/ 1
	Percent error	/ 1
Mission 2: Graph Free Fall	Graph (2 Bounces)	/ 2
	Description	/ 2
Extra Credit:	What's a 'g'?	+ 1
Question 1: How could you improve measurements? Error sources?		/ 2
Question 2: How would data change if measured at center of Earth?		/ 2
Work Not Shown Fee:		-1 -2 -3
Late Lab Fee:		-3
Total:		**/ 18**

Overview:

The question "What up g?" could have inspired Sir Isaac Newton to begin a quest to determine earth's gravitational constant.

In this lab, you will experimentally determine a value for g, and produce a crude graph of position vs. time of a falling golf ball.

You will use the position equation as modified for an object moving under the influence of gravity:

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

Equipment: Meter Stick, Masking Tape, Golf Ball, Stop Watch

Mission 1: Determining g

Working in groups, measure 2.00 m as accurately as possible on a wall and mark it with tape. DO NOT ALLOW THE TAPE TO REMOVE PAINT! Next, measure the time it takes for a ball to fall from your mark to the ground. Be sure to practice a couple times before recording data. Take AT LEAST THREE measurements of this, and record all data in a neat table.

Determine the average of the time measurements and include that in your table.

Isolate g in the free fall equation, and solve for it by plugging in the values of time and position that you measured from your experiment. Show **all** algebraic steps for full credit.

Calculate the percent error of your value, compared to an accepted value of 9.81 m/s^2. The formula is:

$$\% \text{ Error} = \frac{|\text{Experimental - Accepted value}|}{\text{Accepted value}} \times 100\%$$

Mission 2: Graphing Free Fall

Make a graph of position vs. time for two bounces of your ball (end at the top of the arc after the second bounce). Describe exactly how you got time data for your graph. In other words, there are different ways to determine exactly at what point along the time axis you show a bounce, how did your group do it?

Questions: Rephrase and answer in complete sentences for full credit.

1. How could you improve the measurements leading to your value of g? What were sources of error in your survey?

2. How would you expect your data to change if you were somehow able to take measurements at the center of the Earth? In other words, how would things fall there?

E. C. What's a 'g' in the expression "What up g"?

AP Physics 1	Unit 2 - Kinematics				
Application Problems, AP Test Preparation Questions					
Presentation Points:	/ 5	Late Fee:	-2	Completion (Booklet Check)	/ 5

Your grade on this problem set will depend on the presentation you provide for your problem, and whether they are complete when you submit your Booklet at the end of the Unit.

A car accelerates from rest at a constant rate of 2.5 m/s^2 for 7.0 s. Answer questions 1 and 2:

1. A. What is the velocity of the car at the end of that time?
   B. How far does the car travel in this time?

2. A boat traveling on a straight course slows uniformly from 16.7 m/s to 11.1 m/s in 50.0 m. What's the boat's acceleration?

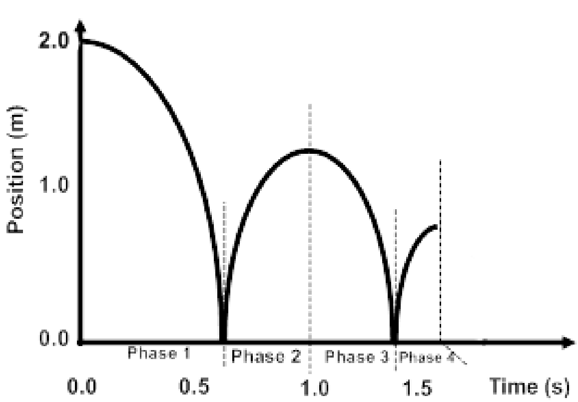
3. A roller coaster travelling at 20.0 m/s on a level track comes to an incline. The car's acceleration up the incline is 0.750 m/s^2. What is the car's velocity after 10.0 seconds?

A student drops a ball off a tall building, and it takes 2.8 s to hit the ground. Answer questions 4 & 5.

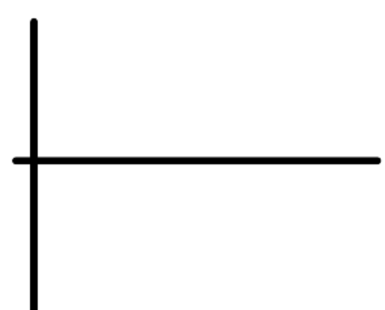
4. What was the ball's velocity just before hitting the ground?

5. How high is the building?

6. A. From the following graph of position vs. time of a ball dropped from 2.0 m off the ground, make a rough graph of velocity vs. time. The shape of the graph is what’s important, not how accurate it is. Hint: use the different phases of the graph to help track your object
   B. From the following graph, make a rough graph of acceleration vs. time.



A. Velocity Vs. Time



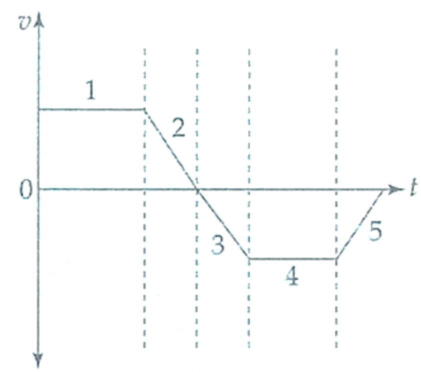
B. Acceleration Vs. Time

Unit 2 Practice AP Multiple Choice Questions

The following problems (multiple choice and free response) are designed to train you to take the AP Physics 1 test in the spring, and will be scored at the end of the Unit – based on completion and accuracy.

1. An object moving with constant speed travels once around a circular path. Which of the following statements are true concerning this motion? Select two answers.
   a. The displacement is zero. b. The average speed is zero.
   c. The acceleration is zero. d. The velocity is changing.

2. In section 5 of this velocity-time graph, the object is
   a. Speeding up moving in the positive direction.
   b. Slowing down moving in the positive direction.
   c. Speeding up moving in the negative direction.
   d. Slowing down in the negative direction.



3. Which of the following statements are about uniformly accelerated motion?
   a. If an object's acceleration is constant, then it must move in a straight line.
   b. If an object's acceleration is zero, then its speed must remain constant.
   c. If an object's speed remains constant, then its acceleration must be zero.
   d. If the object's direction of motion is changing then its acceleration is not zero.

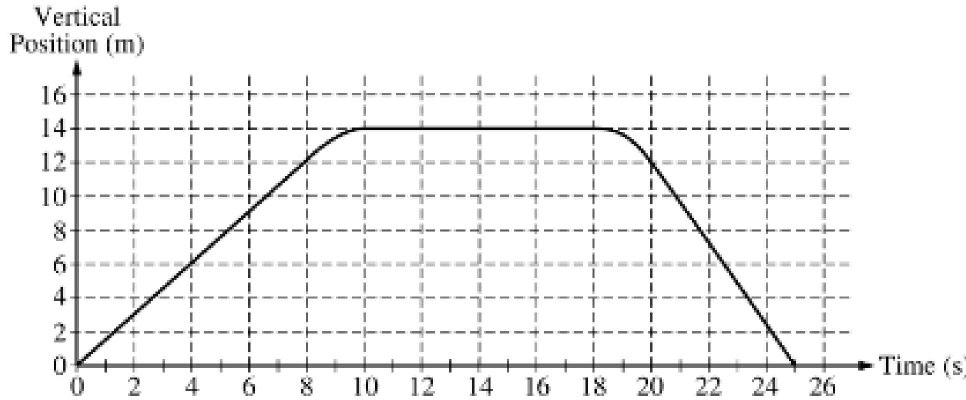
4. A baseball is thrown straight upward. What is the ball's acceleration at its highest point?
   a. ½ g, downward b. g, downward c. ½ g, upward d. g, upward

5. How long would it take a car, starting from rest and accelerating uniformly in a straight line at 5.0 m/s^2 to cover a distance of 200 m?
   a. 9.0 s b. 10.5 s c. 12.0 s d. 15.5 s

6. A rock is dropped off a cliff and strikes the ground with a velocity of 30.0 m/s. How high was the cliff?
   a. 20 m b. 30 m c. 45 m d. 60 m

Unit 2 Example AP Question – Free Response

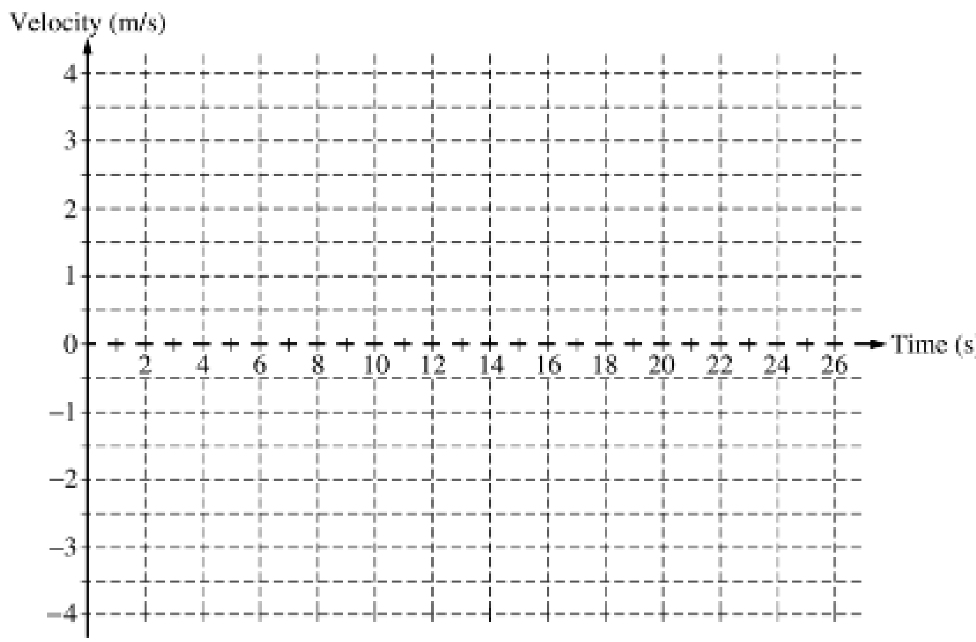
Note: Point values listed do not apply, and part c requires not-yet-encountered information.



1. (10 points)

The vertical position of an elevator as a function of time is shown above.

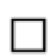
(a) On the grid below, graph the velocity of the elevator as a function of time.



(b)

i. Calculate the average acceleration for the time period $t = 8$ s to $t = 10$ s.

ii. On the box below that represents the elevator, draw a vector to represent the direction of this average acceleration.



(c) Suppose that there is a passenger of mass 70 kg in the elevator. Calculate the apparent weight of the passenger at time $t = 4$ s.

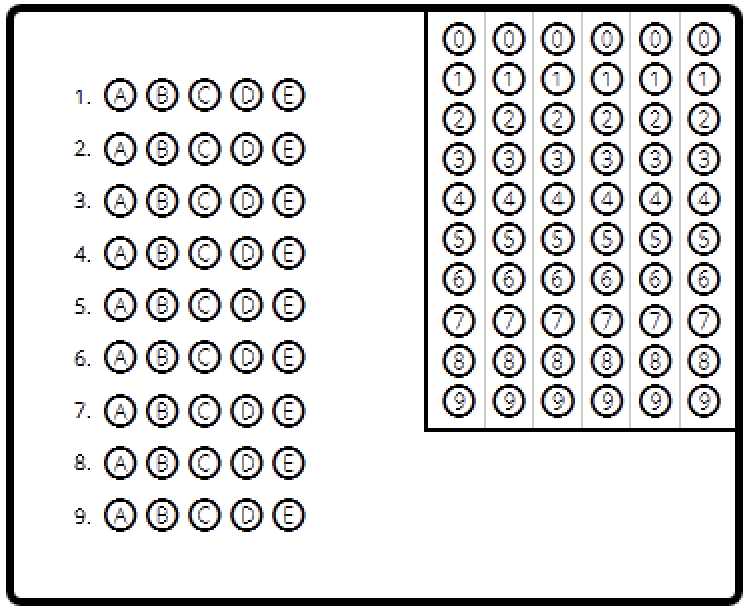
AP Physics 1		Unit 2 Review - Kinematics					
Points:	/ 18	Late or Incomplete Fee:	-2 -4 -6	Correction Credit:		Final Score:	

Solve these problems here, THEN enter your responses in the bubble sheet provided. On the due date, I will scan your responses in class, mark which problems you missed, and enter your score in Powerschool.

If you submit your responses on time, you will have one attempt to correct errors you made (for half credit back).

If you are late, you will only get one attempt, and will only receive half credit for the problems you got right.

Each question is worth two points.



1. A hunter fires a bullet at a target using a gun that produces constant acceleration. What is the average acceleration acting on the bullet if the barrel of the gun is 0.65 meters and the bullet leaves the barrel at a rate of 365 m/s?

A) 4.8 E 5 m/s^2 B) 1,450 m/s^2 C) 1.0 E 5 m/s^2 D) 1.38 E 4 m/s^2

2. If a target is 2.00 E 2 meters down range of the shooter in problem 1, how long will the bullet take to reach it, neglecting air resistance?

A) 0.55 s B) 1.10 s C) 0.26 s D) 0.75 s E) 0.85 s

3. If the speed of sound is 343 m/s in air, will the target from problem 2 hear the gunshot or get hit by the bullet first?

A) The target would hear the shot first. B) The target would get hit by the bullet first.

4. A firework manufacturing company makes mortar shells that are fired straight up in the air. If they are designed to detonate exactly at the apex of their flight, 5.00 seconds after launching, what is the velocity of launch? Neglect air resistance.

A) 0.0 m/s B) 25.8 m/s C) 49.1 m/s D) 51.6 m/s E) 35.6 m/s

5. A firework manufacturing company makes mortar shells that are fired straight up in the air. If they are designed to detonate exactly at the apex of their flight, 5.00 seconds after launching, how high would the shell fly?

A) 49.1 m B) 246 m C) 157 m D) 123 m E) 119 m

6. A car accelerates from rest at a constant rate of 2.0 m/s^2 for 5.0 s. What is the velocity of the car after that time?

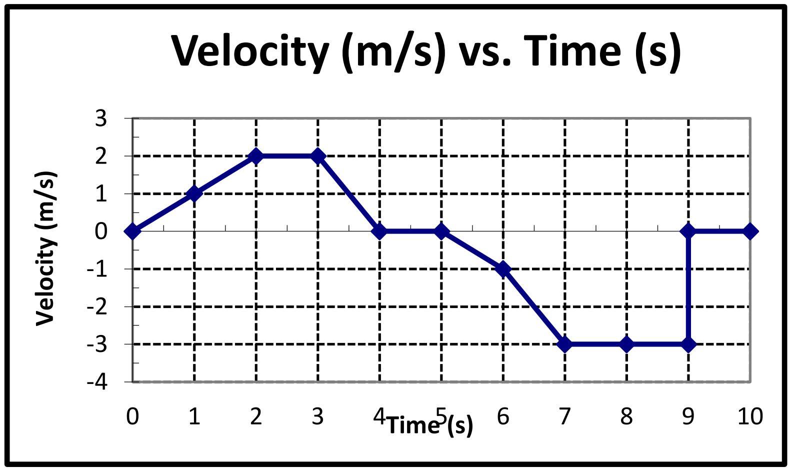
A) 50. m/s B) 10. m/s C) 25 m/s D) 15 m/s E) 35 m/s

7. How far did the car from problem 6 travel in 5.0 seconds?

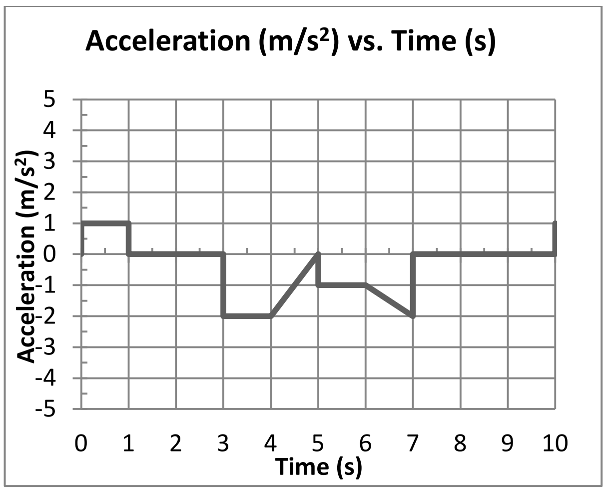
A) 25 m B) 10. m C) 50. m D) 15 m E) 0.0 m

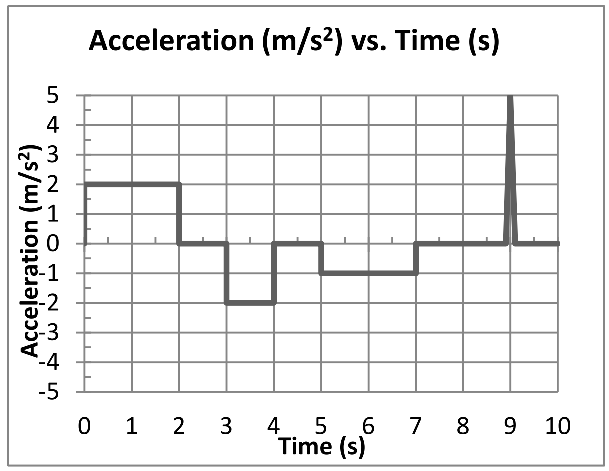
Use the following graph to complete Problems 8 and 9.

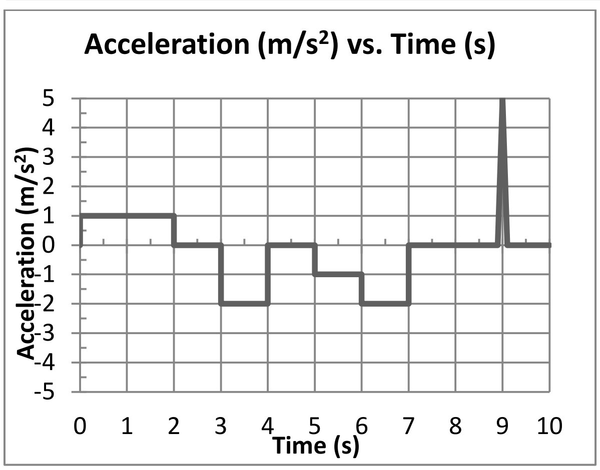
Imagine a car parked in front of its garage, but facing directly away from it. The garage door is open. Consider the following velocity vs. time graph of the car as its owner leaves for work in the morning:

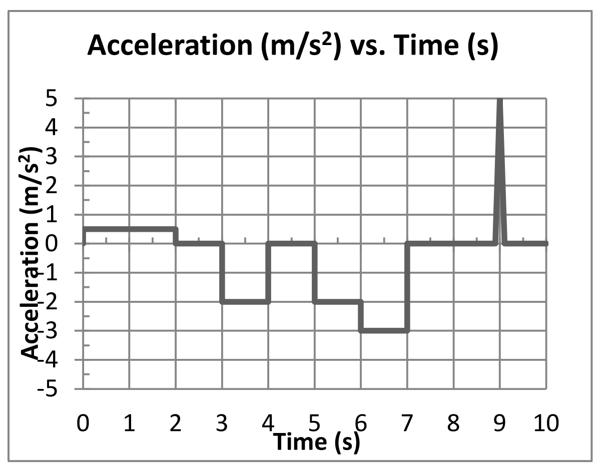


8. Identify the appropriate acceleration vs. time graph of the car's movement.

A)


B)


C)


D)


9. Using the position equation iteratively, ($x = x_0 + v_0t + \frac{1}{2}at^2$), determine what position the car will be at t = 5.0 s.

A) 2.5 m B) 5.0 m C) 6.5 m D) 7.25 m E) 14.2 m