Name: ____________________

Unit P1-01 – Motion in One Dimension
Reading Notes

Directions: Read each section on the night it is assigned, with emphasis on answering the questions below. Do not do anything marked "example", but do problems marked "test your understanding".

Section 2-1: Reference Frames and Displacement

Explain what "frame of reference" is in terms a junior-high student could understand.

Define "distance" and "displacement" as briefly as possible using the word "length":

Distance is ____.

Displacement is ____.

Explain what a vector is. If you use the word "magnitude", then say what that word means.

Explain what a scalar is.

What letter is the symbol for displacement used in mathematical equations? _____

Distance and displacement are measured in what units? __________

Section 2-2: Average Velocity

Give a word-equation for average speed and a word-equation for average velocity. Circle the key difference in each the two equations.

What does velocity have that speed does not have? _______________

What is the symbol for time? _____ Time is measured in what units? __________

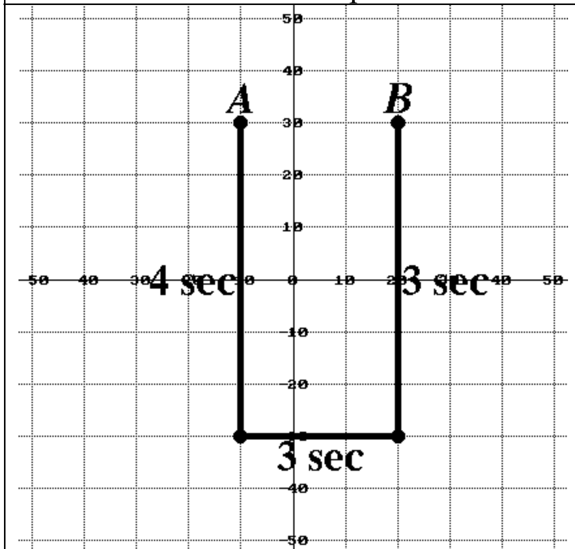
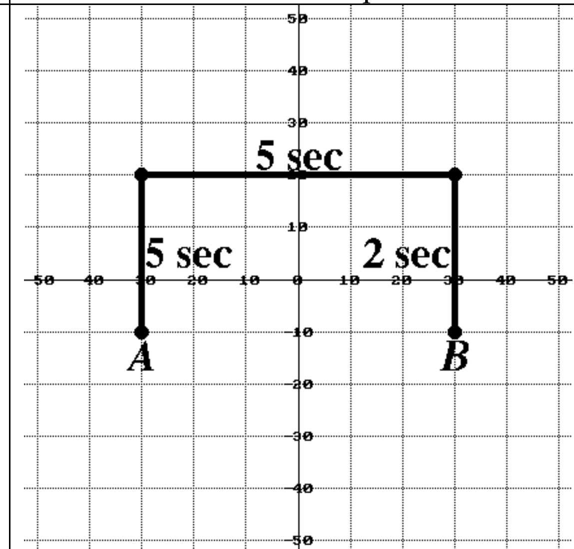
What is the symbol for velocity? _____ Velocity is measured in what units? _______________

How is "average" indicated on the symbol for velocity? _______________________________

What symbol represents the word "change"? ____________________

What mathematical operation is used when finding "change"? (+) (–) (×) (÷)

Test Your Understanding: Below you will see diagrams showing a trip taken by Fred and a trip taken by Frank. For each person, find their distance, displacement, average speed, and average velocity from *A* to *B*. Each square is 1 meter wide, and use words like *north*, *south*, *east*, and *west* for direction.

	Fred's Trip	Frank's Trip
		
Distance		
Displacement		
Average Speed		
Average Velocity		

Example: The first thing Fred did was go south for 4 seconds. If he wanted to cut his average speed in half, how long should that southward motion last (assuming the other two motions happen in the same time as shown)? Explain your reasoning.

Would this amount of wait-time have also halved his average velocity? __________

Section 2-3: Instantaneous Velocity

Explain what "instantaneous velocity" is in the simplest terms possible. Make sure you point out the difference between this and "average velocity". Use phrases like "period of time" or "moment in time".

Test Your Understanding: What does a speedometer in a car measure?

(a) Average Speed
(b) Average Velocity
(c) Instantaneous Speed
(d) Instantaneous Velocity

Explain why it is average or instantaneous and why it is velocity or speed.

Test Your Understanding: What two instruments in a car can be used to measure the car's average speed during a long car trip? Explain how to use these instruments to calculate average speed.

Section 2-4: Acceleration

Write a word-equation for acceleration.

What is the symbol for acceleration? _____ Acceleration is measured in what units? __________

Explain where the "square" in the units for acceleration comes from.

Test Your Understanding: Fill in the following Madlibs about acceleration:

A car's acceleration is +5 m/s^2. That means that the car's ________________ (physical quantity) increases by 5 ________________ (physical units) every ________________ (physical unit) of ________________ (physical quantity).

A car is advertised to "go from zero to 60 mph in 2 seconds." While this happens, the car's ________________ (physical quantity) ________________ (present-tense verb) by ________________ (number) ________________ (physical units) every ________________ (physical unit) of ________________ (physical quantity). The car's acceleration is ________________ (number) ________________ (physical units).

The acceleration of a falling object is 10 m/s^2. If a penny is dropped from the top of the Empire State Building, the ________________ (possessive noun) ________________ (physical quantity) ________________ (present-tense verb) ________________ (preposition) ________________ (number) ________________ (physical units) ________________ (indefinite adjective) ________________ (physical unit) ________________ (preposition) ________________ (physical quantity).

Test Your Understanding: Write two almost-identical sentences below using the words "rate of change of".

Velocity is ____

Acceleration is ____

Section 2-5: Motion at Constant Acceleration

In this section, Giancoli *derives* four equations that describe motion with *constant acceleration*. "Derive" means start from one or more known statements of math and apply algebra to create new statements of math. Giancoli shows his steps, so it is difficult to find which of all of the equations you see are the equations that you need to become familiar with. They have the blue words next to them and are summarized on page 28. They are also written below (rearranged for simplification).

$x = \bar{v}t + x_0$ $\qquad x = \frac{1}{2}at^2 + v_0 t + x_0$ $\qquad v = at + v_0$ $\qquad v^2 = 2ax + v_0{}^2$

Identify every symbol that you used in the four equations above.

$x =$ $\qquad v =$ $\qquad a =$

$x_0 =$ $\qquad v_0 =$ $\qquad t =$

Multiple Representations of Acceleration Exercises: Each exercise gives you either a position vs. time equation or a velocity vs. time equation that looks like the middle two equations above. For each exercise, fill in the blank numbers in the other equations. Then make a table of position, velocity, and acceleration vs. time. Then plot points that represent your table on the three graphs given and create a motion map (draw a ○ for the dot at time $t = 0$ and a ● for all other dots). All units are meters and seconds.

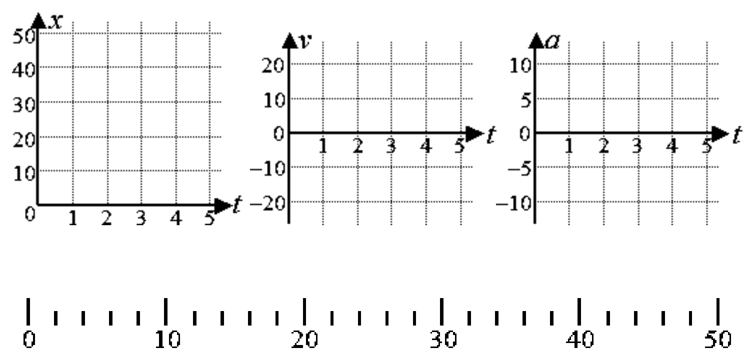
$x = 2t^2 - 20t + 50$

$v =$ ______ $t +$ ______

$a =$ ______

Circle one for each:
Veloc is (+) (–)
Accel is (+) (–) (0)

t	x	v	a
0			
1			
2			
3			
4			
5			



= =

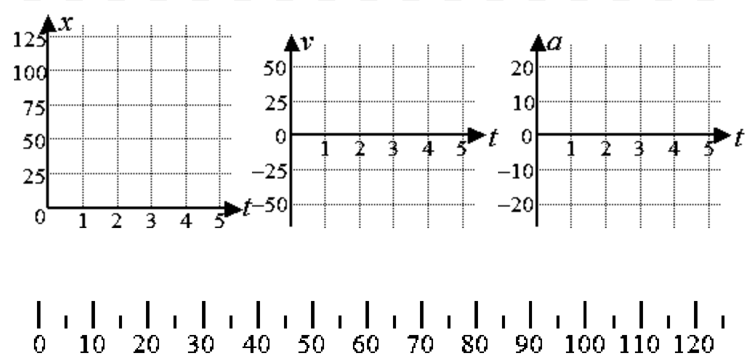
$x = 125 - 5t^2$

$v =$ ______ $t +$ ______

$a =$ ______

Circle one for each:
Veloc is (+) (–)
Accel is (+) (–) (0)

t	x	v	a
0			
1			
2			
3			
4			
5			



= =

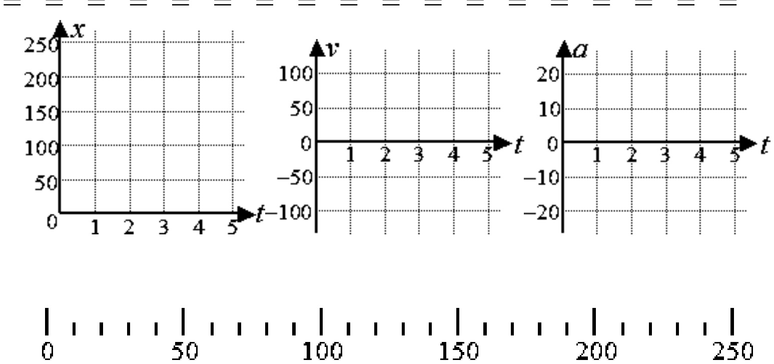
$x = 10t^2$

$v =$ ______ $t +$ ______

$a =$ ______

Circle one for each:
Veloc is (+) (–)
Accel is (+) (–) (0)

t	x	v	a
0			
1			
2			
3			
4			
5			



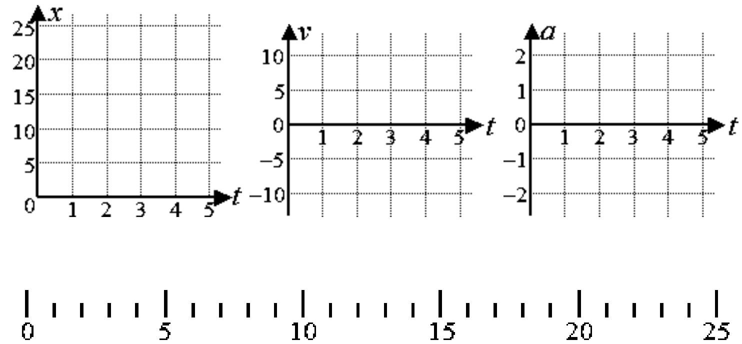
$x = 10t - t^2$

$v =$ ______ $t +$ ______

$a =$ ______

Circle one for each:
Veloc is (+) (–)
Accel is (+) (–) (0)

t	x	v	a
0			
1			
2			
3			
4			
5			



= =

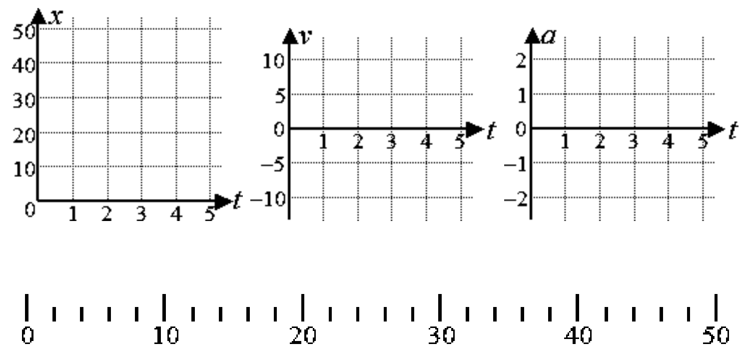
$x = 50 - 10t$

$v =$ ______ $t +$ ______

$a =$ ______

Circle one for each:
Veloc is (+) (–)
Accel is (+) (–) (0)

t	x	v	a
0			
1			
2			
3			
4			
5			



= =

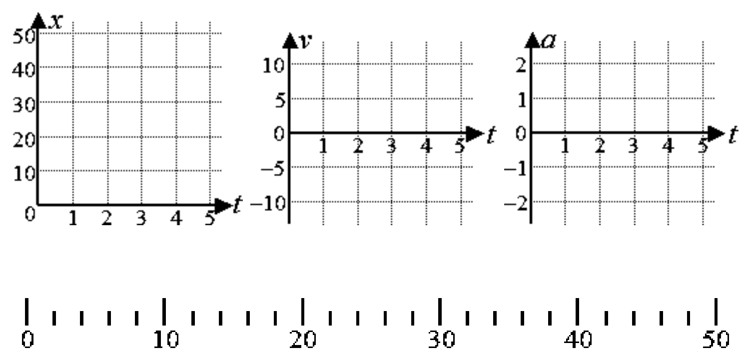
$x = 5t + 10$

$v =$ ______ $t +$ ______

$a =$ ______

Circle one for each:
Veloc is (+) (–)
Accel is (+) (–) (0)

t	x	v	a
0			
1			
2			
3			
4			
5			



Look at the six situations you just considered and complete the following general rules:

When velocity is positive, the position graph ____.

When velocity is negative, the position graph ____.

When acceleration is positive, the position graph ____.

When acceleration is negative, the position graph ____.

When acceleration is zero, the position graph ____.

When acceleration is positive, the velocity graph ____.

When acceleration is negative, the velocity graph ____.

When acceleration is zero, the velocity graph ____.

When the object is speeding up, acceleration and velocity _____________________________________.

When the object is slowing down, acceleration and velocity ___________________________________.

Section 2-6: Solving Problems

$x = \bar{v}t + x_0$ $x = \frac{1}{2}at^2 + v_0t + x_0$ $v = at + v_0$ $v^2 = 2ax + {v_0}^2$

Use the "GUESS" method to solve the following problems:

- GIVEN: Write your given information as a symbol equal to a number with units.
- UNKNOWN: Write your unknown as a symbol equal to a question mark.
- EQUATION: Write the basic equation that has the given information and unknown.
- SOLVE: Solve the equation by moving symbols around algebraically.
- SUBSTITUTE: Plug in numbers and state the result with units.

Example: A runner finishes a 100-meter dash in 8 seconds. Determine his average speed.

GU:

E:

SS:

Example: A test car accelerates from rest at 4 m/s^2 over the course of 200 m. How fast does the car go at the end of this acceleration?

GU:

E:

SS:

Example: A car can go from zero to 30 m/s in 2 seconds. Determine the car's average acceleration.

GU:

E:

SS:

Example: Another car can go from zero to 30 m/s in 3 s. How far does the car go while it accelerates?

GU:

E:

SS:

Example: An aircraft starts from rest and accelerates on a straight runway at a rate of 8 m/s^2 for 400 meters. How much time does this take?

GU:

E:

SS:

Example: The radius of Earth's orbit is 1.5×10^{11} m. How fast does Earth move as it orbits the Sun?

Section 2-7: Falling Objects

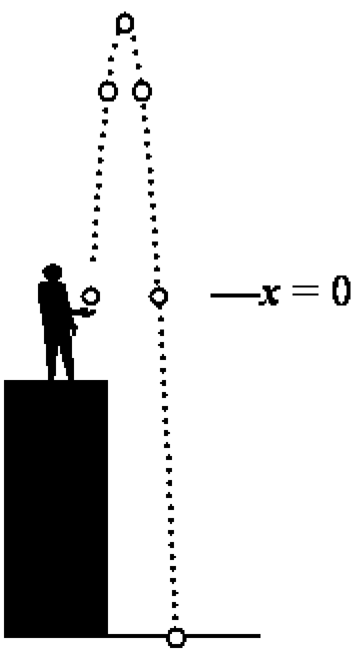
What type of motion is free-fall?

(a) Constant Position (b) Constant Velocity
(c) Constant Acceleration (d) Changing Acceleration

What does the ∝ symbol mean in the top paragraph on page 33 that states "$d \propto t^2$"? How is that different than the = symbol?

Explain Figure 2-17 on page 33. Why does the paper fall differently than the ball in one case, but not in the other?

What is the value of the acceleration of gravity on Earth's surface? What symbol do we give this number?



Test Your Understanding: A person throws a ball upward near the edge of a building as shown. Ignore air resistance and use g = 10 m/s^2. The first white dot is the position of the ball when it leaves the thrower's hand. Each white dot after that represents the ball's position every second after the ball leaves the thrower's hand. In the table below, the time represents how many seconds after the ball leaves the thrower's hand. Fill in speed, velocity, and acceleration each second.

Time (seconds)	Speed (m/s)	Velocity (m/s)	Acceleration (m/s^2)
0			
1			
2			
3			
4			
5			

When the ball is at ____________________, we know for sure its velocity is ________________.

Each second, the ball's velocity ____.

The speed is almost the same as velocity, except ____.

Fill in the ball's acceleration at each time. How does the ball's acceleration vary with time? ____________.

Section 2-8: Graphical Analysis of Linear Motion

How can a curve be considered to have a slope?

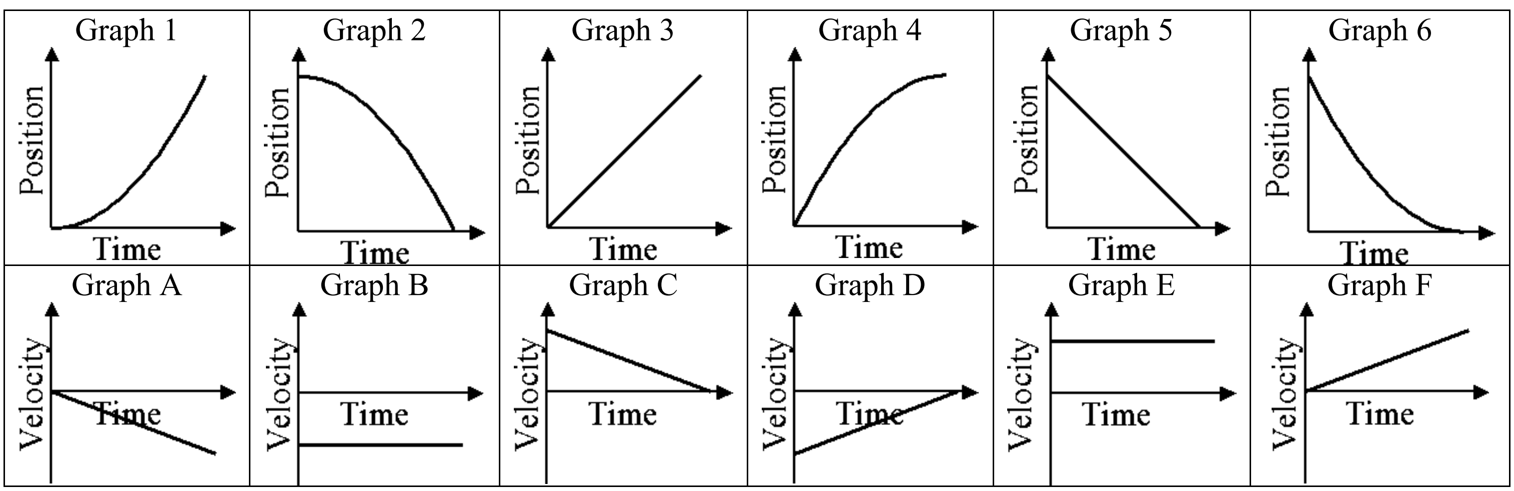
How can velocity at a certain time be found by looking at a position vs. time graph?

How can the change in position between two times be found from a velocity vs. time graph?

How can acceleration at a certain time be found by looking at a velocity vs. time graph?

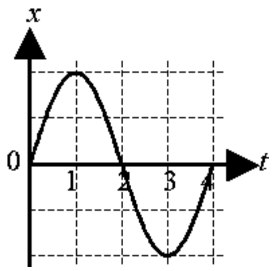
How can the change in velocity between two times be found from an acceleration vs. time graph?

Test Your Understanding: Match graphs 1 – 6 and graphs A – F with each description. Also indicate the sign of acceleration for each case. Your multiple representations from pages 4 and 5 can help!



Description	Position vs. Time Graph	Velocity vs. Time Graph	Acceleration is (Circle One)
The object is moving forward with constant velocity.			(–) (0) (+)
The object is moving backward with constant velocity.			(–) (0) (+)
The object is moving forward and speeding up.			(–) (0) (+)
The object is moving backward and speeding up.			(–) (0) (+)
The object is moving forward and slowing down.			(–) (0) (+)
The object is moving backward and slowing down.			(–) (0) (+)

Example: Use the position vs. time graph below to answer the following questions.



At what time does the object go the fastest forward? _____

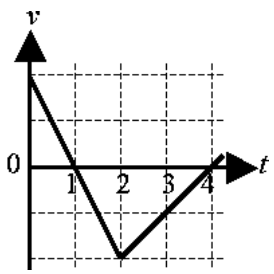
At what time does the object go the fastest backward? _____

At what time(s) does the object have zero velocity? _____ _____

During what interval of time does the object have positive acceleration? __________

During what interval of time does the object have negative acceleration? __________

Example: Use the velocity vs. time graph below to answer the following questions.



At what time does the object go the fastest forward? _____

At what time does the object go the fastest backward? _____

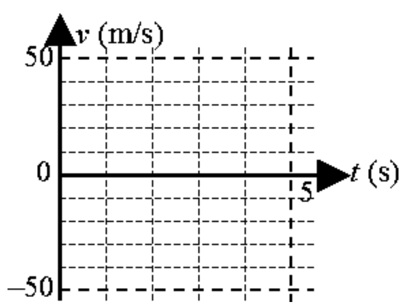
At what time(s) does the object have zero velocity? _____ _____

During what interval of time does the object have positive acceleration? __________

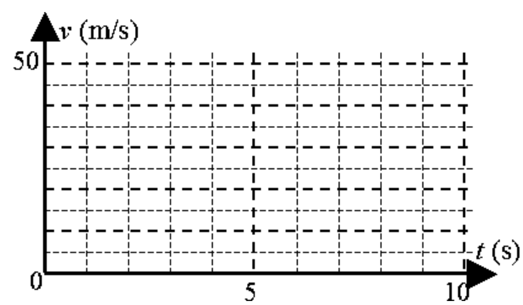
During what interval of time does the object have negative acceleration? __________

Example: For each of the following scenarios, draw a solid line/curve for the motion of the black object and a dotted line/curve for the motion of the white object.

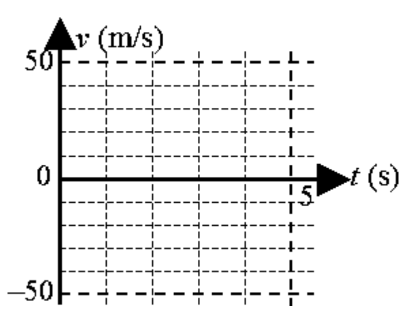
A white ball is dropped from rest at the top of a building. At the same time, a black ball is thrown upward with an initial speed of 30 m/s. Use $g = 10$ m/s^2 and let upward be positive.



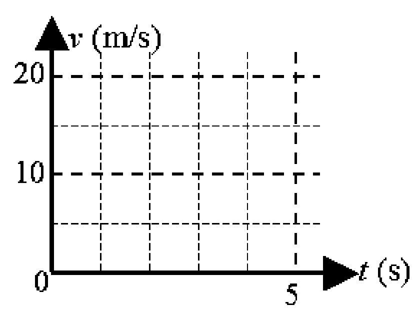
A white car travels forward with a constant speed of 20 m/s. At time $t = 0$, a black car begins to accelerate from rest with an acceleration of 5 m/s^2.



A black car starting from rest travels forward, speeding up to 30 m/s in 3 seconds and then traveling with constant velocity. At the same time, a white car starting from rest travels backward, speeding up to 20 m/s in 2 seconds and then traveling with constant velocity.



A white car initially traveling forward with a speed of 20 m/s stops by having an acceleration of –10 m/s^2. A black car initially traveling forward with a speed of 10 m/s stops by having an acceleration of –2 m/s^2.



Example: An object moves so that it has the velocity vs. time graph shown below. Change this representation into the object's acceleration vs. time graph. Then change the velocity vs. time graph into the object's position vs. time graph assuming the object begins at $x_0 = 2$ m. Finally, draw a quantitative motion map showing the object's position and arrows representing velocity every 2 seconds.