# AP® Physics C

*Summer Assignment*

1. For each of the following equations, solve for the variable in **bold** print. Be sure to show each step you take to solve the equation for the **bold** variable.

a. $v_{rms} = \sqrt{\dfrac{3RT}{\mathbf{M}}}$ _____

b. $F = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q_1 q_2}{\mathbf{r}^2}$ _____

c. $x = x_0 + v_0 t + \dfrac{1}{2}\mathbf{a}t^2$ _____

d. $U = \dfrac{G\mathbf{m}_1 m_2}{r}$ _____

e. $V = \dfrac{4}{3}\pi\mathbf{r}^3$ _____

f. $P + \mathbf{D}gy + \dfrac{1}{2}\mathbf{D}v^2 = C$ _____

g. $K_{avg} = \dfrac{3}{2}k_B\mathbf{T}$ _____

h. $\dfrac{1}{C_{EQ}} = \dfrac{1}{\mathbf{C}_1} + \dfrac{1}{C_2}$ _____

i. $F\left(\Delta\mathbf{t}\right) = m\Delta v$ _____

j. $v^2 = v_0{}^2 + 2\mathbf{a}\Delta x$ _____

k. $P + Dgy + \dfrac{1}{2}D\mathbf{v}^2 = C$ _____

l. $mg\sin\boldsymbol{\theta} = \mu mg\cos\boldsymbol{\theta}\left(\dfrac{M+m}{m}\right)$ _____

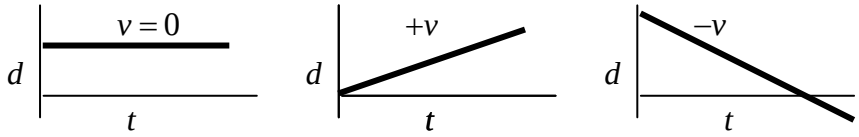
# Rates and Graphing

We often create a graph to describe the motion of an object. Remember that when we state two variables using the "versus" terminology that we always state what is being graphed as a *y*-axis variable versus the *x*-axis variable. You have already learned that the slope of a position vs. time graph for a moving object is the object's velocity and that a straight line on that graph represents *constant* velocity. You have also learned that if a position vs. time graph is a curve, that the object is changing its velocity which means it is experiencing an acceleration. Additional specific features of the motion of objects are demonstrated by both the shape and the slope. In the graphed examples the y intercepts and slopes would depend on where the problem started and on how fast the rate is changing.

- The slope of a position vs. time graph = velocity.
- The slope of a velocity vs. time graph = acceleration.
- Slope is calculated as $\frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{\text{“}rise\text{”}}{\text{“}run\text{”}}$
- If the graph shows a *horizontal* straight line, the object is moving at constant velocity with acceleration = zero.
- If the graph shows a *sloped* straight line, the object's velocity is changing, thus the object is accelerating.

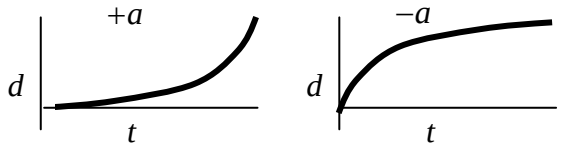
Constant Velocity: change in position $\boxed{v = \frac{d}{t}}$

Velocity is the slope (derivative) of distance versus time graph

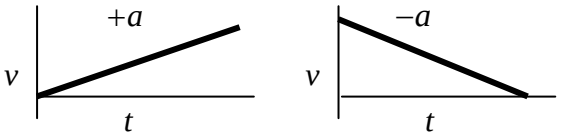



Acceleration:change in velocity $\boxed{a = \frac{\Delta v}{t}}$

Distance increases (or decreases) in an exponential manner.




Acceleration is the slope (derivative) of velocity versus time graph




Importance of Area Under the Curve

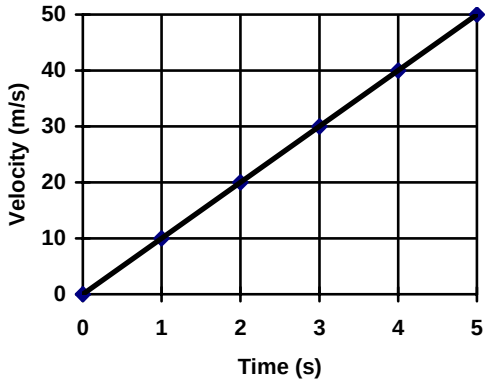
Velocity is the area (integral) under the acceleration versus time graph.
Displacement is the area (integral) under the velocity versus time graph.

Work is the area under the force versus distance curve.

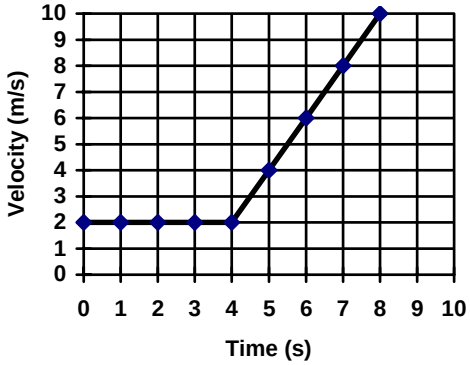
Impulse is the area under the force versus time curve.

*Analyze the following velocity vs. time graphs and answer the questions that follow.*

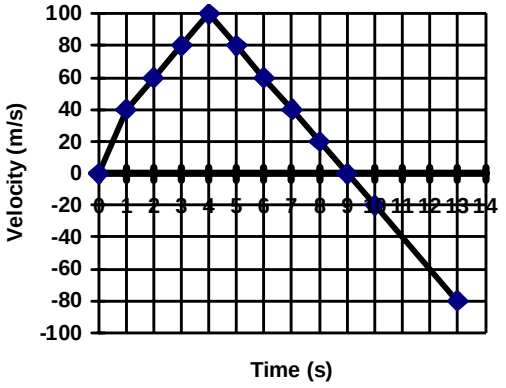
**Graph A**



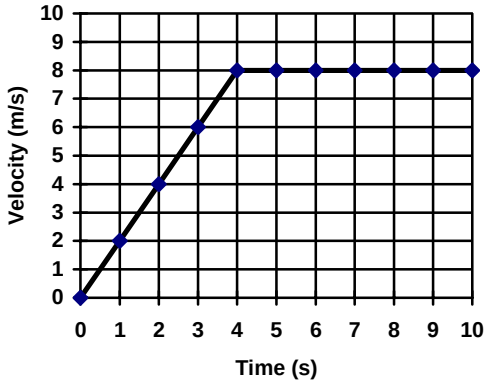

**Graph B**



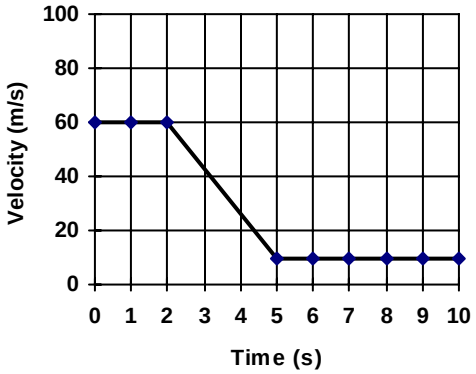

**Graph C**



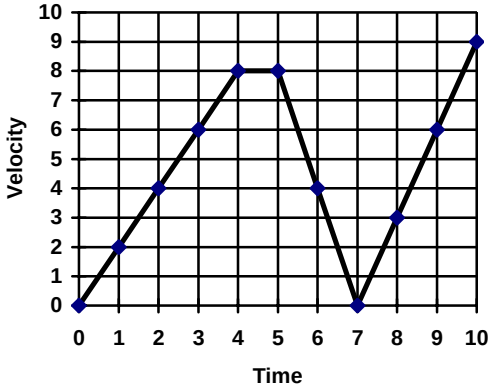

**Graph D**




**Graph E**




**Graph F**



1. Which of the graphs involve a time interval where the velocity of an object was held constant?

2. Which of the graphs involve a time interval where the acceleration of an object was held constant?

3. Calculate the acceleration of the object for any graph(s) you chose as answers to question 2. Show all work in the space provided paying particular attention to units and significant digits.

4. Which of the graphs involve an object that was negatively accelerating?

5. Which of the graphs involve an object that came to a stop?

6. Which of the graphs involve an object that changed direction?

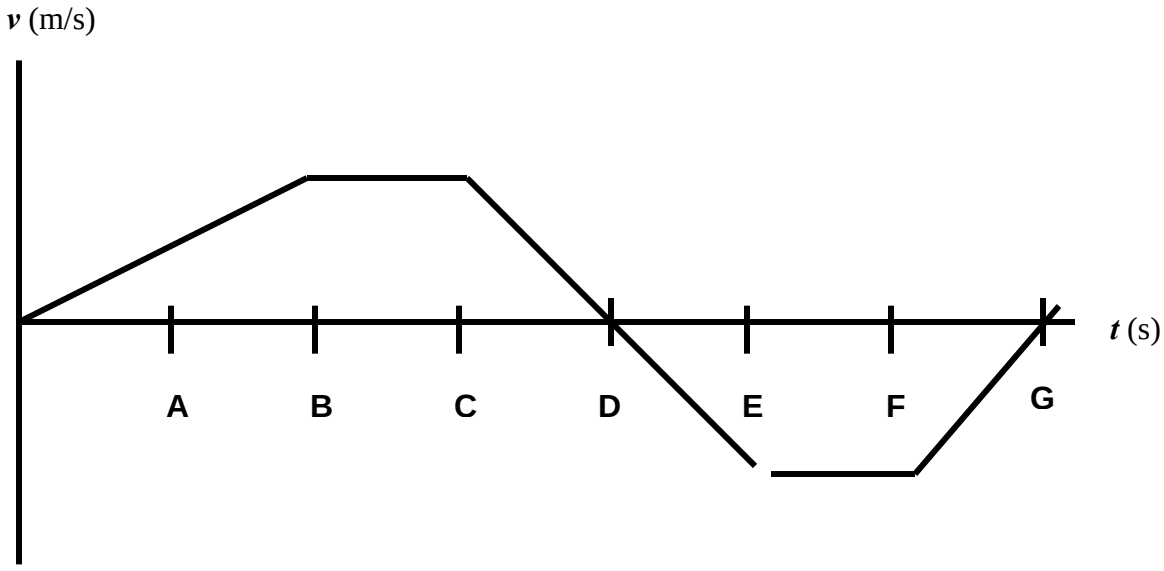
7. Analyze Graph F. For which of the time intervals was the object experiencing the greatest positive acceleration?

8. Calculate the net displacement for the object in Graph B.

9. Calculate the net displacement for the object in Graph D.

10. Calculate the displacement for the object in Graph F for the time interval t = 0s to t = 4 s.

Give a qualitative description of the motion of an object at the different time intervals depicted in the following *velocity* versus *time* graph:




*Answer:*

***A-B*** _____

***B-C*** _____

***C-D*** _____

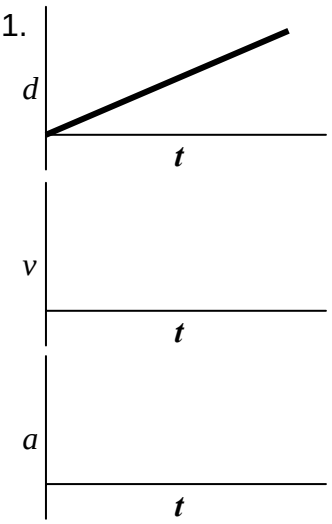
***D-E*** _____

***E-F*** _____

***F-G*** _____

Complete the following series of graphs. For the displacement versus time graphs, construct the velocity versus time, and acceleration versus time graphs. For the velocity versus time graph construct the displacement versus time and acceleration versus time graph.

1.

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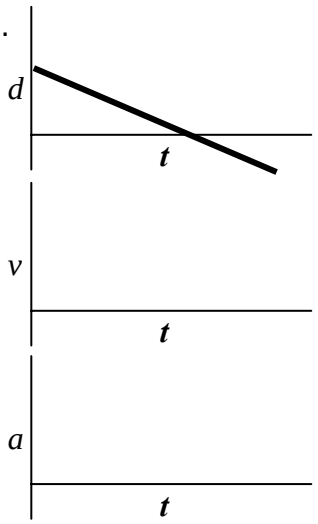


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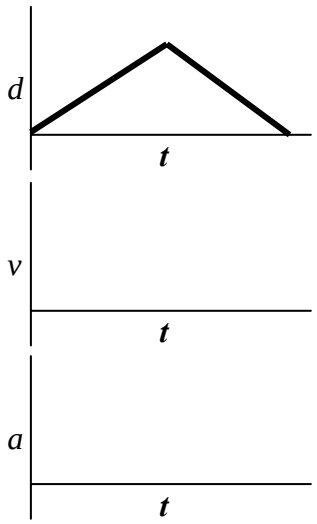
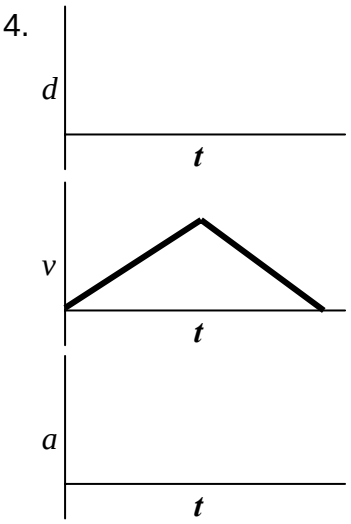



4.

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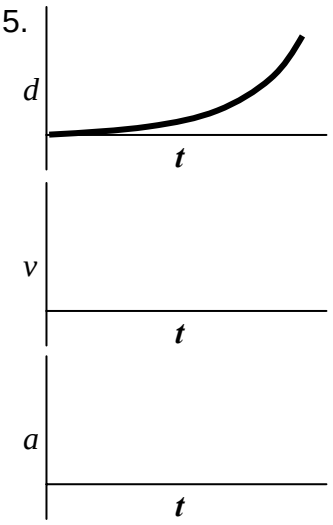


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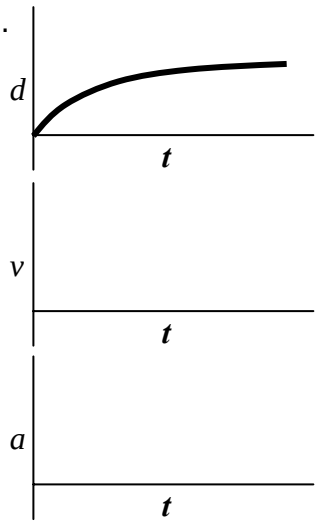


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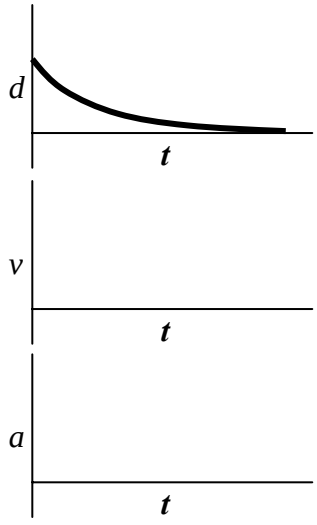
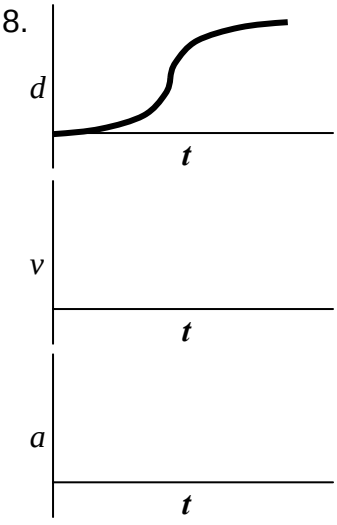



8.

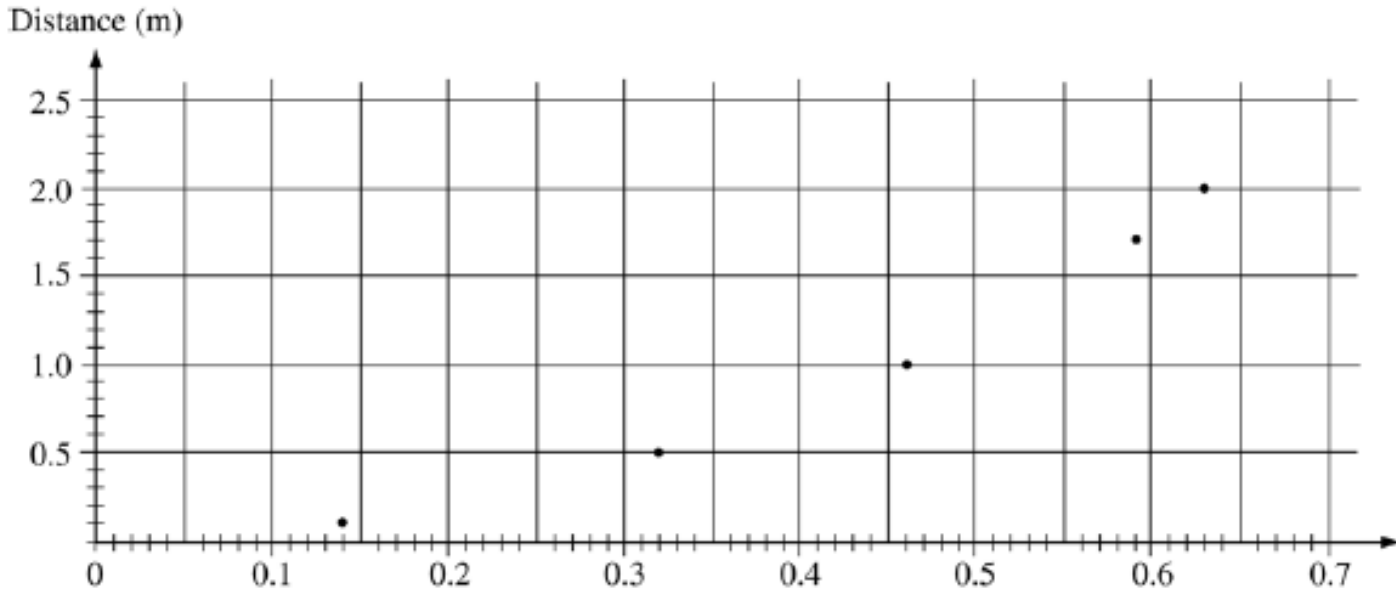


When data are non-linear, it is best to "linearize" the data or straighten the curve. This does not mean to fit the curved data points with a straight line. Rather, it means to modify one of the variables in some manner such that when the data are graphed using this new data set, the resulting data points will appear to lie in a characteristic straight line plot. This is best done by first determining the relationship between the y and x data and then performing some operation (inverse, square, square root, etc) on one of the variables such that the new data will appear to lie in a straight line.

A student wishing to determine experimentally the acceleration g due to gravity has an apparatus that holds a small steel sphere above a recording plate. When the sphere is released, a timer automatically begins recording the time of fall. The timer automatically stops when the sphere strikes the recording plate.

The student measures the time of fall for different values of the distance and records the data in the table below. These data points are also plotted on the graph. On the grid below, sketch the smooth curve that best represents the student's data.

| Distance of Fall (m) | 0.10 | 0.50 | 1.00 | 1.70 | 2.00 |
|---|---|---|---|---|---|
| Time of Fall (s) | 0.14 | 0.32 | 0.46 | 0.59 | 0.63 |



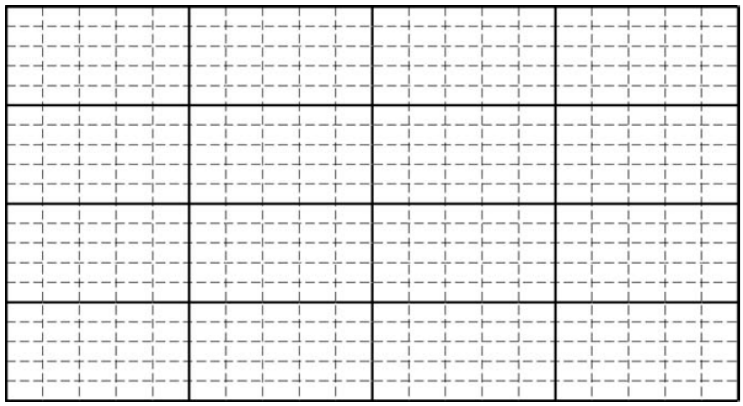
If only the variables D and t are used, what quantities should the student graph in order to produce a linear relationship between the two quantities?

_____ _____

On the graph paper below, linearize the data, label the axes, and draw your best fit line to the data. Write the equation of your best fit line.

_____

_____



Use the slope of your best fit line to calculate the magnitude of the acceleration due to gravity in this experiment.