BIG PICTURE IDEAS

#1) *Vectors*: Vectors have both magnitude and direction. Scalars have magnitude only.

#2) *Uniformly Accelerated Motion (UAM)*: The Kinematics or UAM Equations can be used when the acceleration of an object is uniform (or constant).

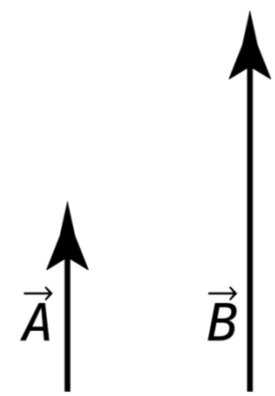
#3) *Projectile Motion*: An object in Projectile Motion has a constant velocity in the x-direction and a constant acceleration in the y-direction. On Earth, the acceleration in the y-direction is $-9.81\ m/s^2$.

#4) *Working with Vectors*: Often, in order to work with vectors, we need to break, or resolve, vectors into components by using the trigonometric functions like sine, cosine, and tangent.

Topic 1.1 – Scalars and Vectors in One Dimension

1) On the AP Physics 1 exam you can basically ignore significant figures. As long as you include roughly 3 in your answers.
2) In order to convert $1\ m^3$ to cm^3 you need to multiply $1\ m^3$ by $100^3\ cm^3$ over $1^3\ m^3$. (Include all units and numbers!)
3) Identify the variables in the table at right as vectors or scalars.
4) The vectors in the following equation $\vec{v}_f = \vec{v}_i + \vec{a}\Delta t$ are identified using an arrow over the variable.
5) The vectors in the following equation $v_{xf} = v_{xi} + a_x\Delta t$ are identified using the subscript x.
    a) Both are acceptable ways of identifying that variables are vectors.
    b) The reason the variable *t* in the above equation does not have an x subscript is because time is a scalar, not a vector.
6) Vectors **A** and **B** as shown to the right are different in that **B** is larger in magnitude than **A**. You know this because the arrow illustrating **B** is longer than the arrow illustrating **A**.

Variable	*Vector or Scalar?*
Time	Scalar
Distance	Scalar
Displacement	Vector
Speed	Scalar
Velocity	Vector
Acceleration	Vector



Topic 1.2 – Position, Velocity, and Acceleration

1) Displacement is the straight-line distance from where the object started to where it ended.
2) Displacement is the change in position of an object.
3) The distance traveled by an object is always greater than or equal to the magnitude of its displacement.
4) The equation for displacement is: $\Delta\vec{x} = \vec{x}_f - \vec{x}_i$
5) The equation for average speed is: $\text{speed} = \dfrac{\text{distance}}{\text{time}}$

Topic 1.2 – Position, Velocity, and Acceleration (continued)

6) The equation for average velocity is: $\vec{v}_{avg} = \dfrac{\Delta\vec{x}}{\Delta t}$

   a) If the time interval used for the above equation is very small, the resulting velocity will be an instantaneous velocity.

7) The equation for average acceleration is: $\vec{a}_{avg} = \dfrac{\Delta\vec{v}}{\Delta t}$

   a) If the time interval used for the above equation is very small, the resulting acceleration will be an instantaneous acceleration.

Topic 1.3 – Representing Motion

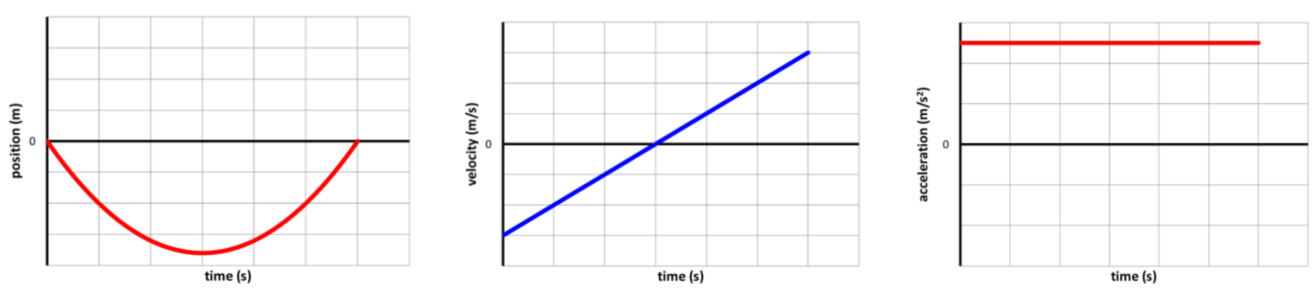
1) The slope of a position vs. time graph is velocity.
2) The slope of a velocity vs. times graph is acceleration.
3) On a velocity vs. time graph, the area between the curve and the time axis is change in position.
4) On an acceleration vs. time graph, the area between the curve and the time axis is change in velocity.
5) Area above the horizontal axis is positive.
6) Area below the horizontal axis is negative.
7) To the right are the 3 Kinematics or UAM Equations which are on the equation sheet.

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

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

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

8) The fourth UAM Equation is $\Delta x = \frac{1}{2}(v_x + v_{x0})\, t$
9) These UAM Equations assume the initial time is zero.
10) Assuming an initial position of zero, complete the position and acceleration as functions of time graphs for motion of an object shown by the velocity as a function of time graph below.

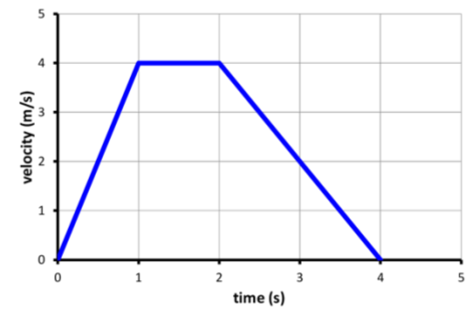


Graph Explanations: The slope of position vs. time is velocity and, according to the velocity vs. time graph, the velocity starts negative, goes to zero halfway through, and ends with a positive velocity which is equal in magnitude to the initial velocity; therefore, the position vs. time graphs starts with a negative slope, and that slope increases to zero and ends with a positive slope which is equal in magnitude to the initial slope.

The slope of a velocity vs. time graph is acceleration and the slope of this velocity vs. time graph has a constant, positive value, therefore, the acceleration vs. time graph has a constant positive value.

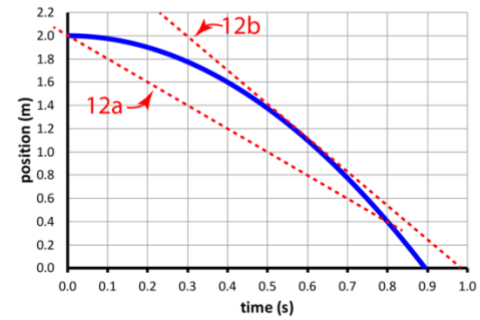
Topic 1.3 – Representing Motion (continued)

11) You *cannot* use Uniformly Accelerated Motion Equations on the graph at right from 0 to 4 seconds because the acceleration is not uniform from 0 to 4 seconds.



   a) However, you *can* use the UAM Equations if you split the motion into three parts because the acceleration of the motion of the object is uniform from 0 to 1 seconds, 1 to 2 seconds, and 2 to 4 seconds.
   b) From 1 to 2 seconds, the velocity of the object is constant and the acceleration of the object is zero.
   c) For the third part of the motion, which is from 2 to 4 seconds, the acceleration of the object is:

$$a_3 = \frac{\Delta v_3}{\Delta t_3} = \frac{v_{3f} - v_{3i}}{t_{3f} - t_{3i}} = \frac{0\frac{m}{s} - 4\frac{m}{s}}{4s - 2s} = -2\frac{m}{s^2}$$



12) For the graph of the motion of the object shown at right
   a) The velocity from 0 to 0.8 seconds is:

$$v_{0\to0.8s} = \frac{x_{0.8s} - x_0}{t_{0.8s} - t_0} = \frac{0.4m - 2m}{0.8s - 0s} = -2\frac{m}{s}$$

      i) This velocity is called an average velocity.
      ii) This velocity is the slope of a line drawn from (0s, 2.0m) to (0.8s, 0.4m).
   b) The velocity of the object at 0.6 seconds is approximately:

$$v_{0.6s} = \text{slope}_{0.6s} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{0m - 2.2m}{0.98s - 0.24s} = -2.973 \approx -3\frac{m}{s}$$

      i) This velocity is called an instantaneous velocity.
      ii) This velocity is the slope of the line tangent to the curve at 0.6 seconds.

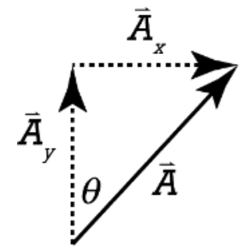
13) When an object is near the surface of planet Earth and air resistance is negligible, the acceleration of the object caused by the force of gravity is vertical, downward, and has a magnitude of 9.81 m/s^2. This is often called free fall motion and g = 9.81 m/s^2.
   a) 9.8 m/s^2 and 10 m/s^2 are also acceptable values to use on the AP Physics 1 exam.
      i) It is recommended that you use 10 m/s^2 on the exam because that makes all the calculations easier.
   b) This is a special case of Uniformly Accelerated Motion where the acceleration of the object is always known.
   c) The velocity of the object at the top of its path in the y-direction is zero.
   d) A heavy object and a light object are dropped at the same time from the same height above the ground. Which object reaches the ground first? Both objects reach the ground at the same time. (Both have a_y = -9.81 m/s^2, regardless of mass.)

Topic 1.4 – Reference Frames and Relative Motion

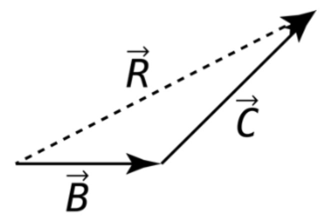
1) The description of the motion of an object changes depending on the reference frame of the observer.
2) Combining the motion of an object and the motion of an observer in a reference frame involves vector addition.
   a) The AP Physics 1 exam restricts relative motion problems to one dimensional motion.
3) The acceleration of an object is independent of reference frame as long as they are all inertial reference frames.

Topic 1.5 – Vectors and Motion in Two Dimensions

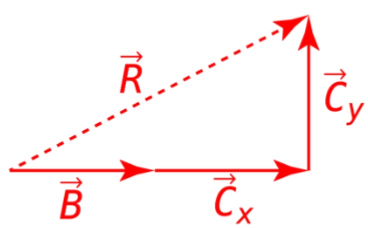
1) The y-component of vector **A** at right is $A\cos\theta$. $\cos\theta = \frac{\text{adjacent}}{\text{hypotenuse}} = \frac{A_y}{A} \Rightarrow A_y = A\cos\theta$



2) The reason we cannot use the Pythagorean theorem, sine, cosine, and tangent on the **B** + **C** = **R** vector addition diagram at right is because the triangle does not have a right angle (or an angle of 90°).



   a) In order to determine R, the resultant vector, we would need to break vector C into its components in the x and y directions.
   b) Draw the new vector diagram of **B** + $\mathbf{C}_x$ + $\mathbf{C}_y$ = **R**.



   c) Now we are able to use the Pythagorean theorem, and the equations for sine, cosine, and tangent because the vector addition diagram triangle *does* have a right angle (or an angle of 90°).
3) When an object is in projectile motion:
   a) Because the object is moving at a constant velocity in the x-direction, the equation we can use for the motion of the object in the x-direction is $\vec{v}_x = \frac{\Delta\vec{x}}{\Delta t}$.
      i) In the x-direction, we need to know two variables in order to determine the other one variable.
   b) Because the object is in free fall in the y-direction, the equations we can use for the motion of the object in the y-direction are the Uniformly Accelerated Motion Equations with an acceleration, on Earth, of $-9.81\ m/s^2$.
      i) In the y-direction, we need to know three variables in order to determine the other two variables.
   c) The variable which is the same in both the x and y-directions is change in time because it is a scalar.

Topic 1. 5 – Vectors and Motion in Two Dimensions (continued)

- d) The velocity of the object at the top of its path is zero in the y-direction.
- e) On Earth, the acceleration of the object at the moment it is at the top of its path is $-9.81\ m/s^2$ in the y-direction.

4) All of the following examples have an initial velocity of zero in the y-direction; a mobile phone launched horizontally, a ball rolling off a horizontal table, a skydiver dropped from a plane flying with a constant horizontal velocity.
5) When an object enters projectile motion at an angle which is not horizontal, often the first step is to break its initial velocity into components in the x and y-directions.
6) At the same time and from the same height above the ground, a ball is dropped and a rock is launched horizontally.
   - a) Which object reaches the ground first? Both objects reach the ground at the same time.
   - b) Which object has the largest speed right before striking the ground? The rock. (The ball has zero horizontal velocity.)
7) First a ball is dropped and then a rock is thrown vertically downward. For the first second, the change in velocity of the ball is the same as the change in velocity of the rock.
   - i) (Yes, the rock will be moving faster, however, the *change in* velocity of both objects is the same.)
8) Sometimes when doing projectile motion problems, you will have to take the square root using your calculator; especially when using this equation: $v_x^2 = v_{0x}^2 + 2a_x(x - x_0)$
   - a) When taking the square root using my calculator, I need to remember to be smarter than my calculator and remember the calculator only gives the positive answer. I need to decide if the number is positive or negative.
     - i) (For example, if we know the object is going down, the final velocity in the y-direction will be negative!)
   - b) In projectile motion, assuming a constant launch speed, the launch angle which will give the largest horizontal displacement is 45°.