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Module 3, Lesson 2 - Objectives & Standards

In this lesson about Displacement, Velocity and Time, you will:

- Pb: Demonstrate an understanding of the principles of force and motionand relationships between them.
- Pb.2: Apply formulas for velocity or speed and acceleration to one and two-dimensional problems.
- Pb.3: Interpret the velocity or speed and acceleration of one and two-dimensional motion on distance-time, velocity-time, or speed-time, and acceleration-time graphs.

As you progress through the lesson think about the following questions:

- How can the displacement of a moving object be found if the velocity and time are known?
- How can the displacement of a moving object be determined from a velocity-time graph?

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Module 3, Lesson 2 - Shifting to Equations from Graphs

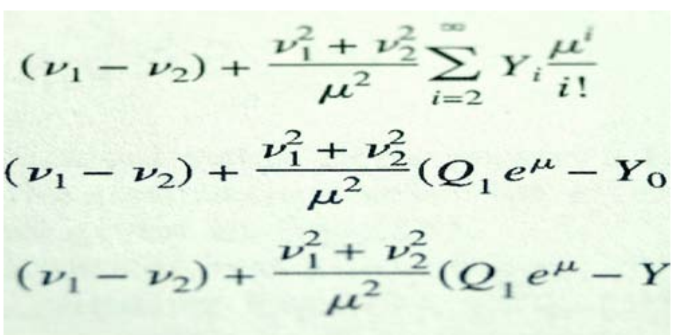

Photo Attribution
Description: Position-time Graph
Source: DoDEA

In Module 2 we studied the **characteristics of position-time and velocity-time graphs**. We used those graphs to calculate many things - velocity, acceleration, displacement, etc.

In this lesson, we will shift from graphs to using equations to solve for these same values. There are **4 basic equations** that we will use. In this lesson, we will concentrate on using the basic equations to determine displacement.

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Module 3, Lesson 2: Underlying Assumptions

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Description: Fast Car
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Similar to the start of our **study of motion**, we will make an assumption to simplify our equations.

- We will assume that any acceleration that occurs will be constant throughout any problem.
- So, when we brake our cars, we assume that the brakes cause a constant acceleration.
- When we step on the gas, the engine causes a constant acceleration.

The **velocity-time graph** is therefore assumed to be a **straight line**.

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Module 3, Lesson 2:
Equation 1 from Definition of Average Acceleration

In Lesson 1 of this module, average acceleration was defined in equation form as:

Average Acceleration =
ΔVelocity ÷ ΔTime = (final velocity - initial velocity) ÷ (final time - initial time)

So, let's define the values involved in this equation:

Final velocity = v_f
Initial velocity = v_o
Acceleration = a
Change in time = Δt
So, $a = (v_f - v_o) \div \Delta t$

Rearranging the above equation using algebra:

$$v_f = v_o + a(\Delta t)$$

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Description: Equations
Source: DoDEA

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Module 3, Lesson 2:
Equation 2 from Definition of Average Velocity

If we start at some initial velocity and end at a final velocity, we can calculate the average velocity as we would calculate the average of any two numbers.

Average velocity will be represented by $\bar{V}$. So,

$$\text{Average velocity} = \bar{v} = (v_f + v_o) \div 2$$

Equation 2

Photo Attribution
Description: Equations
Source: DoDEA

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Module 3, Lesson 2:
Equation 3 from Area under Velocity-Time Graph

In Module 2 and in Lesson 1 of this Module, we have made the assertion that displacement equals the area under the velocity-time graph and above the x axis.

$$\text{Displacement} = \text{final position} - \text{initial position} = (x_f + x_o)$$

If you look at the graph, you can see that the area under the graph equals the average velocity times the change in time. So,

$$x_f - x_o = ((v_f + v_o) \div 2)(\Delta t)$$

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Description: Equations
Source: DoDEA

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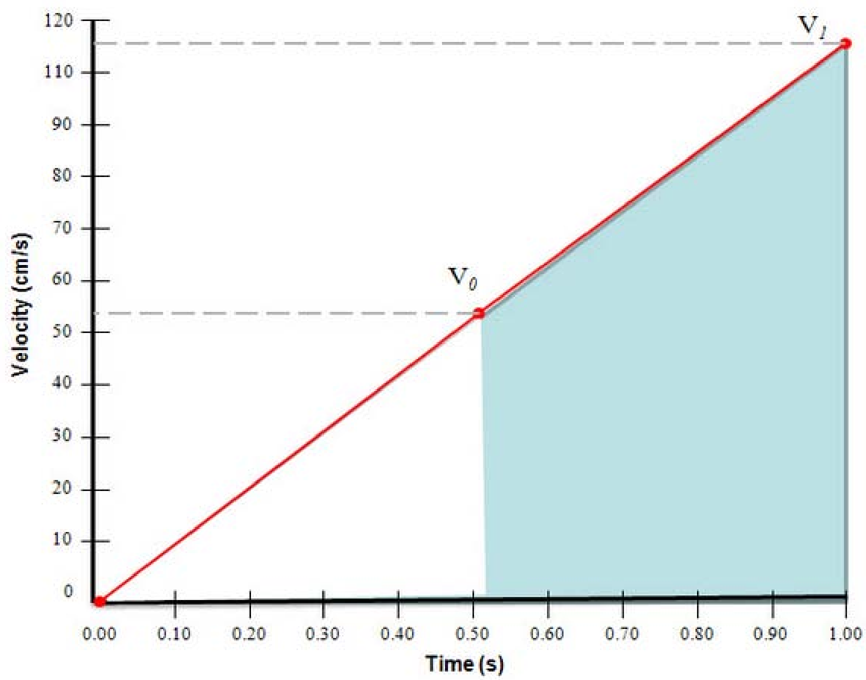
Module 3, Lesson 2:
Equation 3 from Area under Velocity-Time Graph

Photo Attribution
Description: Velocity-time Graph
Source: DoDEA

Shaded Area = Displacement



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Module 3, Lesson 2:
Equation 3 from Area under Velocity-Time Graph

If you substitute for using Equation 1 and rearrange the equation, you get:

$$\text{Displacement} = x_f - x_o = v_o(\Delta t) + {}^{1}/_{2}(a)(\Delta t)^2$$ **(Equation 3)**

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Description: Equations
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Module 3, Lesson 2: Equation 4 Without Time Term

If you combine Equation 1 and Equation 3 by substituting for the Δt term, you can get an equation that does not have a Δt term. Here's that equation:

$$(v_f)^2 = (v_o)^2 + 2(a)(x_f - x_o)$$ **(Equation 4)**

Equation 4 is helpful if a problem **gives no information about time** but asks you to solve for another unknown.

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Description: Equations
Source: DoDEA

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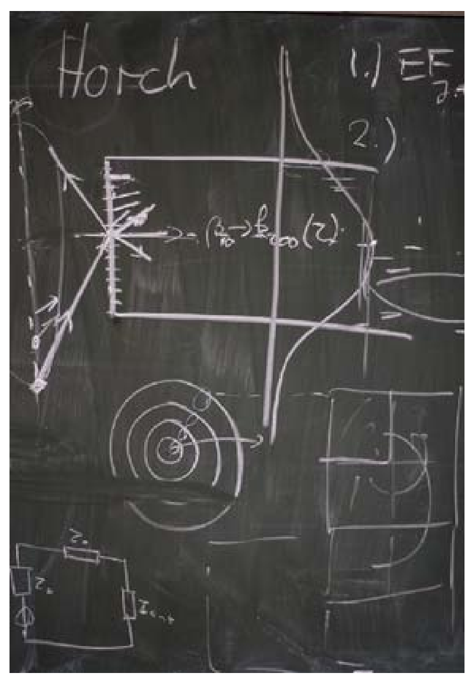
Module 3, Lesson 2: Problem-Solving Tips

When presented with a problem, the temptation is to pick equations at random and try to blindly plug in the given information. Some simple organizational steps can help make your approach a little more systematic:



- Draw a diagram of the given situation. Pick your frame of reference and decide which direction is positive.
- List the given information in the problem.
- List the desired information.
- Select the appropriate equation to solve for the unknown info. Sometimes, there may be multiple steps to get to the final desired information.
- Pay attention to significant digits. Round after all calculations to show the correct number of significant digits.

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Description: Graphs on a Chalkboard
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Module 3, Lesson 2: Pay Attention to Units

For any equation, the units of one side of the equal sign must be the same as the units of the other side. When working with these kinematic equations, be sure to use the same units throughout the equation.

For example, all lengths must be the same unit (for example: meters). You can't use meters for one variable and then miles for another. All times must be the same unit as well. You can't use miles per hour for velocity and seconds for time. You would have to convert to one common unit.

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