

Litany for Kinematics Problems [©2004 RJ Bieniek]

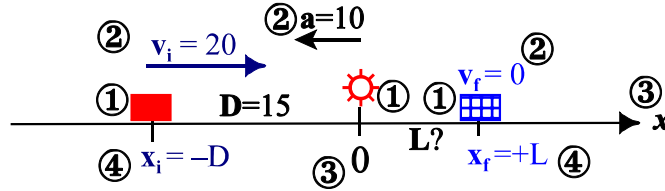
Learning proper methods for solving homework problems will lead to improved performance on exams. This Litany will cover one-dimensional kinematic techniques. The same procedures apply to solving higher-dimensionality problems (e.g., 2-D) along each axis. A fully worked example is given showing these techniques on the back of this sheet, with the relevant "suggestion" numbers below circled at the steps. *You will find that following this procedure will rather assuredly lead you to a correct answer.*

Suggested Steps ("suggested" means "must" in *Bieniek's Newspeak Dictionary*)

1. Draw a basic representative sketch of the physical situation.
2. Draw and appropriately label vectors for the relevant dynamical quantities (e.g., initial velocity v_i and acceleration a) that you are given in both initial and final states. If you do not know the direction of a particular vector, you may wish to put a small question mark next to it. These can be superimposed on the sketch if done clearly, with the vectors drawn *darker* than the lines of the sketch. **Each of these vectors must be distinctly and legibly drawn.**
3. Draw an axis with an arrow at one end indicating its positive direction. Make sure you indicate the origin (zero position) of the axis.
4. Indicate and label with appropriate subscripts the initial and final positions along the axis.
5. As an initial mathematical step, you **MUST** begin with an appropriate *Official Starting Equation*. You will want to choose an *OSE* that contains the unknown quantity and as many of the known ones as possible. All subsequent steps must mathematically follow from this beginning point and reference to your diagram.
6. In the next step(s), replace the generic component quantities with the information given in the problem. For example, if you know the initial direction of motion is to the right and the final direction is to the left, then substitute $(+v_i)$ for v_{ix} and $(-v_f)$ for v_{fx} if the x axis is to the right. If the axis is pointed to the left, then substitute $(-v_i)$ for v_{ix} and $(+v_f)$ for v_{fx} . Remember that a vector's label without an axis subscript is the magnitude of the vector, i.e., a non-negative quantity. If you are not given the direction of the vector, then leave the symbol as a component with the axis subscript.
7. Solve for the desired quantity algebraically. Do not do multiple steps in your head, which tends to produce too many mistakes. One plodding step in each line gives a much higher probability of success. If you use a symbol in an equation, it must appear in your diagram. Make sure you do this **before** you substitute any values for the symbols, to decrease chance of error or inconsistency. Let the mathematics flow from the *Official Starting Equation* you have chosen and the symbol-labels in your diagram.
8. Hold off on the substitution of numerical values for the symbols until the end (or toward the end) of the solution. Draw a box around your final answer.

Example of a One-Dimensional Kinematics Problem

You are speeding on a city street late at night at 20 m/s. A traffic light turns red, and you slam on your brakes 15 m before the intersection. Your car then slows down at a rate magnitude of 10 m/s². How far into the intersection will your car be when it finally comes to a stop?



Note that we have drawn the acceleration vector opposite to the initial velocity vector because we are *told* that car is slowing down so that velocity vector will get shorter.

(5) Since we are not given times, we first look for a kinematic equation that relates the given quantities: acceleration, velocities, and positions. We find and begin with an appropriate *Official Starting Equation*:

$$v_{fx}^2 = v_{ix}^2 + 2a_x(x_f - x_i)$$

$$(6) \quad (0)^2 = (+v_i)^2 + 2(-a)[+L - (-D)]$$

$$(7) \quad 2a(L+D) = V^2$$

$$L+D = \frac{1}{2}V^2/a$$

$$L = \frac{1}{2}V^2/a - D$$

$$(8) \quad L = \frac{1}{2}(20)^2/(10) - 15 = +5 \text{ m}$$

$$L = 5 \text{ m}$$

Note that if we had drawn the x axis to the left instead of the right, several quantities would change signs:

$$V_x = -V = -20 \text{ m/s} \quad a_x = +a = +10 \text{ m/s}^2 \quad x_i = +D = +15 \text{ m} \quad x_f = -L$$

But the final physical answer remains the same: $L = 5 \text{ m}$