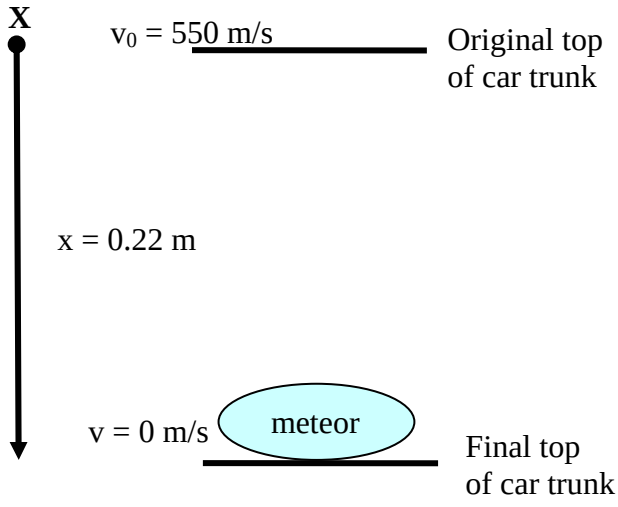
Physics 151 – Kinematics Problem Solving Example-KEY

Problem: On October 9, 1992, a 27-pound meteorite struck a car in Peekskill, NY, leaving a dent 22 cm deep in the trunk. If the meteorite struck the car with a speed of 550 m/s, what was the magnitude of its deceleration, assuming it to be constant?

Draw a simple diagram showing the meteor's starting and ending points and the origin and direction of increase of your coordinate system.



Write out the values of the known and solve variables.

Known:

v_0 = 550 m/s
v = 0 m/s
x = 0.22 m

Solve:

a = ?

What is the variable "Not Involved"? **t**

Which kinematic equation does that suggest that you should use? $v^2 = v_0^2 + 2ax$

Solve that kinematic equation for the variable of interest?

$$v^2 = v_0^2 + 2ax$$
$$v^2 - v_0^2 = 2ax$$
$$\frac{v^2 - v_0^2}{2x} = a$$

Plug in the known values and solve for the desired quantity?

$$a = \frac{v^2 - v_0^2}{2x} = \frac{\left(0\frac{m}{s}\right)^2 - \left(550\frac{m}{s}\right)^2}{2(0.22m)} = -6.9\times10^5 \frac{m}{s^2}$$

And since we are asked for magnitude, the minus sign is not needed.

Are the units on your answer correct? **YES** Correct number of sigfigs? **YES – 2!**
Does your answer appear reasonable? **Hard to say -- we should certainly expect a large value of acceleration since the meteor is brought to a stop very quickly.**

2. A model rocket rises with constant acceleration to a height of 3.2 m, at which point is speed is 26.0 m/s.
(a) How much time does it take for the rocket to reach this height?

Note that since the rocket has a constant acceleration (the only type of problem that we know how to handle) and the initial velocity is zero, the average velocity must be half of the final velocity. So I would write,

$$x = \bar{v}t$$

$$t = \frac{x}{\bar{v}} = \frac{3.2\text{ m}}{13.0\ \frac{\text{m}}{\text{s}}} = 0.25s$$

While your textbook writes:

$$t = \frac{2(x - x_0)}{v_0 + v} = \frac{2(3.2\text{ m} - 0\text{ m})}{0\ \frac{\text{m}}{\text{s}} + 26.0\ \frac{\text{m}}{\text{s}}} = \boxed{0.25\text{ s}}$$

(b) What was the magnitude of the rocket's acceleration?

$$a = \frac{v - v_0}{t} = \frac{26.0\ \frac{\text{m}}{\text{s}} - 0\ \frac{\text{m}}{\text{s}}}{0.246\text{ s}} = \boxed{110\ \text{m/s}^2}$$

(c) Find the height and speed of the rocket 0.10 s after launch.

$$x = x_0 + v_0 t + \frac{1}{2}at^2 = 0\text{ m} + \left(0\ \frac{\text{m}}{\text{s}}\right)(0.10\text{ s}) + \frac{1}{2}\left(105.6\ \frac{\text{m}}{\text{s}^2}\right)(0.10\text{ s})^2 = \boxed{0.53\text{ m}}$$

$$v = at = \left(105.6\ \frac{\text{m}}{\text{s}^2}\right)(0.10\text{ s}) = \boxed{11\ \text{m/s}}$$