Linear Motion

Dr. Venkat Kaushik

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Clicker Question 1 (30 s)

TRIP 1:
An automobile travels on a straight road for 1 mi at 20 mi/hr

How far (in mi) did the automobile travel during trip 1?

Answer: 1 mi

Clicker Question 2 (30 s)

TRIP 2:
The same automobile travels further on the same road for another 2 mi at 40 mi/hr

How far (in mi) did the automobile travel during trip 2?

Answer: 2 mi

Clicker Question 3 (30 s)

TRIP 1: 1 mi at 20 mi/hr
TRIP 2: 2 mi at 40 mi/hr

What is the average speed (in mi/hr) for the combined trips ?

Total distance: 1 + 2 = 3 mi
Total time: (1/20 + 2/40) hr = 1/10 hr
Avg Speed = 3 mi / (1/10 hr) = 30 mi/hr

Clicker Question 4 (30 s)

TRIP 1: 1 mi at 20 mi/hr
TRIP 2: 2 mi at 40 mi/hr

If it made a pit stop for gas for 20 minutes between the trips, the average speed of the combined trip

1. INCREASES
2. DECREASES
3. STAYS THE SAME
4. CANNOT BE DETERMINED

It takes more time (including pit stop) for the same displacement. Therefore

1D Motion

- Instead of 3 dimensions (x,y,z), we deal with one
  - We arbitrarily choose (say) x-axis/origin our choice to describe motion
- In this special case, all our vectors have one component, the x-component
  - We can drop the subscript (x) and implicitly assume motion in 1D
  - They take on one of two values (positive or negative), drop the vector notation since it's assumed to be along +x (positive) or –x (negative)

$$v_{avg} = \frac{\Delta x}{\Delta t} \qquad v_{inst} = \frac{dx}{dt}$$

$$a_{avg} = \frac{\Delta v}{\Delta t} \qquad a_{inst} = \frac{dv}{dt} = \frac{d^2x}{dt^2}$$

1D: Constant Acceleration

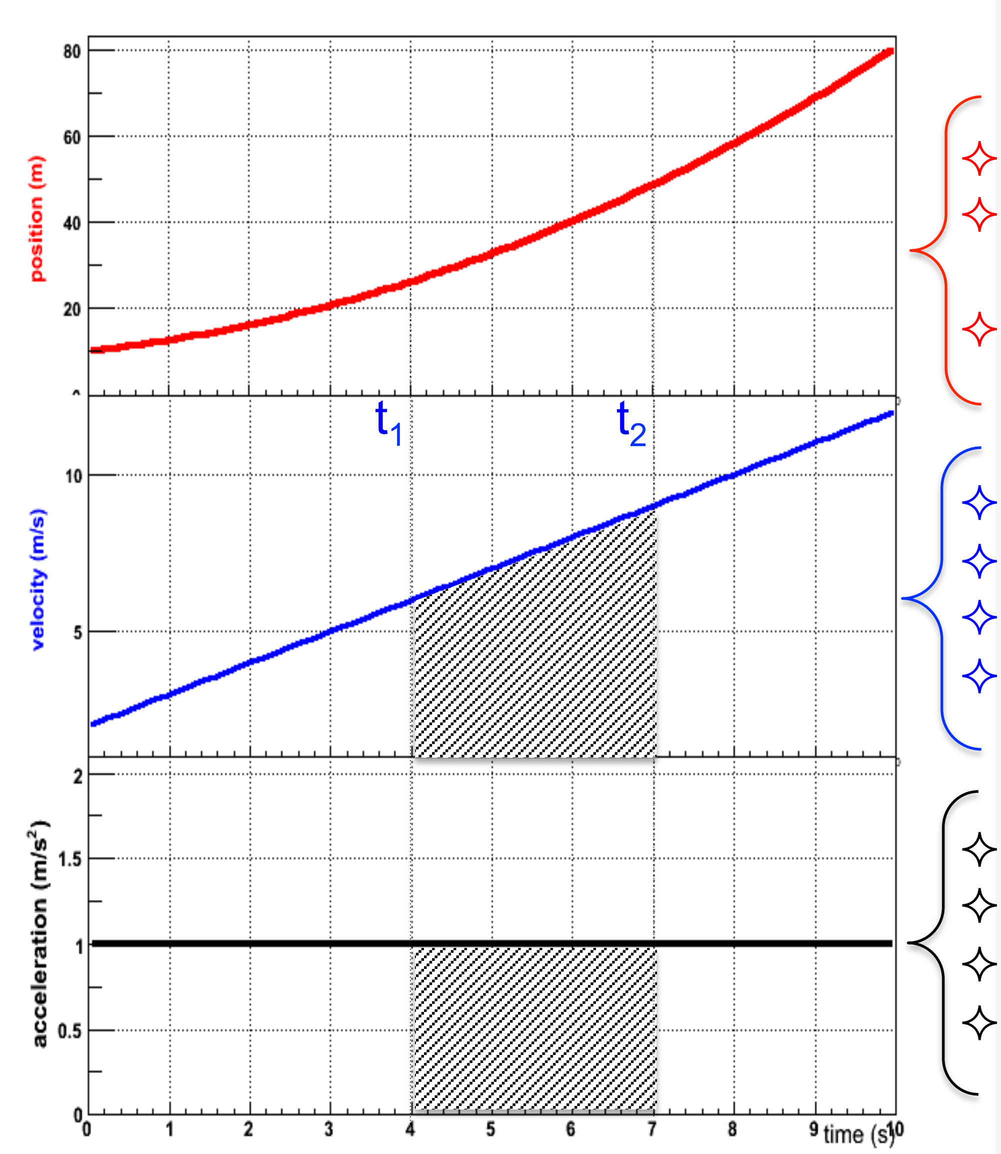
- Assume constant acceleration
  - $a_{avg} = a_{inst} = a$ (any constant)
  - For free fall close to earth's surface, $a = g = 9.8\ \text{m/s}^2$ directed toward center of the earth

$$\frac{d^2x}{dt^2} = a$$
$$\int_{t=0}^{t=t} \frac{d^2x}{dt^2} dt = a \int_0^t dt$$
$$\left|\frac{dx}{dt}\right|_0^t = at$$
$$v - v_0 = at$$
$$\Rightarrow v = v_0 + at \qquad (1)$$

$$\frac{dx}{dt} = v_0 + at$$
$$\int_{t=0}^{t=t} \frac{dx}{dt} dt = \int_0^t v_0\, dt + a \int_0^t t\, dt$$
$$\left|x\right|_0^t = \left|v_0 t + \frac{1}{2}at^2\right|_0^t$$
$$x - x_0 = v_0 t + \frac{1}{2}at^2$$
$$\Rightarrow x = x_0 + v_0 t + \frac{1}{2}at^2 \qquad (2)$$

$$t = \frac{v - v_0}{a}$$
$$\Rightarrow x - x_0 = \frac{v^2 - v_0^2}{2a} \qquad (3)$$

Graphical Solution



Motion with constant acceleration

- graph of x(t)
- slope of the curve at a time t is the instantaneous velocity at t
- slope changes with time

- graph of v(t)
- slope of the curve is acceleration
- slope is constant = acceleration
- area under the curve gives $x(t_2) - x(t_1)$

- graph of a(t)
- slope is zero
- y-value at any time t is = acceleration
- area under the curve gives $v(t_2) - v(t_1)$

Problems

- We worked on a few problems for 1D motion from Chapter 2