PHYS 1441 – Section 004
Lecture #4

Monday, Feb. 2, 2004
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- Chapter two: Motion in one dimension
  - Acceleration (Average and instantaneous)
  - One dimensional motion at constant acceleration
    - Free Fall
  - Coordinate systems

Announcements

- Homework Registration: 58/61
  - Roster has been locked
  - Come see me if you haven't registered.
- E-mail distribution list (phys1441-004-spring04)
  - 43 of you subscribed as of 10am this morning
  - Send an e-mail to listserv@listserv.uta.edu with
    - "subscribe phys1441-004-spring04 fn ln"
    - Without a subject. Put the above in the body ONLY!
  - 1 point extra credit if done by 6pm Monday, Feb. 2
  - Test message will be issued Wednesday, Feb. 4
- Lab begins today, Monday, Feb. 2
- Use the Physics Clinic
  - When: MWF: 12-7pm, T,Th: 12-7:30pm
  - Where: SH010
- Quiz
  - Average 49
  - Top score: 90

Instantaneous Velocity and Speed

- Can average quantities tell you the detailed story of the whole motion?
- Instantaneous velocity is defined as:

$$v_x = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

  - What does this mean?
    - Displacement in an infinitesimal time interval
    - Mathematically: Slope of the position variation as a function of time

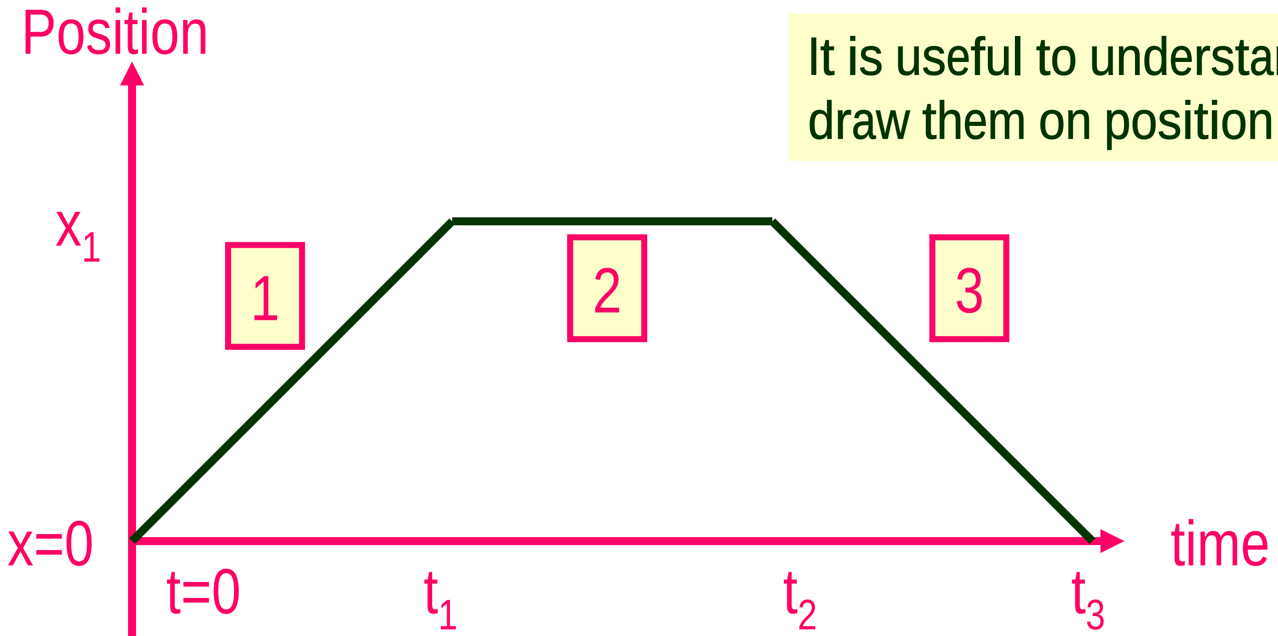
•Instantaneous speed is the size (magnitude) of the velocity vector:

$$|v_x| = \left| \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} \right| = \left| \frac{dx}{dt} \right|$$

*Magnitude of Vectors are Expressed in absolute values

Position vs Time Plot

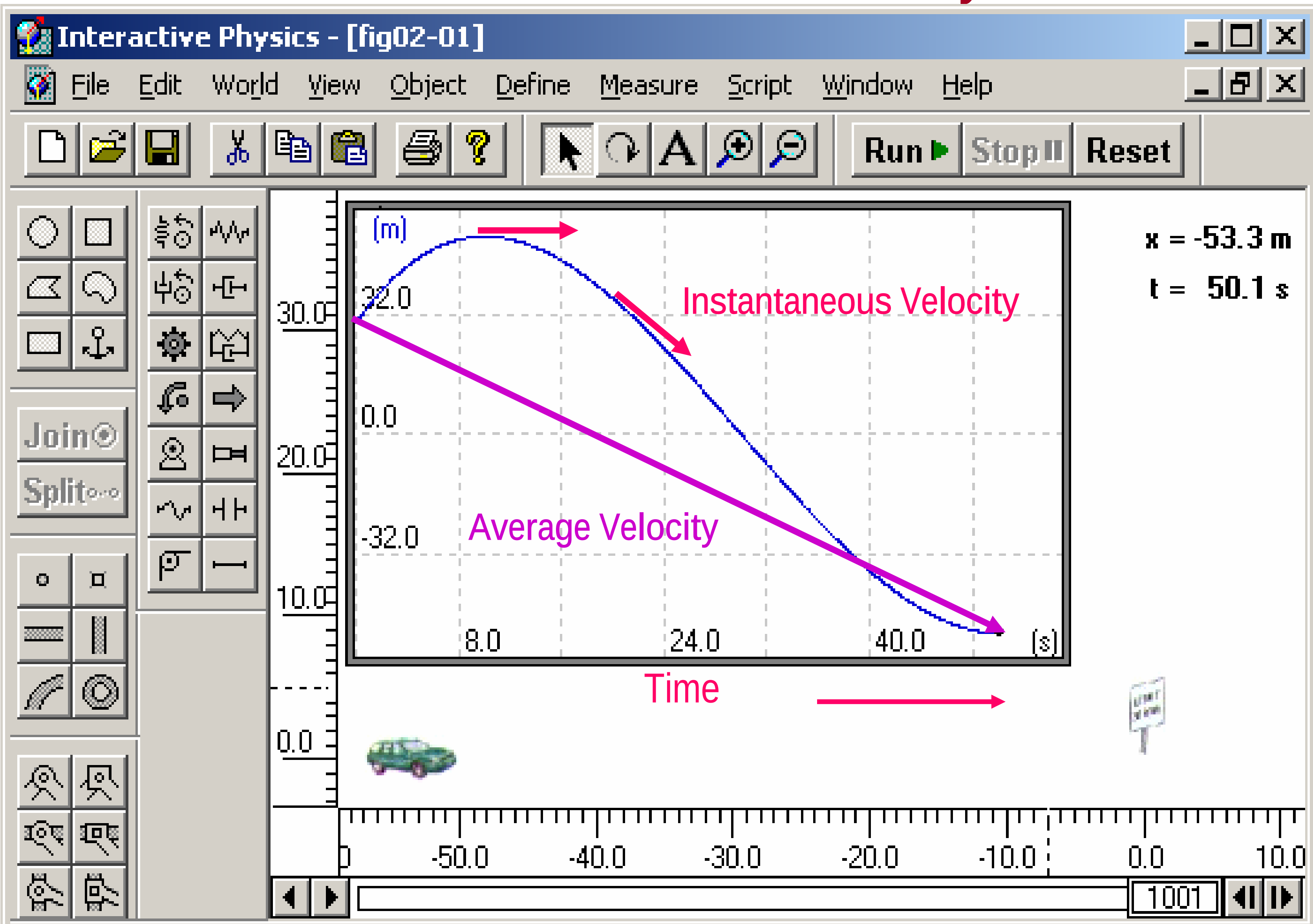
It is useful to understand motions to draw them on position vs time plots.



1. Running at a constant velocity (go from $x=0$ to $x=x_1$ in t_1, Displacement is + x_1 in t_1 time interval)
2. Velocity is 0 (go from x_1 to x_1 no matter how much time changes)
3. Running at a constant velocity but in the reverse direction as 1. (go from x_1 to $x=0$ in t_3-t_2 time interval, Displacement is - x_1 in t_3-t_2 time interval)

Does this motion physically make sense?

Instantaneous Velocity



Displacement, Velocity and Speed

Displacement

$$\Delta x \equiv x_f - x_i$$

Average velocity

$$v_x \equiv \frac{x_f - x_i}{t_f - t_i} = \frac{\Delta x}{\Delta t}$$

Average speed

$$v \equiv \frac{\text{Total Distance Traveled}}{\text{Total Time Spent}}$$

Instantaneous velocity

$$v_x = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

Instantaneous speed

$$|v_x| = \left| \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} \right| = \left| \frac{dx}{dt} \right|$$

Acceleration

Change of velocity in time (what kind of quantity is this?)

- Average acceleration:

$$a_x \equiv \frac{v_{xf} - v_{xi}}{t_f - t_i} = \frac{\Delta v_x}{\Delta t} \quad \text{analogs to} \quad v_x \equiv \frac{x_f - x_i}{t_f - t_i} = \frac{\Delta x}{\Delta t}$$

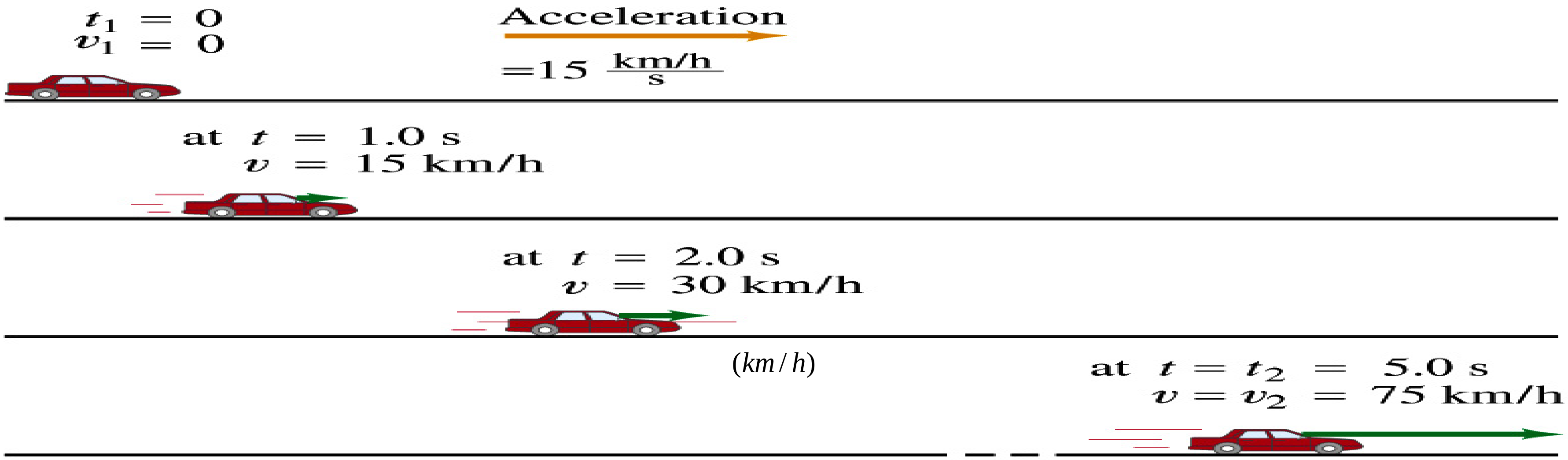
- Instantaneous acceleration:

$$a_x \equiv \lim_{\Delta t \to 0} \frac{\Delta v_x}{\Delta t} = \frac{dv_x}{dt} = \frac{d}{dt}\left(\frac{dx}{dt}\right) = \frac{d^2x}{dt^2} \quad \text{analogs to} \quad \boxed{v_x \equiv \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}}$$

- In calculus terms: A slope (derivative) of velocity with respect to time or change of slopes of position as a function of time

Example 2.4

A car accelerates along a straight road from rest to 75km/h in 5.0s.



What is the magnitude of its average acceleration?

$$v_{xi} = 0\ m/s$$

$$v_{xf} = \frac{75000m}{3600s} = 21\ m/s$$

$$\bar{a}_x = \frac{v_{xf} - v_{xi}}{t_f - t_i} = \frac{\Delta v_x}{\Delta t} = \frac{21-0}{5.0} = \frac{21}{5.0} = 4.2(m/s^2)$$

$$= \frac{4.2\times(3600)^2}{1000} = 5.4\times10^4(km/h^2)$$

Example for Acceleration

- Velocity, v_x, is express in: $v_x(t) = \left(40 - 5t^2\right) m/s$
- Find average acceleration in time interval, t=0 to t=2.0s

$$v_{xi}(t_i = 0) = 40(m/s)$$

$$v_{xf}(t_f = 2.0) = \left(40 - 5 \times 2.0^2\right) = 20(m/s)$$

$$a_x = \frac{v_{xf} - v_{xi}}{t_f - t_i} = \frac{\Delta v_x}{\Delta t} = \frac{20 - 40}{2.0 - 0} = -10(m/s^2)$$

- Find instantaneous acceleration at any time t and t=2.0s

Instantaneous Acceleration at any time

$$a_x(t) \equiv \frac{dv_x}{dt} = \frac{d}{dt}\left(40 - 5t^2\right) = -10t$$

Instantaneous Acceleration at any time t=2.0s

$$a_x(t = 2.0)$$
$$= -10 \times (2.0)$$
$$= -20(m/s^2)$$

Meanings of Acceleration

- When an object is moving in a constant velocity ($v=v_0$), there is no acceleration ($a=0$)
  – Is there any acceleration when an object is not moving?
- When an object is moving faster as time goes on, ($v=v(t)$), acceleration is positive ($a>0$)
  – Incorrect since an object might be moving in negative direction initially
- When an object is moving slower as time goes on, ($v=v(t)$), acceleration is negative ($a<0$)
  – Incorrect since an object might be moving in negative direction initially
- In all cases, velocity is positive, unless the direction of the movement changes.
  – Incorrect since an object might be moving in negative direction initially
- Is there acceleration if an object moves in a constant speed but changes direction?

The answer is YES!!