PHYS 1441 – Section 002
Lecture #5

Wednesday, Jan. 30, 2008
Dr. Jaehoon Yu

- Acceleration
- Motion under constant acceleration
- One-dimensional Kinematic Equation
- Motion under constant acceleration

Announcements

- E-mail distribution list: 32 of you subscribed to the list so far
  - 3 point extra credit if done by midnight today, Wednesday, Jan. 30
  - I will send out a test message Thursday evening
    - Need your confirmation reply → Just to me not to all class please….
- Physics Department colloquium schedule at
  - http://www.uta.edu/physics/main/phys_news/colloquia/2008/Spring2008.html
- Phantom Submission problem started appearing on HW#2.
  - Get your homework worked out but do not submit yet.
  - Let me delete and re-create the exact the same homework
  - I will do this for you to start submitting starting at 7pm tonight
  - If you see them again, do not submit answers but let me know of the problem via e-mail

Special Problems for Extra Credit

- Derive the quadratic equation for $yx^2-zx+v=0$
  ➔ 5 points
- Derive the kinematic equation $v^2 = v_0^2 + 2a\left(x - x_0\right)$ from first principles and the known kinematic equations ➔ 10 points
- You must show your work in detail to obtain the full credit
- Due next Wednesday, Feb. 6

Physics Department
The University of Texas at Arlington
COLLOQUIUM

Medical Imaging and Medical Physics

Dr. Jack L. Lancaster
Chief, Biomedical Image Analysis Division
The University of Texas Health Science Center at San Antonio

3:30 pm Wednesday January 30, 2008
Room 101 SH

Abstract

The primary area of research interest at the UTHSCSA's Research Imaging Center is the brain. Positron emission tomography (PET) and magnetic resonance imaging (MRI) systems are the main imaging tools used in brain research. PET and functional MRI (fMRI) studies provide a means to measure changes in regional brain blood flow associated with subtle changes in brain activity. Detailed studies of regional brain anatomy are done using special MRI imaging techniques. These 3-D measurements of function and anatomy are advancing our understanding of what happens where in the brain, a field generally referred to as brain mapping. Non-imaging devices such as transcranial magnetic stimulation (TMS) systems allow researchers to directly stimulate neuronal activity. Using TMS with PET imaging we can monitor changes in blood flow at the stimulated site and at other regions of the brain connected to the same system-level network. Analysis of 3-D images requires a sound background in physics, math, anatomy, physiology and computer science to achieve meaningful results. Examples of research with PET, fMRI, anatomical MRI, diffusion tensor MRI, and TMS will be presented.

Refreshments will be served in the Physics Library at 3:00 pm

Physics Department
The University of Texas at Arlington
COLLOQUIUM

Current Topics in Clinical Medical Physics

Dr. Geoffrey D. Clarke

Professor and Vice-Chair of Graduate Education in Radiology, UTHSCSA

3:30 pm Wednesday January 30, 2008
Room 101 SH

Abstract

This presentation will cover the current and future trends in clinical medical physics, which continues to progress with the increasing adoption of advances in solid-state physics and signal processing technologies. Increases in the number of sensors, i.e. the numbers of x-ray detectors in computed tomography and parallel receiver coils in MRI are pushing the speeds of these imaging modalities to ever higher levels. In radiation therapy physics, image-guided approaches to delivering radiation treatments are being implemented while tailored therapies, combining radiation with chemotherapy and disruptive agents such as ultrasound and radiofrequency ablation are seriously being explored. Recently there have also been major investments in heavy particle treatment methods, particularly proton therapy.

Refreshments will be served in the Physics Library at 3:00 pm

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

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

Instantaneous speed

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

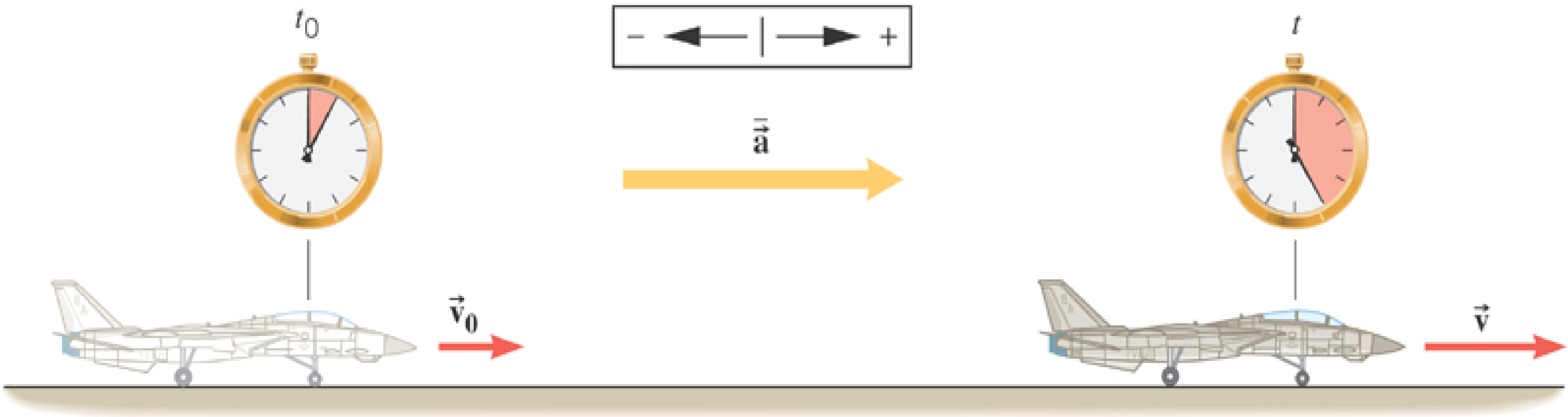
Acceleration

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

Vector!!

Concept of Acceleration

The notion of ***acceleration*** emerges when a change in velocity is combined with the time during which the change occurs.



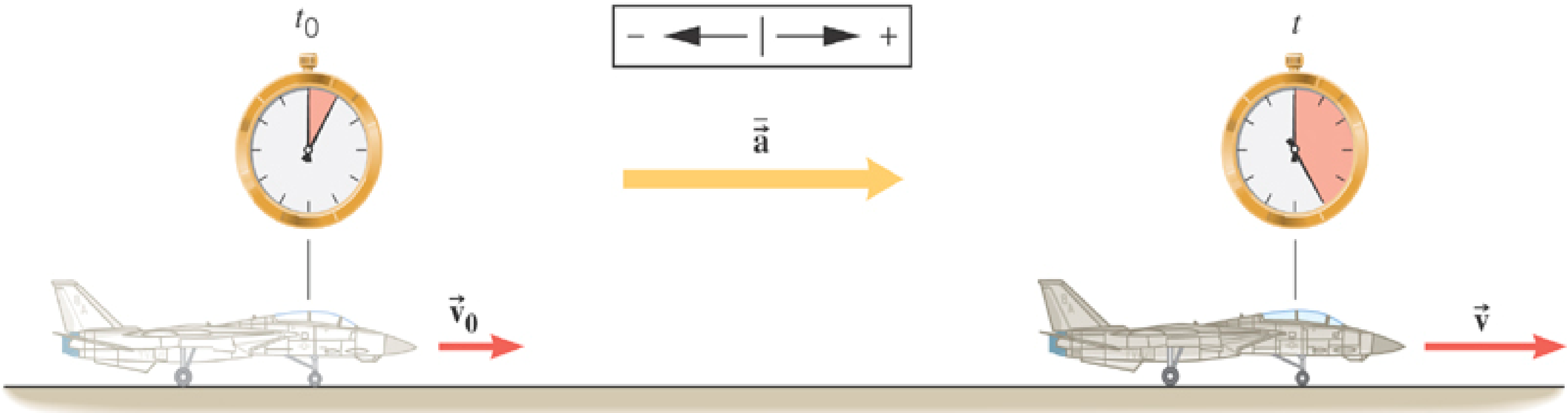
Acceleration

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

- Average acceleration:

$$\bar{\vec{a}} \equiv \frac{\vec{v}_f - \vec{v}_i}{t_f - t_i} = \frac{\Delta\vec{v}}{\Delta t}$$ analogous to $$\bar{\vec{v}} \equiv \frac{\vec{x}_f - \vec{x}_i}{t_f - t_i} = \frac{\Delta\vec{x}}{\Delta t}$$

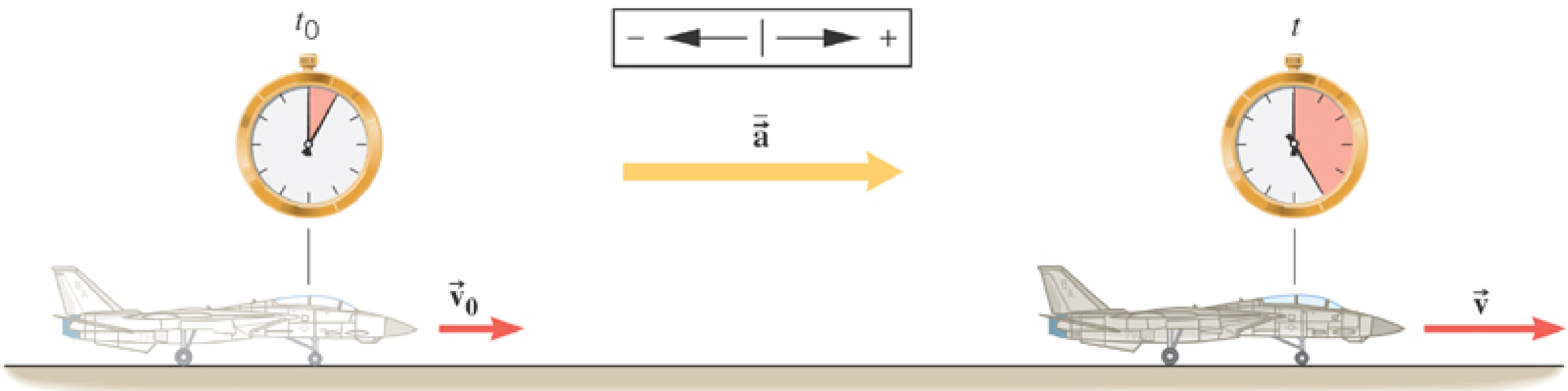
Definition of Average Acceleration



$$\bar{\vec{a}} \equiv \frac{\vec{v} - \vec{v}_0}{t - t_0} = \frac{\Delta \vec{v}}{\Delta t}$$

Ex. 3: Acceleration and Increasing Velocity

Determine the average acceleration of the plane.



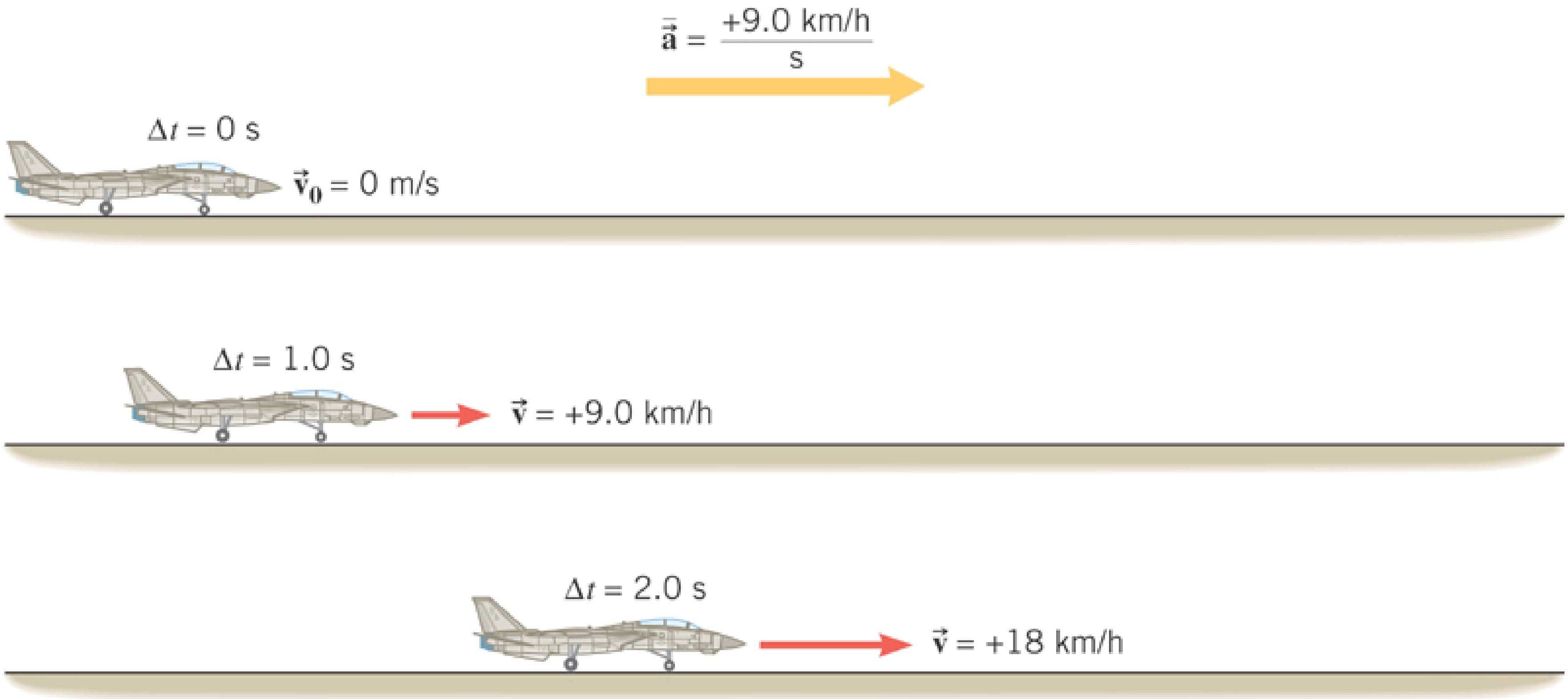
$t_o = 0\ \text{s} \quad \vec{\mathbf{v}}_o = 0\,\text{m/s}$

$t = 29\ \text{s} \quad \vec{\mathbf{v}} = 260\,\text{km/h}$

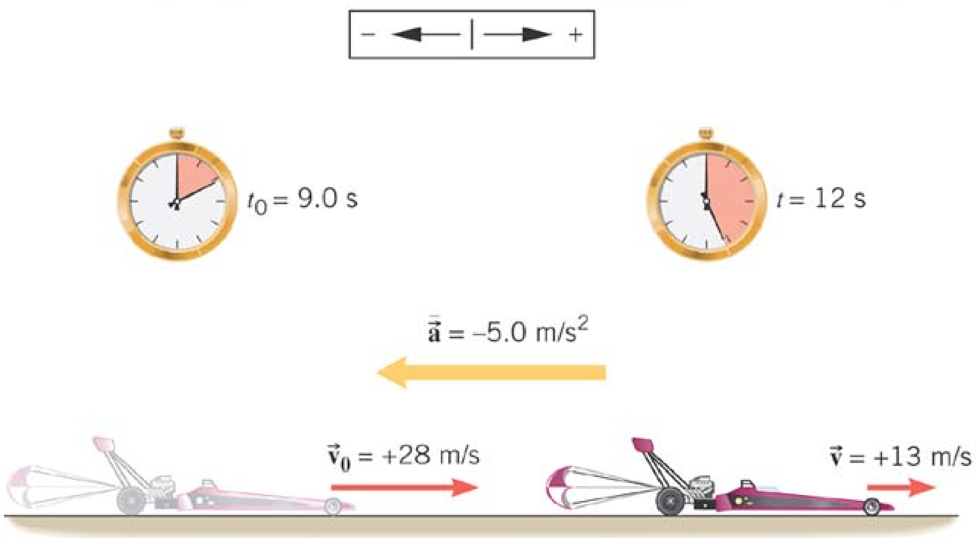
$$\bar{\vec{\mathbf{a}}} = \frac{\vec{\mathbf{v}} - \vec{\mathbf{v}}_o}{t - t_o} = \frac{260\,\text{km/h} - 0\,\text{km/h}}{29\ \text{s} - 0\ \text{s}} = +9.0\frac{\text{km/h}}{\text{s}} =$$

$$+\frac{9 \cdot 1000m}{3600s \cdot s} = 2.5\,m/s^2$$

2.3 Acceleration

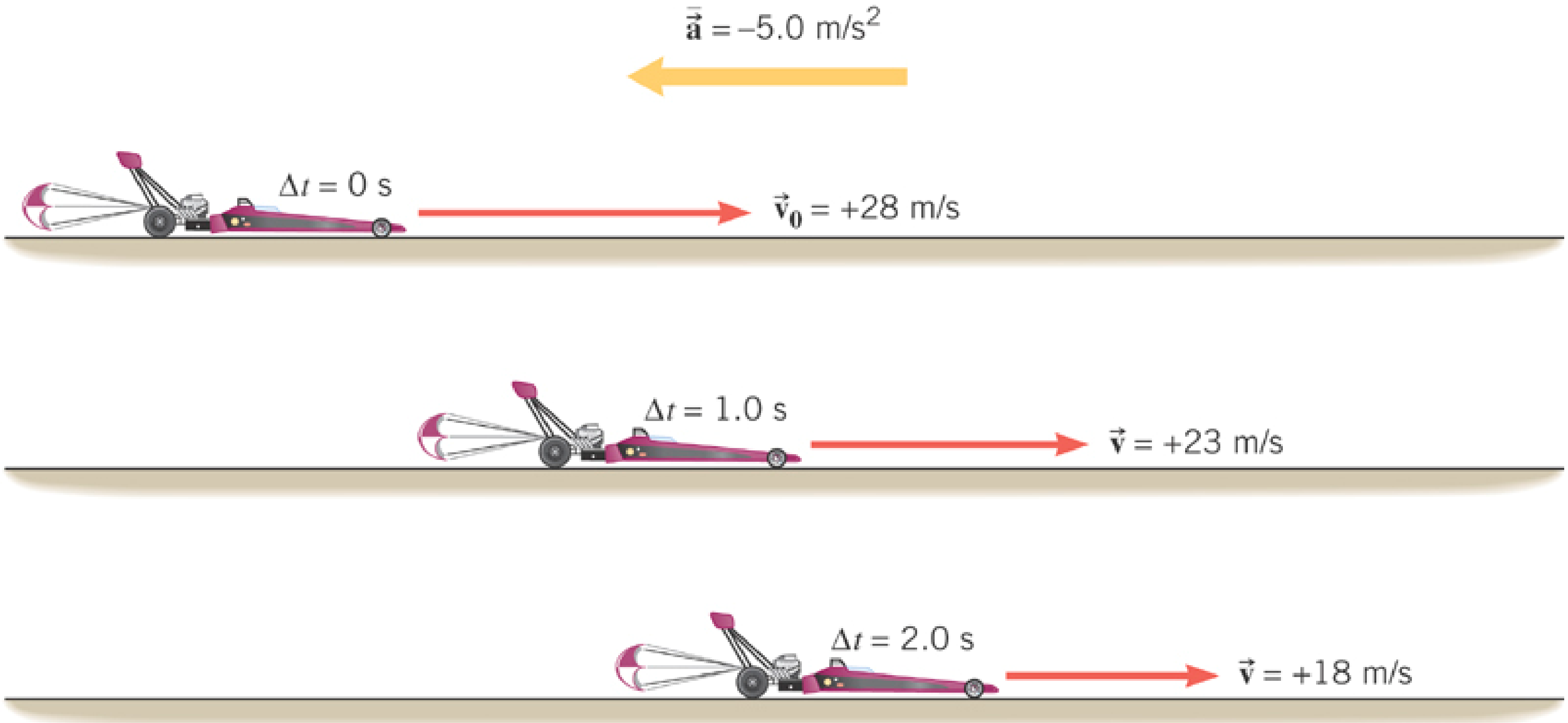


Ex.4 Acceleration and Decreasing Velocity



(b)

$$\overline{\vec{\mathbf{a}}} = \frac{\vec{\mathbf{v}} - \vec{\mathbf{v}}_o}{t - t_o} = \frac{13\,\mathrm{m/s} - 28\,\mathrm{m/s}}{12\ \mathrm{s} - 9\ \mathrm{s}} = -5.0\,\mathrm{m/s^2}$$



Deceleration is an Acceleration in the opposite direction!!

Acceleration

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

- Average acceleration:

$$\bar{\vec{a}} \equiv \frac{\vec{v}_f - \vec{v}_i}{t_f - t_i} = \frac{\Delta \vec{v}}{\Delta t}$$ analogous to $$\bar{\vec{v}} \equiv \frac{\vec{x}_f - \vec{x}_i}{t_f - t_i} = \frac{\Delta \vec{x}}{\Delta t}$$

- Instantaneous acceleration:

$$a_x \equiv \lim_{\Delta t \to 0} \frac{\Delta v_x}{\Delta t}$$ analogous to $$v_x \equiv \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$$

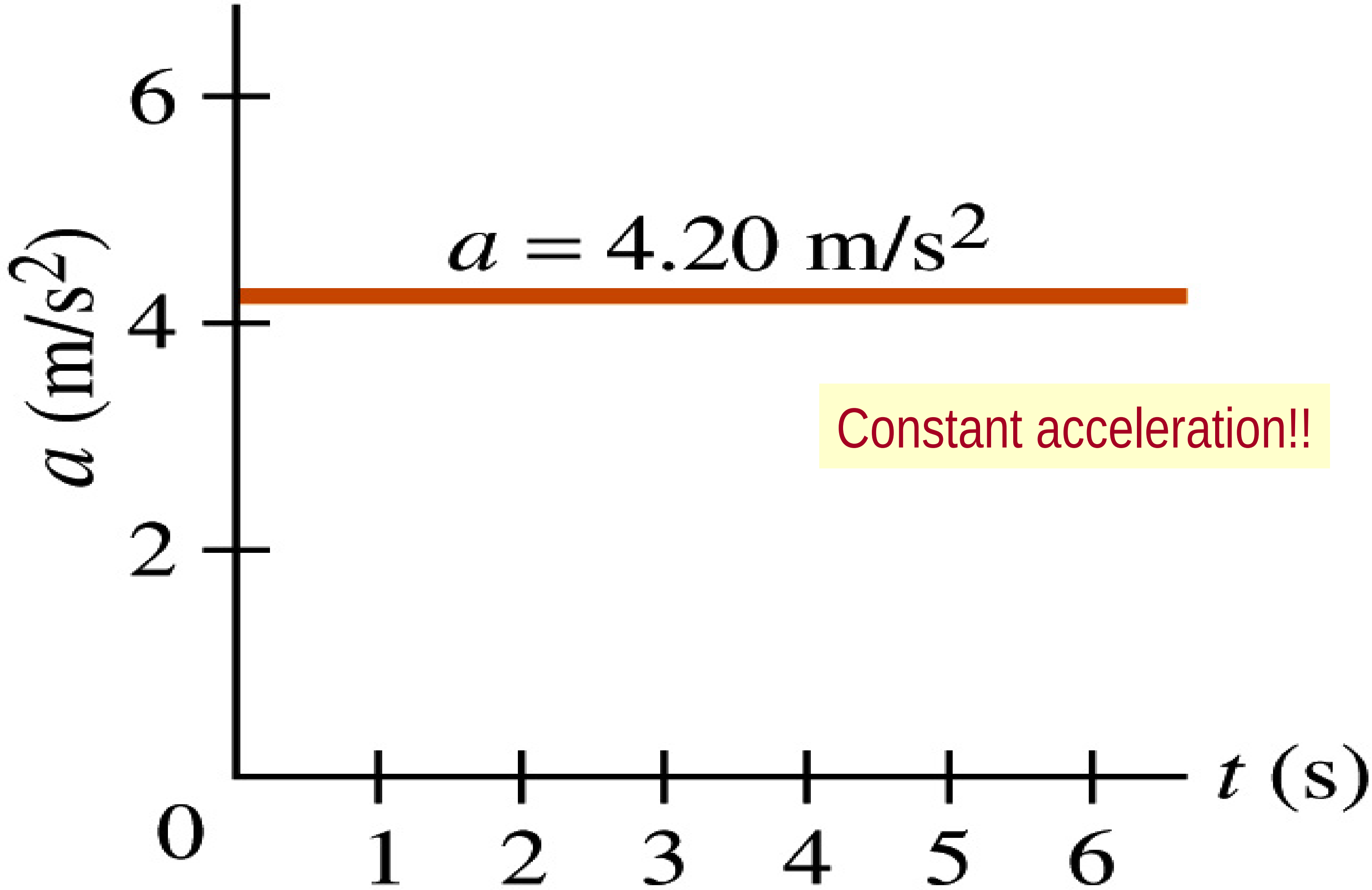
Meanings of Acceleration

- When an object is moving at a constant velocity ($v=v_0$), there is no acceleration ($a=0$)
  - Is there any net acceleration when an object is not moving?
- When an object speeds up as time goes on, ($v=v(t)$), acceleration has the same sign as v.
- When an object slows down as time goes on, ($v=v(t)$), acceleration has the opposite sign as v.
- Is there acceleration if an object moves in a constant speed but changes direction? YES!!

One Dimensional Motion

- Let's start with the simplest case: the acceleration is constant ($a=a_0$)

Acceleration vs Time Plot



Constant acceleration!!

Equations of Kinematics

- Five kinematic variables
  - displacement, x
  - acceleration (constant), a
  - final velocity (at time t), v
  - initial velocity, v_o
  - elapsed time, t

One Dimensional Kinematic Equation

- Let's start with the simplest case: the acceleration is constant ($a=a_0$)
- Using definitions of average acceleration and velocity, we can derive equation of motion (description of motion, position *wrt* time)

$$\bar{a} = \frac{v - v_0}{t - t_0} = a$$

Let $t=t$ and $t_0=0$

$$a = \frac{v - v_0}{t}$$

Solve for v

$$v = v_0 + at$$

One Dimensional Kinematic Equation

For constant acceleration, simple numeric average

$$\bar{v} = \frac{v + v_0}{2} = \frac{2v_0 + at}{2} = v_0 + \frac{1}{2}at$$

$$\bar{v} = \frac{x - x_0}{t - t_0}$$

Let $t=t$ and $t_0=0$

$$\bar{v} = \frac{x - x_0}{t}$$

Solve for x

$$x = x_0 + \bar{v}t$$

Resulting Equation of Motion becomes

$$x = x_0 + \bar{v}t = x_0 + v_0 t + \frac{1}{2}at^2$$

Kinematic Equations of Motion on a Straight Line Under Constant Acceleration

$$v(t) = v_0 + at$$

Velocity as a function of time

$$x - x_0 = \frac{1}{2}\bar{v}t = \frac{1}{2}(v + v_0)t$$

Displacement as a function of velocities and time

$$x = x_0 + v_0 t + \frac{1}{2}at^2$$

Displacement as a function of time, velocity, and acceleration

$$v^2 = v_0^2 + 2a(x - x_0)$$

Velocity as a function of Displacement and acceleration

You may use different forms of Kinematic equations, depending on the information given to you in specific physical problems!!

How do we solve a problem using a kinematic formula under constant acceleration?

- Identify what information is given in the problem.
  - Initial and final velocity?
  - Acceleration?
  - Distance, initial position or final position?
  - Time?
- Convert the units of all quantities to SI units to be consistent.
- Identify what the problem wants
- Identify which kinematic formula is **appropriate and easiest** to solve for what the problem wants.
  - Frequently multiple formulae can give you the answer for the quantity you are looking for. ➔ Do not just use any formula but use the one that can be easiest to solve.
- Solve the equations for the quantity or quantities wanted.