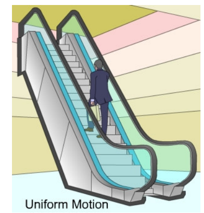
Accelerated Motion

Physics @ phuhs.schrock

Acceleration

- You can feel a difference between **uniform** (constant) and **nonuniform** (accelerated) motion.
- When you move in a **nonuniform motion**, you feel pushed or pulled.
- In contrast, when you are in **uniform motion** and your eyes are closed, you feel as though you are not moving at all.



Acceleration

- So far, we've talked about "***how far***" and "***how fast***"…now we want to study "***how fast an object is getting faster***"
- The rate at which an object's velocity changes is called ***acceleration***.
- ***acceleration*** is measured in m/s/s or m/s².

Acceleration

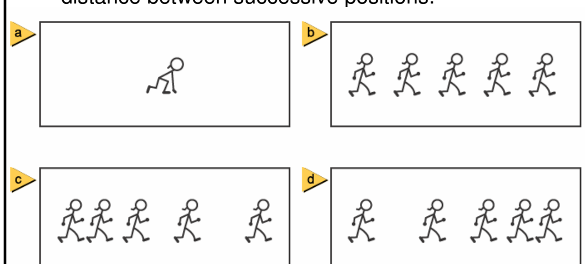
- ***average acceleration***
  - the change in velocity during some measurable time interval divided by that time interval.

$$\bar{a} \equiv \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

- ***instantaneous acceleration***
  - the change in velocity at an instant of time

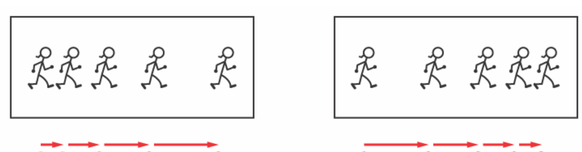
Acceleration

- Consider the motion diagram below showing the distance between successive positions.



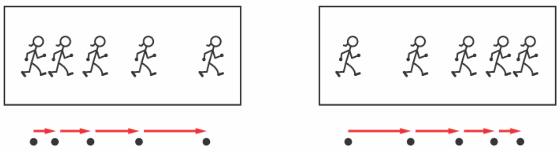
Acceleration

- two major indicators of change in velocity.
  - The change in the spacing of the dots and
  - the differences in the lengths of the velocity vectors



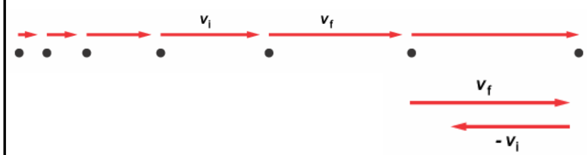
Acceleration

- If an object speeds up, each subsequent velocity vector is longer.
- If the object slows down, each vector is shorter than the previous one.
- Both types of motion diagrams give an idea of how an object's velocity is changing.



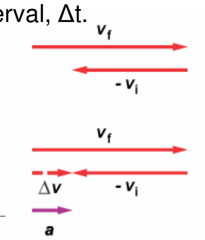
Displaying Acceleration on a Motion Diagram

- To determine the length and direction of an average acceleration vector,
  - subtract two consecutive velocity vectors, as shown below.

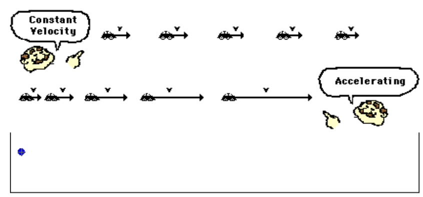


Displaying Acceleration on a Motion Diagram

- You will have: **$\Delta v = v_f - v_i$** $= v_f +$ **$(-v_i)$**
- Then divide by the time interval, Δt.



Position, Velocity, Acceleration

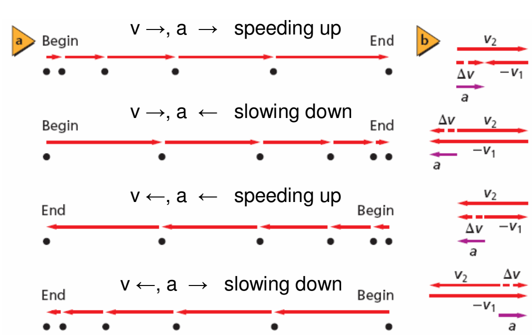


http://www.physicsclassroom.com/Class/1DKin/U1L2c.html

Positive and Negative Acceleration

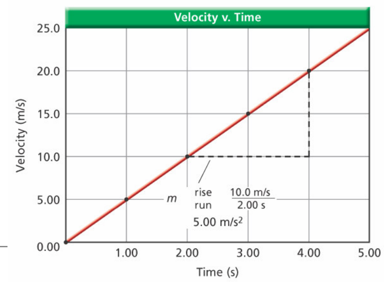
- When the object's ***acceleration*** is in the same direction as its ***velocity***,
  - the object's **speed increases**.
- When they are in opposite directions,
  - the **speed decreases**.
- Study the figure that follows…

Positive and Negative Acceleration



Velocity-Time (v-t) Graph

Slope = acceleration
Slope is constant = acceleration is constant



Determining Acceleration from a v-t Graph

- The following equation expresses average acceleration as the slope of the velocity-time graph.

$$\bar{a} \equiv \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

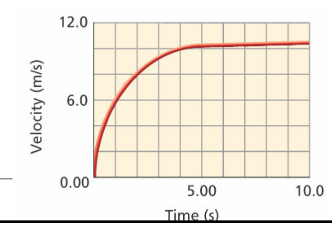
- Average acceleration is equal to the change in velocity, divided by the time it takes to make that change.
- Units: m/s/s or m/s^2

Velocity and Acceleration

v_i	a	Motion
+	+	speeding up
−	−	speeding up
+	−	slowing down
−	+	slowing down
− or +	0	constant velocity
0	− or +	speeding up from rest
0	0	remaining at rest

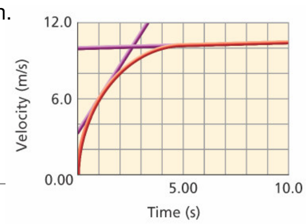
Velocity-Time (v-t) Graph

- If slope is **not** constant
  → acceleration is **not** constant
- How would you describe the sprinter's velocity and acceleration as shown on the graph?

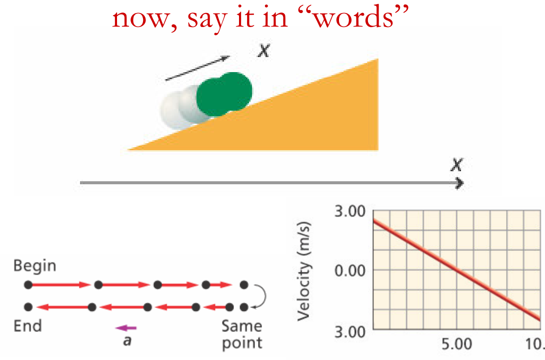


Average and Instantaneous Acceleration

- The **instantaneous acceleration** can be found by drawing a tangent line on the velocity-time graph at the point of time in which you are interested.
- The slope of this line is equal to the instantaneous acceleration.

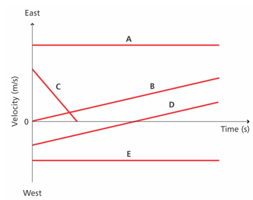


3 "pictures" for the same acceleration… now, say it in "words"

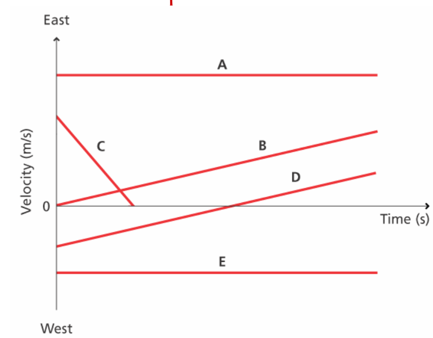


Determining Acceleration from a v-t Graph

- **Graphs** A, B, C, D, and E, as shown on the right, represent the motions of five different runners.
- Assume that the positive direction has been chosen to be east.



Determining Acceleration from a v-t Graph



Determining Acceleration from a v-t Graph

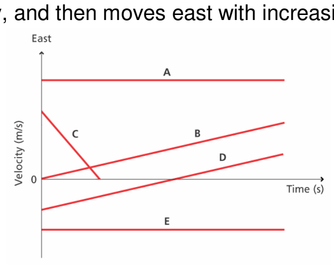
- The slopes of ***Graphs A*** and ***E*** are zero. Thus, the accelerations are zero. Both ***Graphs A*** and ***E*** show motion at a constant velocity— ***Graph A*** to the east and ***Graph E*** to the west.
- ***Graph B*** shows motion with a positive velocity. The slope of this graph indicates a constant, positive acceleration.

Determining Acceleration from a v-t Graph

- ***Graph C*** has a negative slope, showing motion that begins with a positive velocity, slows down, and then stops. This means that the acceleration and velocity are in opposite directions.
- The point at which ***Graphs C*** and ***B*** cross shows that the runners' velocities are equal at that point. It does not, however, give any information about the runners' positions.

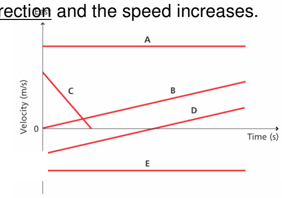
Determining Acceleration from a v-t Graph

- ***Graph D*** indicates movement that starts out toward the west, slows down, and for an instant gets to zero velocity, and then moves east with increasing speed.



Determining Acceleration from a v-t Graph

- The slope of ***Graph D*** is positive.
  - Because the velocity and acceleration are in opposite directions, the speed decreases and equals zero at the time the graph crosses the axis.
  - After that time, the velocity and acceleration are in the same direction and the speed increases.



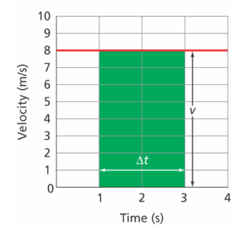
Finding the Displacement from a v-t Graph

- A unique **position-time graph** cannot be created using a **velocity-time graph** because it does not contain any information about the object's position
- However, the **velocity-time graph** does contain information about the object's ***displacement***.
- Recall that for an object moving at a constant velocity,

$$v = \bar{v} = \frac{\Delta d}{\Delta t}, \quad \text{so } \Delta d = v\Delta t$$

Finding the Displacement from a v-t Graph

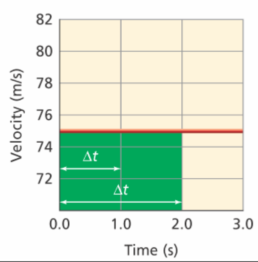
- On the graph shown on the right, **v** is the height of the plotted line above the t-axis, while **Δt** is the width of the shaded rectangle.
- The area of the rectangle, then, is **vΔt**, or **Δd**.
- Thus, the area under the v-t graph is equal to the object's displacement.



$$\Delta d = v\Delta t$$

Finding the Displacement from a v-t Graph

- The v-t graph below shows the motion of an airplane. Find the displacement of the airplane at Δt = 1.0 s and at Δt = 2.0 s.



$$\Delta d = v\Delta t$$

Section Check

- Which of the following statements correctly define acceleration?

A. Acceleration is the rate of change of displacement of an object.

B. Acceleration is the rate of change of velocity of an object.

C. Acceleration is the amount of distance covered in unit time.

D. Acceleration is the rate of change of speed of an object.

Section Check

- What happens when the **velocity vector** and the **acceleration vector** of an object in motion are in same direction?

A. The acceleration of the object increases.

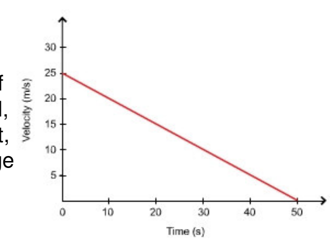
B. The speed of the object increases.

C. The object comes to rest.

D. The speed of the object decreases.

Section Check

- On the basis of the velocity-time graph of a car moving up a hill, as shown on the right, determine the average acceleration of the car?



A. **0.5 m/s²**

B. **- 0.5 m/s²**

C. **2 m/s²**

D. **- 2 m/s²**