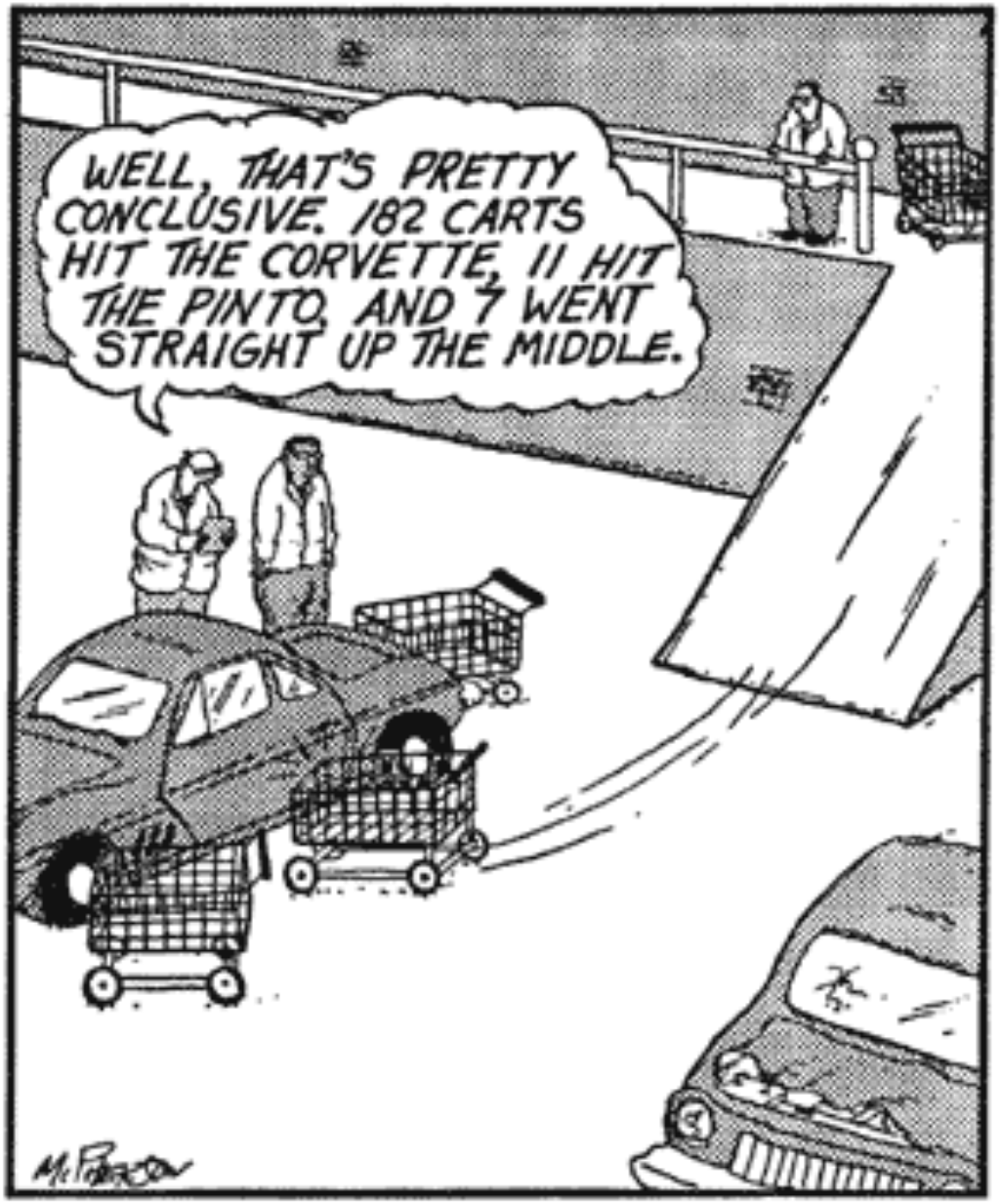


Researchers at MIT prove that rolling shopping carts will almost invariably hit the most expensive car in their vicinity.

Kinematics

The study of motion in
One Dimension

Unit 2 Motion

- Relative motion
- Quantifying Motion
  - Scalar vs. Vector
  - Speed vs. Velocity
  - Distance vs. Displacement
  - Acceleration
  - Kinematic equations
- Graphical interpretation of motion
- Free fall motion

Classification of Physics Quantities

Vector - quantity with both magnitude (size) and direction

Scalar - quantity with magnitude only

<u>Vectors</u>:

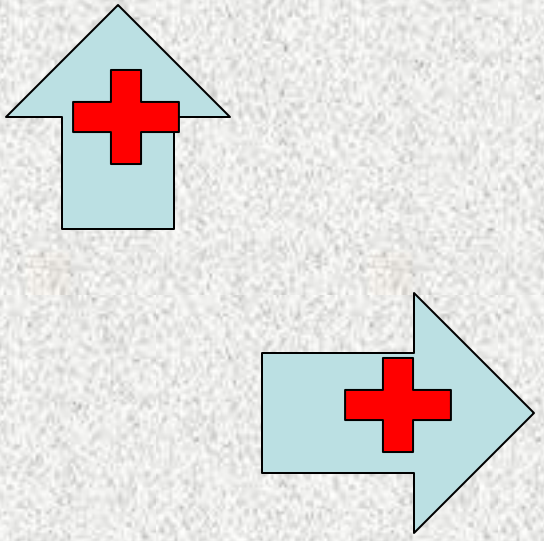
- Displacement
- Velocity
- Acceleration
- Momentum
- Force

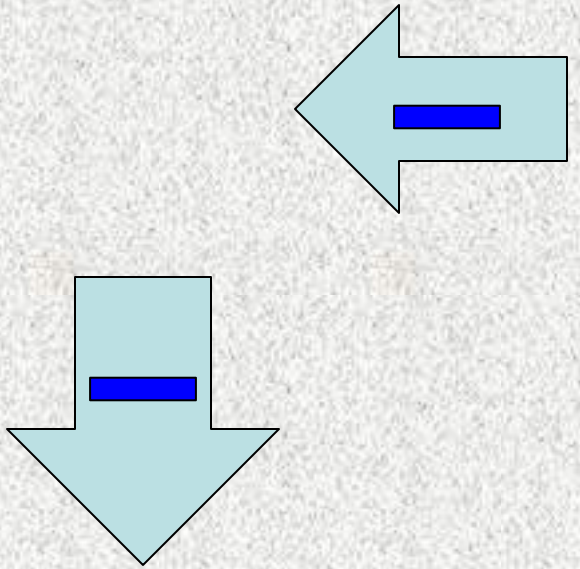
<u>Scalars:</u>

- Distance
- Speed
- Time
- Mass
- Energy

Sign Conventions

- Positive sign
  - Travel East, to the right or travel North, upwards
- Negative sign
  - Travel West, to the left or travel South, downwards





Units

Units are not the same as quantities!

Quantity . . . Unit (symbol)

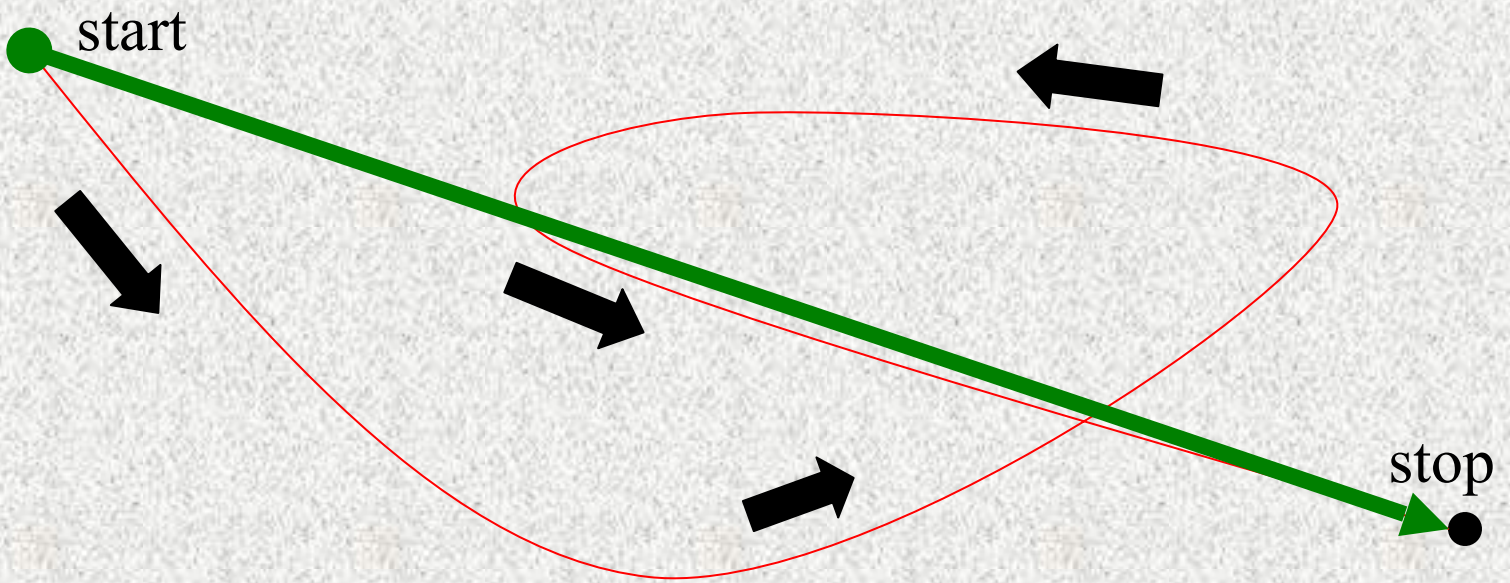
- Displacement & Distance . . . meter (m)
- Time . . . second (s)
- Velocity & Speed . . . (m/s)
- Acceleration . . . (m/s^2)
- Mass . . . kilogram (kg)
- Momentum . . . ($kg \cdot m/s$)
- Force . . .Newton (N)
- Energy . . . Joule (J)

Kinematics definitions

- Kinematics – branch of physics; study of motion
- Distance (*d*) – how far you have traveled, regardless of direction (length of the path traveled)
- Displacement (*d*) – where you are in relation to where you started, includes direction (length and direction from start to finish)

Distance vs. Displacement

- You drive the path, and your odometer goes up by 8 miles (your distance).
- Your displacement is the shorter directed distance from start to stop (green arrow).
- What if you drove in a circle?



Speed, Velocity, & Acceleration

- Speed (v) – how fast you go
- Velocity ($\boldsymbol{v}$) – how fast and which way; the rate at which displacement changes
- Acceleration ($\boldsymbol{a}$) – how fast you speed up, slow down, or change direction; the rate at which velocity changes

Speed vs. Velocity

- Speed is a scalar (it does not consider direction) Ex: v = 20 mph
- Speed is often the magnitude of velocity.
- Velocity is a vector (it considers both speed and direction). Ex: $\boldsymbol{v}$ = 20 mph at 15° south of west

Velocity & Acceleration Sign Chart

		VELOCITY	
		+	−
ACCELERATION	+	Moving forward; Speeding up	Moving backward; Slowing down
	−	Moving forward; Slowing down	Moving backward; Speeding up

Kinematics Formula Summary

For 1-D motion with *constant* acceleration:

- $v_f = v_i + a\,t$
- $\overline{v} = (v_i + v_f)/2$
- $d = v_i t + \frac{1}{2} a t^2$
- $v_f^2 = v_i^2 + 2\,a\,d$
- $\overline{a} = \Delta v/t$
- $v = d/t$

Problem-Solving Method

V_i	
V_f	
ΔV	
V_{bar}	
a	
Δx	
Δt	

Graphing Motion

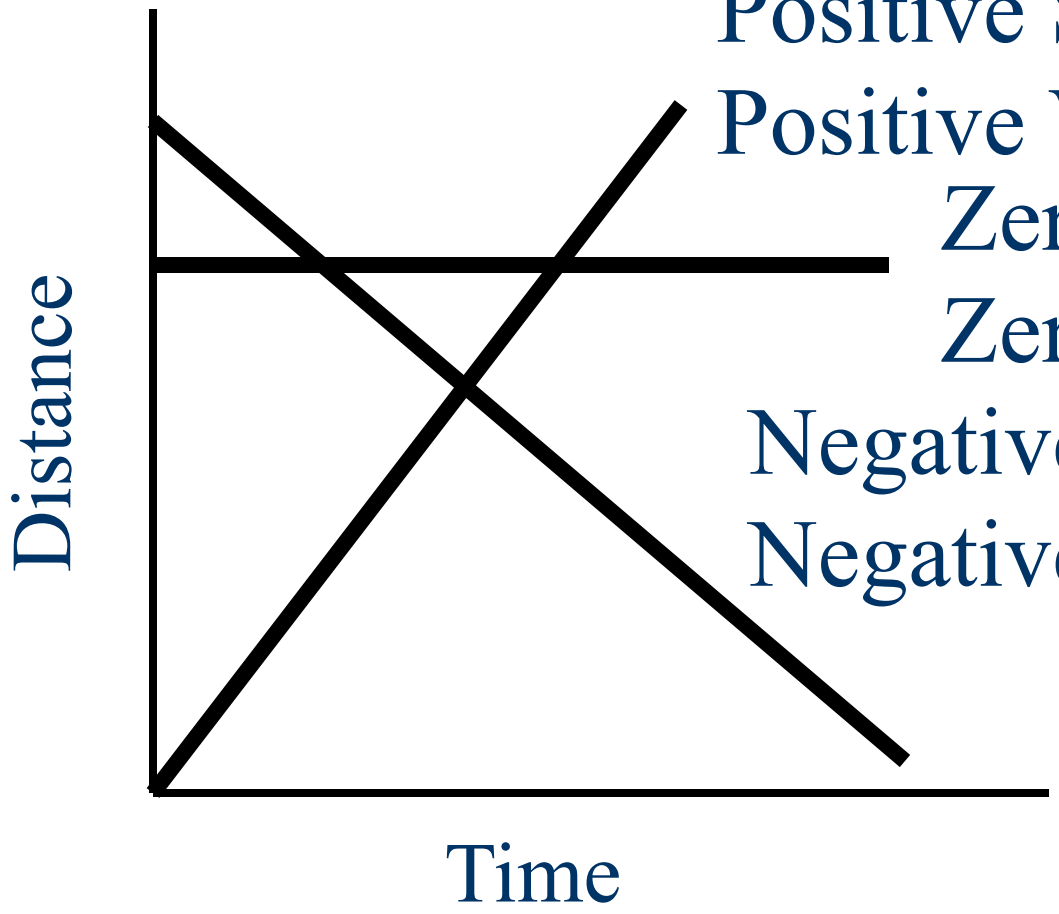
Types of Motion Graphs

- d-t displacement vs. time
- v-t velocity vs. time
- a-t acceleration vs. time

d-t Graph with Constant Speed

- The slope of a distance-time graph represents velocity.
- A constant slope means a constant velocity.
- The slope can be positive, negative , or zero.

Distance-Time Graph



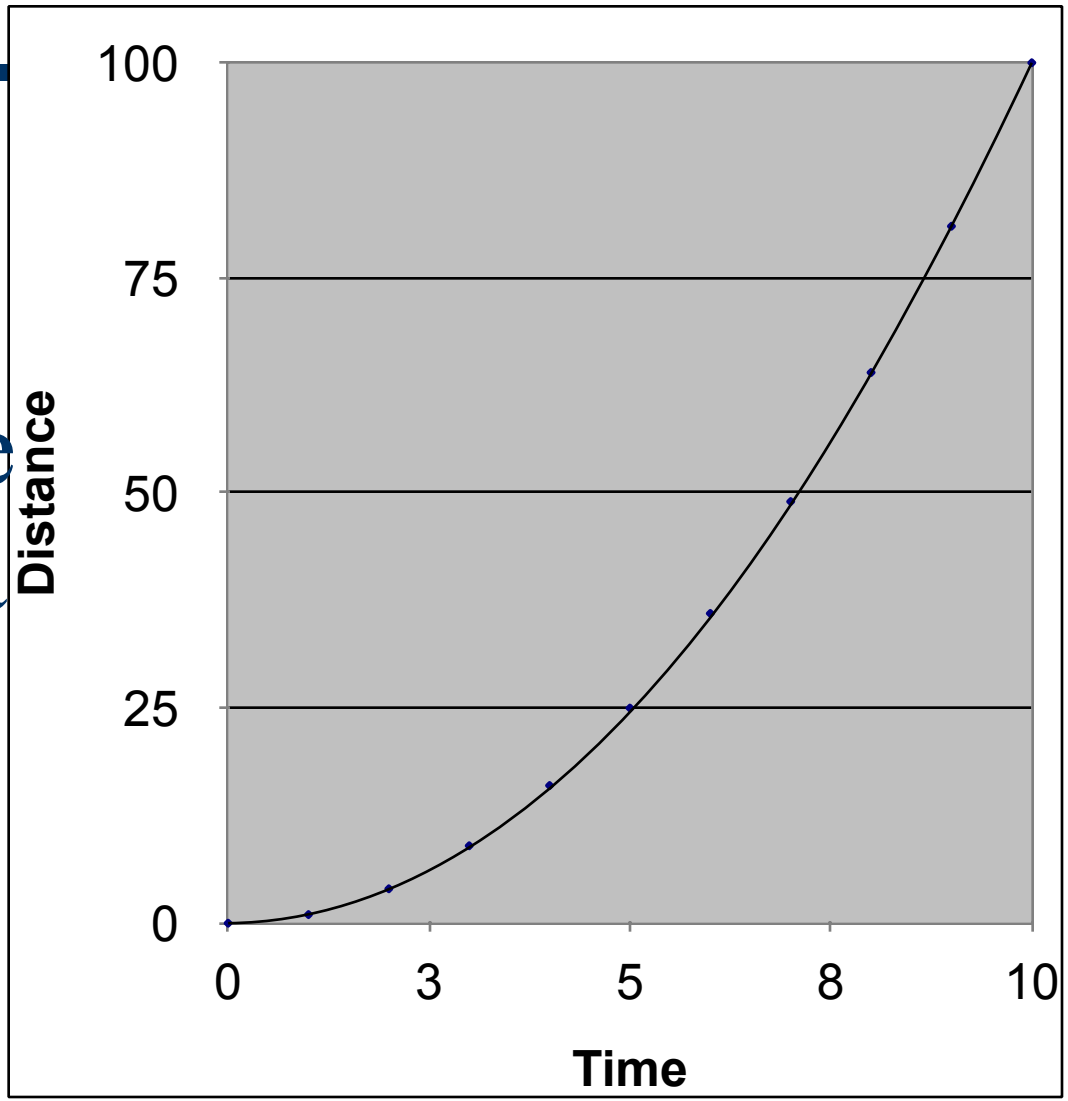
Positive Slope=
Positive Velocity

Zero Slope =
Zero Velocity

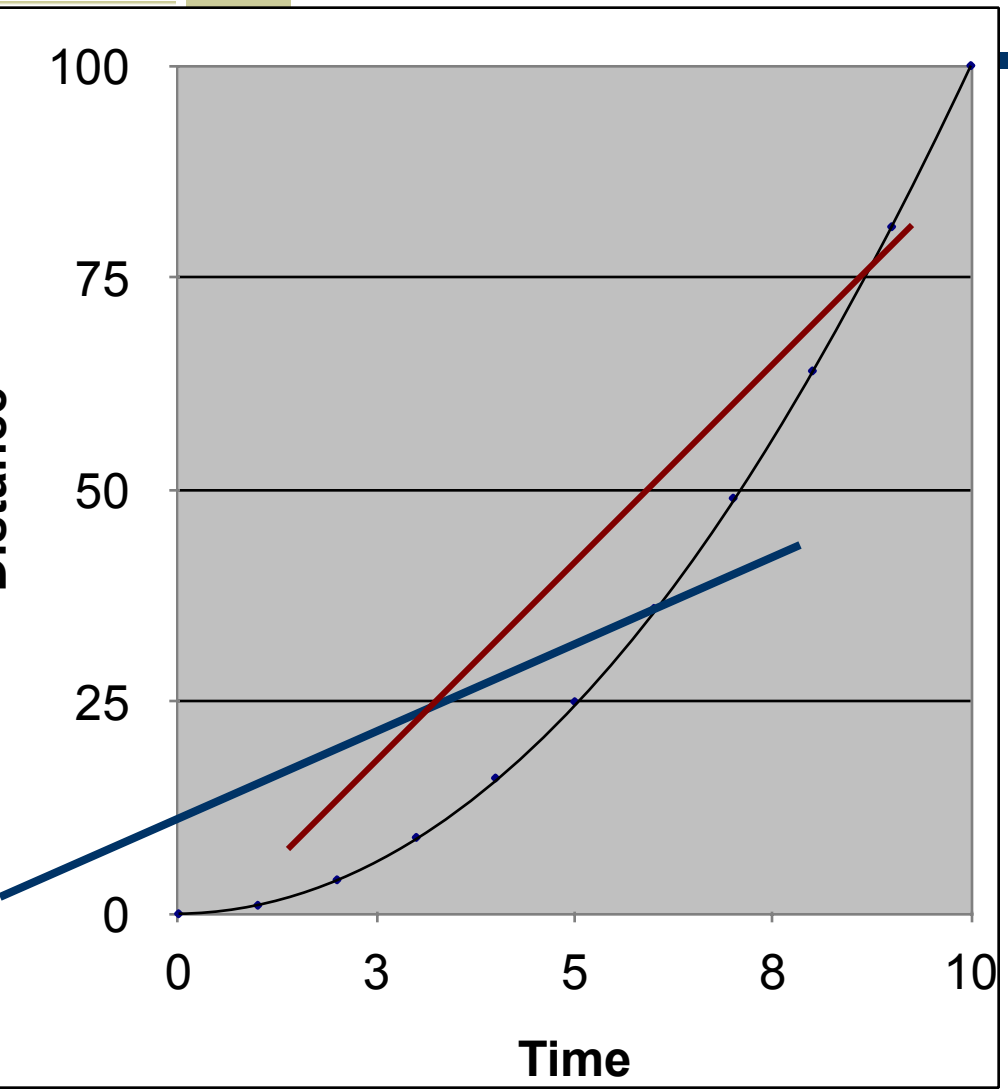
Negative Slope=
Negative Velocity

d-t Graph with Changing Velocity

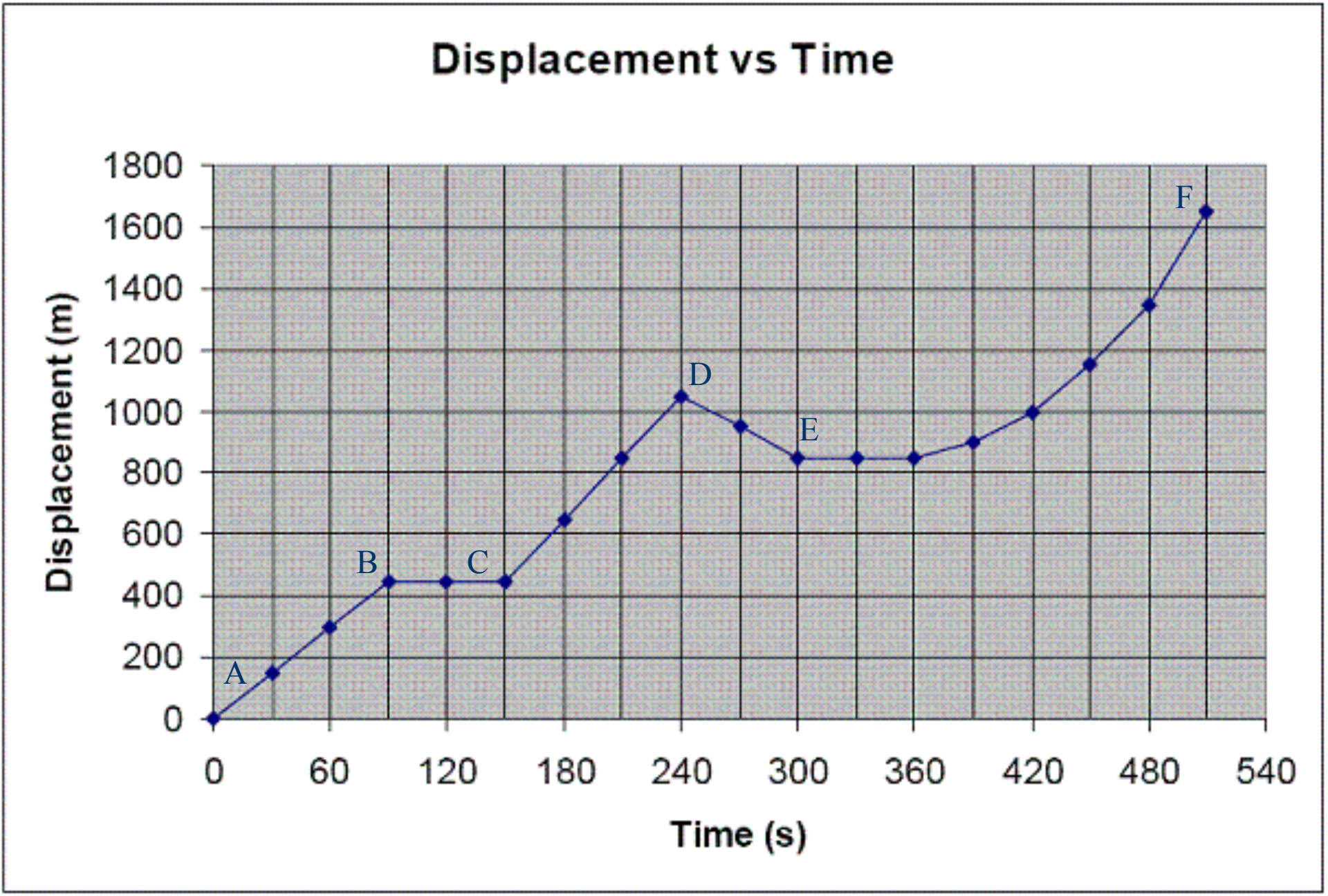
This curve shows a changing slope which means a changing velocity

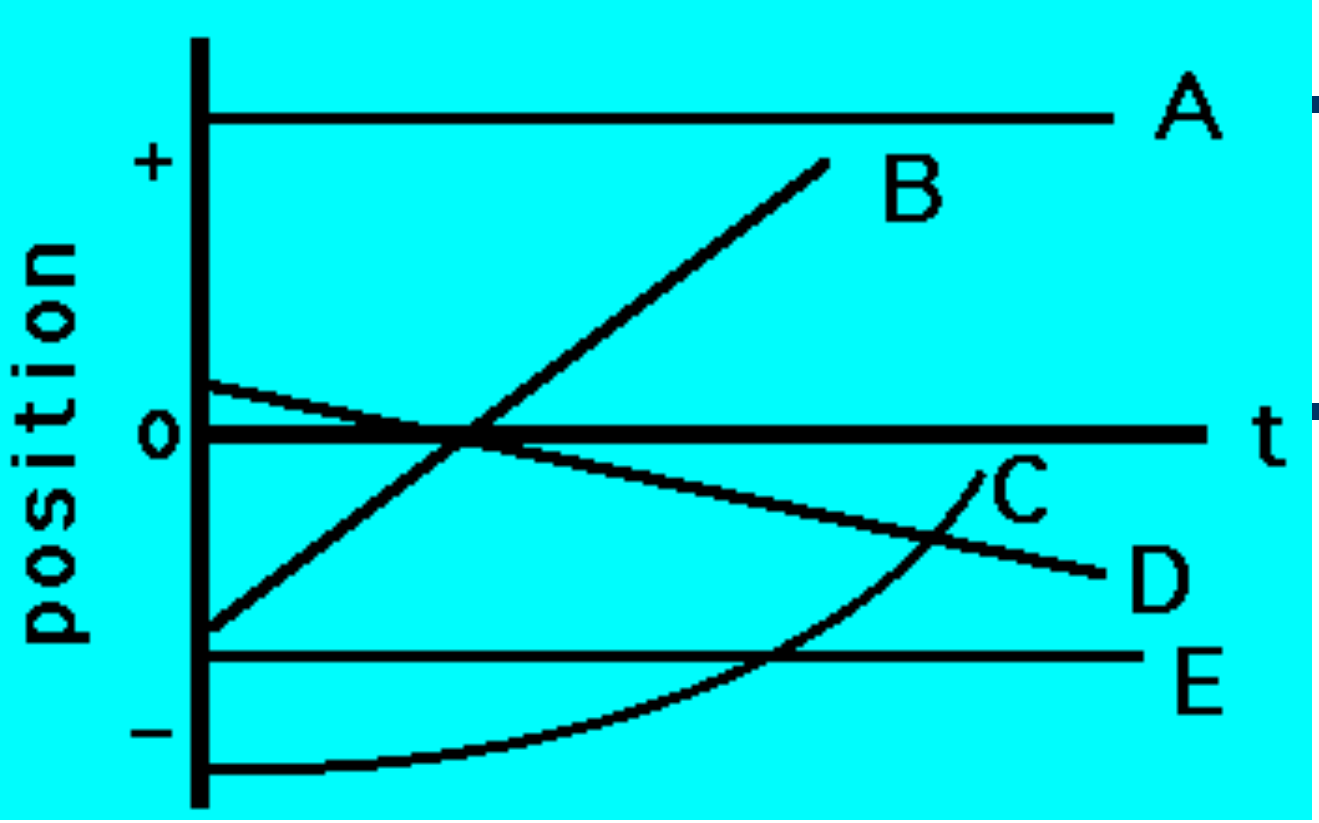


Finding the Velocity



The slope of the tangent line to the curve represents the instantaneous velocity


Displacement vs Time
Displacement (m)
1800
1600
1400
1200
1000
800
600
400
200
0
0
60
120
180
240
300
360
420
480
540
Time (s)
A
B
C
D
E
F



Which one(s) are motionless?

Which one(s) have a constant velocity?

Which one(s) are accelerating?

Which one(s) return to their starting position?

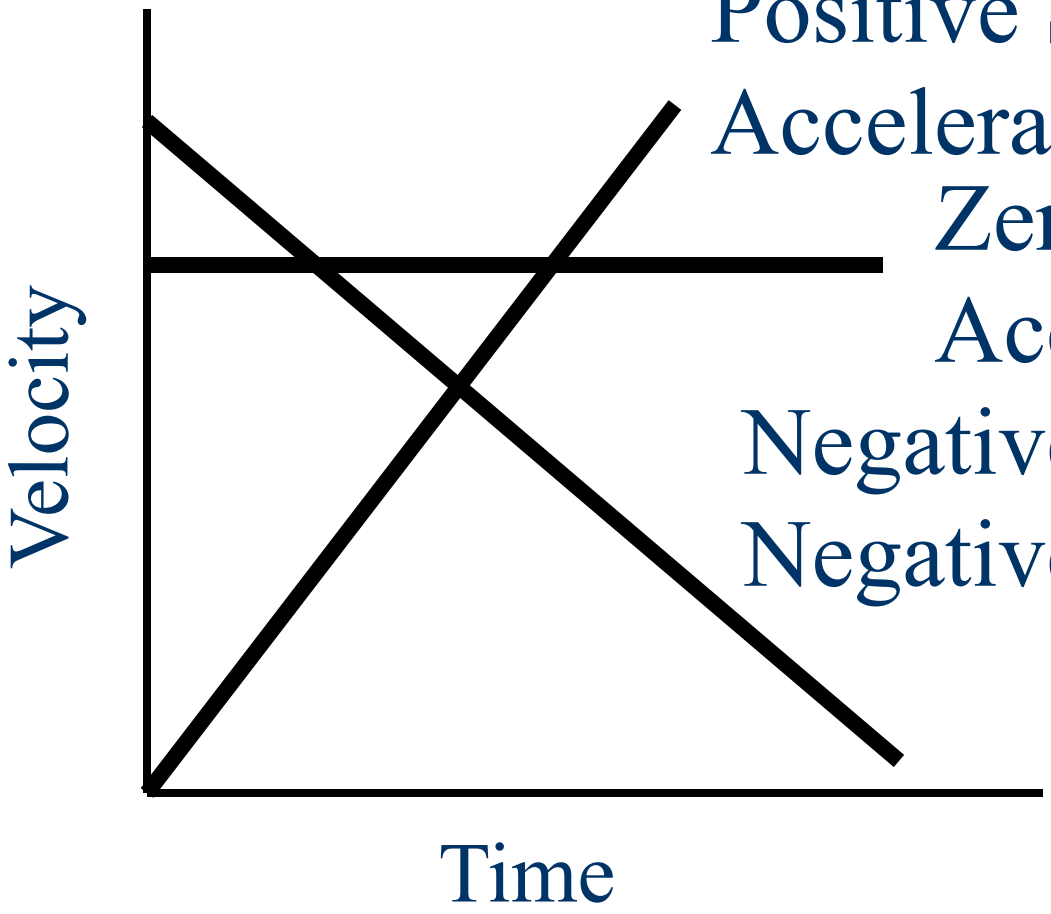
Which one(s) have a positive velocity?

Which one(s) meet?

v-t Graph with Constant Acceleration

- The slope of a speed time graph represents acceleration.
- A constant slope implies a constant acceleration.
- The slope can be positive, negative, or zero

Velocity-Time Graph



Positive Slope= Positive Acceleration

Zero Slope = Zero Acceleration

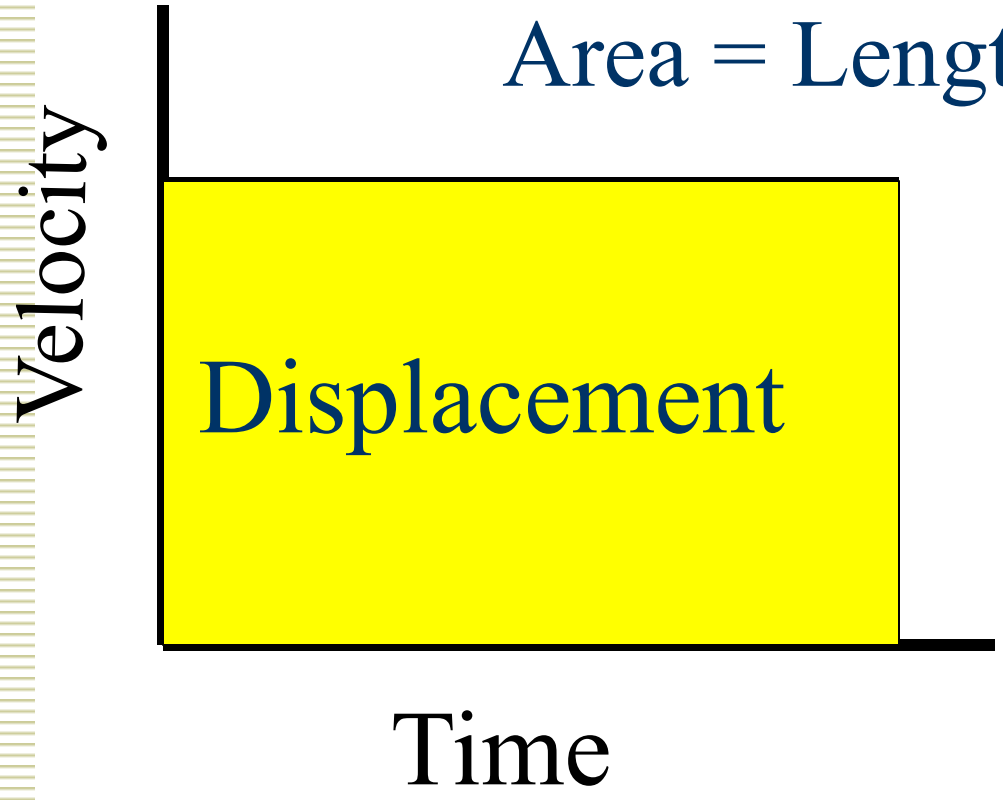
Negative Slope= Negative Acceleration

v-t Graph Displacements

- The area under the curve to the t-axis represents the displacement of the object.
- The area can be found using simple geometry formulas.
- The area may be “negative” if the curve lies under the t-axis.

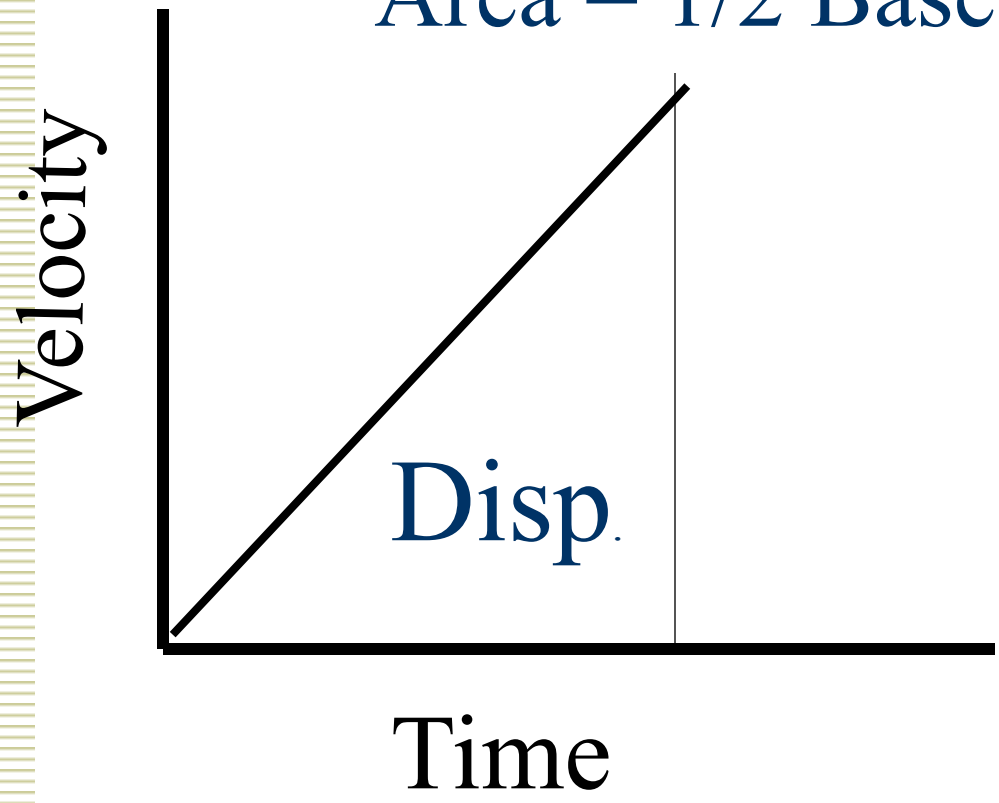
v-t Graph Displacements

Area = Length x Width

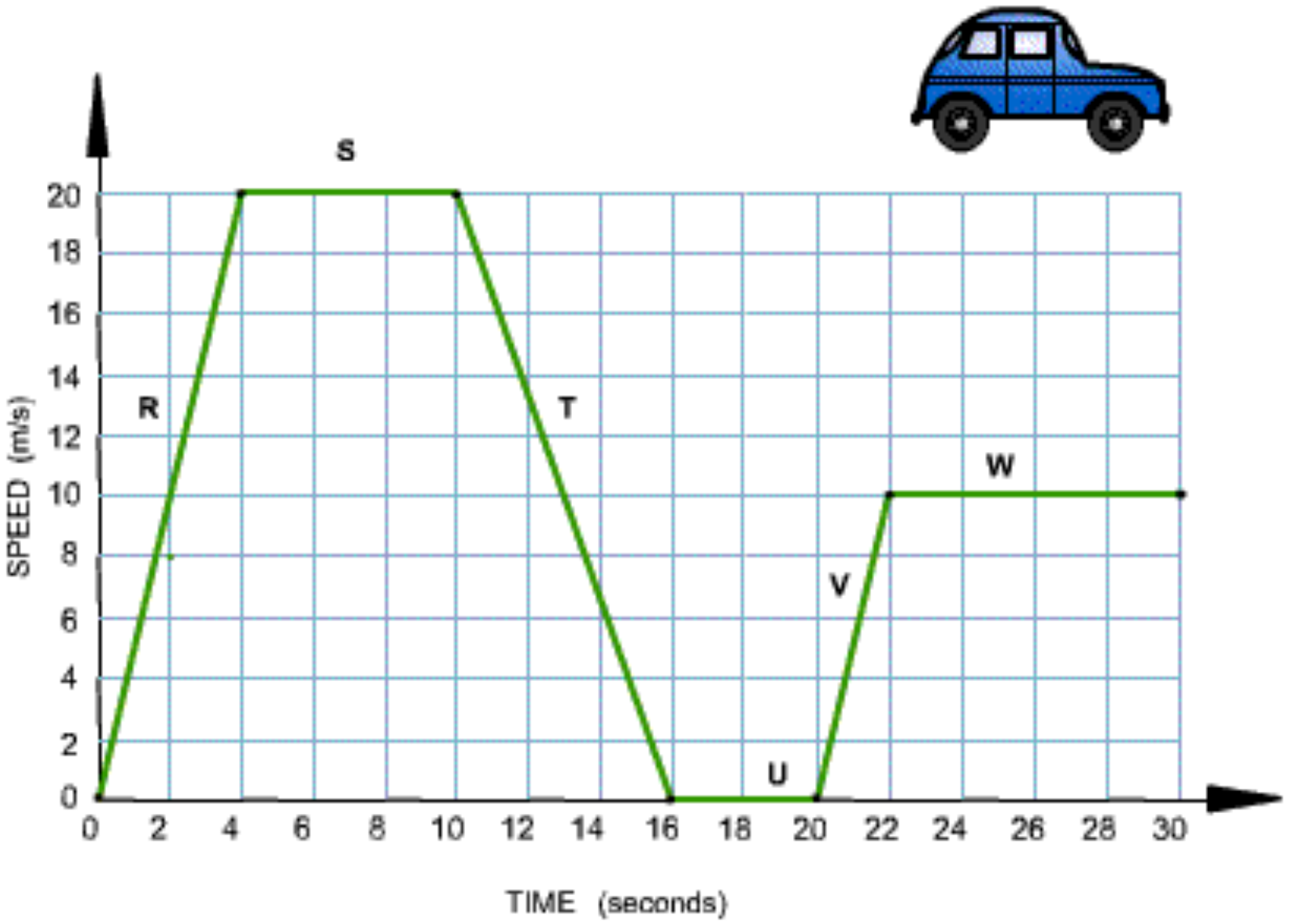


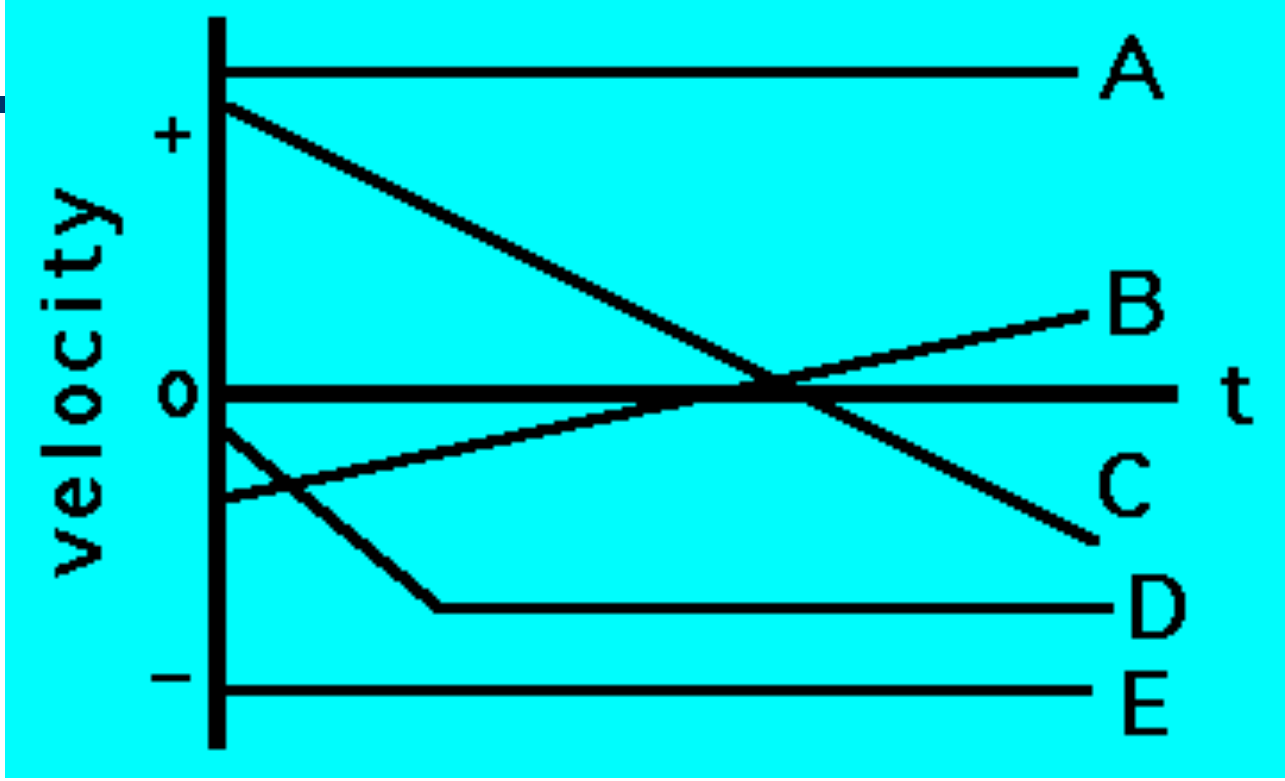
v-t Graph Displacements

Area = 1/2 Base x Height



Speed of a car v. time





Which one(s) are motionless?

Which one(s) change their motion?

Which one(s) have a constant velocity?

Which one(s) have a positive velocity?

Which one(s) are accelerating?

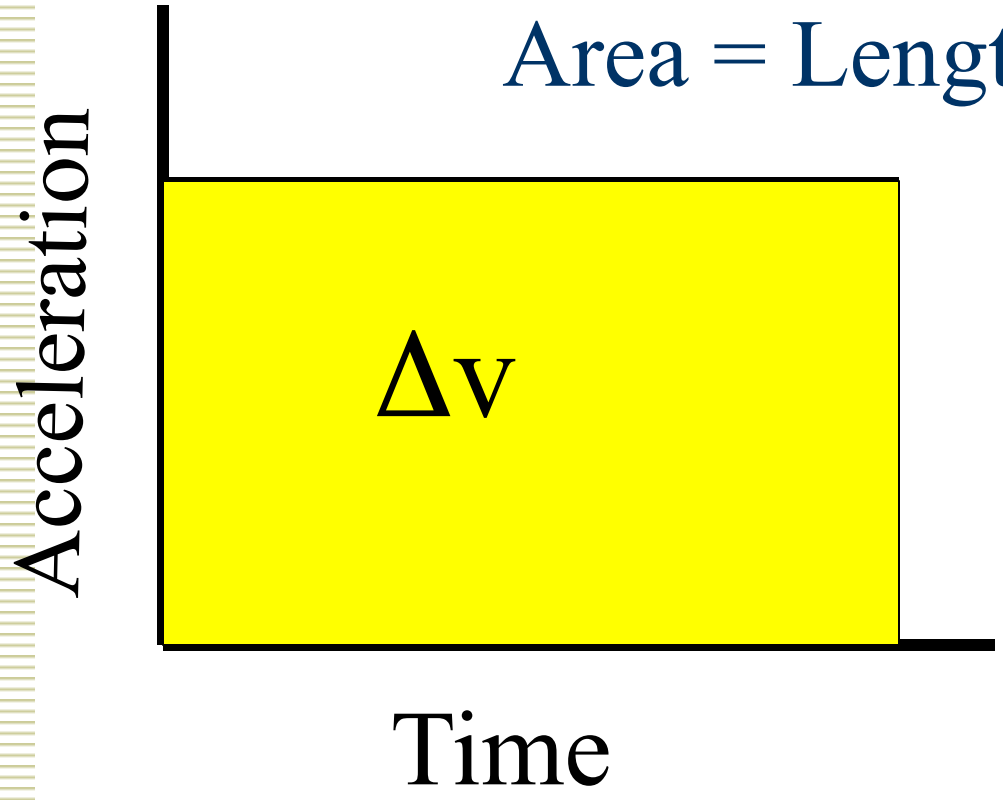
Which one(s) displace the least?

a-t Graph with Constant Acceleration

- The slope of an acceleration-time graph will be zero in this course.
- A zero slope implies a constant acceleration.
- The area under the curve represents the change in velocity of the object.

a-t Graph Change in Velocities

Area = Length x Width



Summary

- d-t Graph
  - Slope represents velocity
- v-t Graph
  - Slope represents acceleration
  - Area under curve represents displacement
- a-t Graph
  - Area under curve represents Δv