Ch. 2 & 3
Velocity & Acceleration

Objective: Student will be able to…

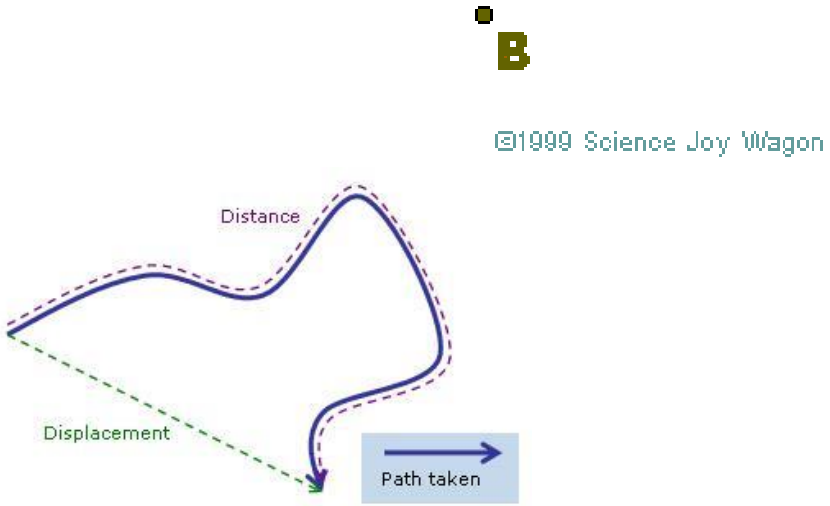
- *Compare Velocity to Speed*
- *Identify what is acceleration*
- *Calculate velocity and acceleration from an equation and from slope of a graph.*

Distance vs. Displacement

- Distance (**scalar**) = add all movements up to get your total. (odometer)
  - Base unit = meters

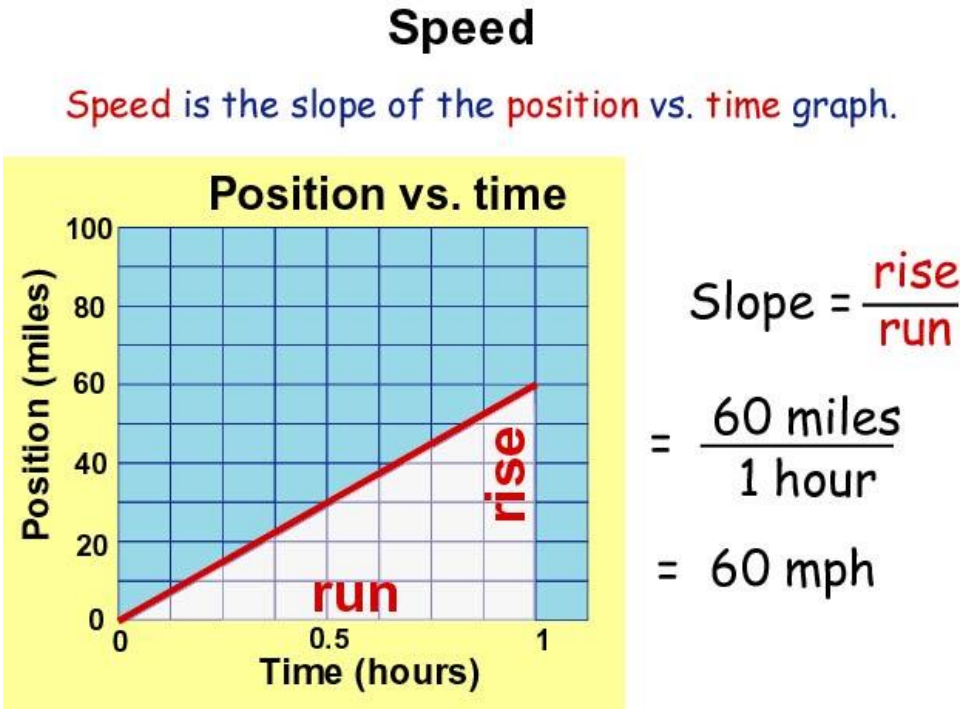
distance
displacement

- Displacement (**vector**) = Just measures the shortest distance from start point to end point.
  - Base unit = meters



Speed (scalar)

- Speed is defined as the rate of change of distance.
- Units:
  - m/s
- Equation:
  - $\text{Speed} = \frac{\text{Distance}}{\text{Time}}$



Other Units for Speed

Any combination of units for distance and time that are useful and convenient are legitimate for describing speed:

- miles per hour (mi/h)
- kilometers per hour (km/h)
- centimeters per day
- light-years per century

- A cheetah is the fastest land animal over distances less than 500 meters and can achieve peak speeds of 100 km/h.

Table 4.1 **Approximate Speeds in Different Units**

12 mi/h =	20 km/h =	6 m/s	(bowling ball)
25 mi/h =	40 km/h =	11 m/s	(very good sprinter)
37 mi/h =	60 km/h =	17 m/s	(sprinting rabbit)
50 mi/h =	80 km/h =	22 m/s	(tsunami)
62 mi/h =	100 km/h =	28 m/s	(sprinting cheetah)
75 mi/h =	120 km/h =	33 m/s	(batted softball)
100 mi/h =	160 km/h =	44 m/s	(batted baseball)

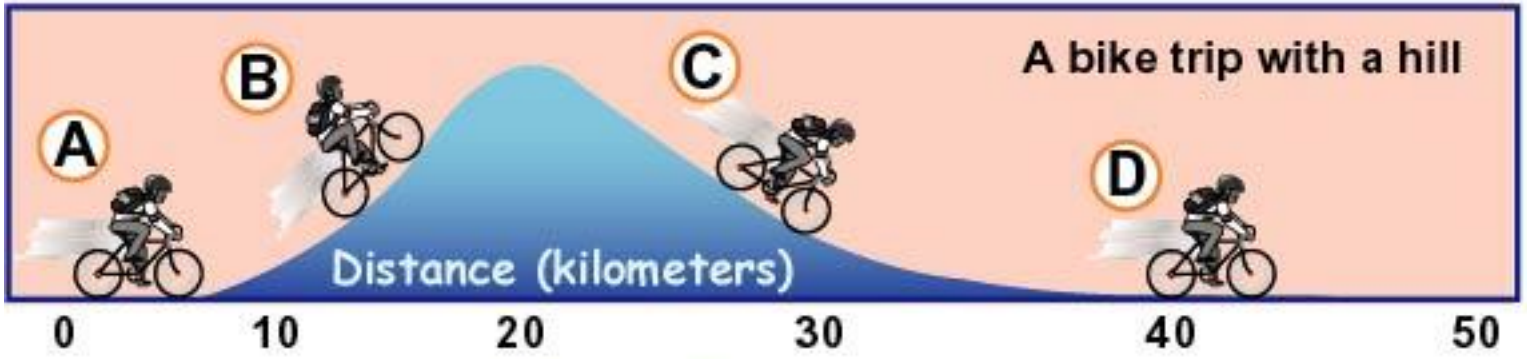
Think

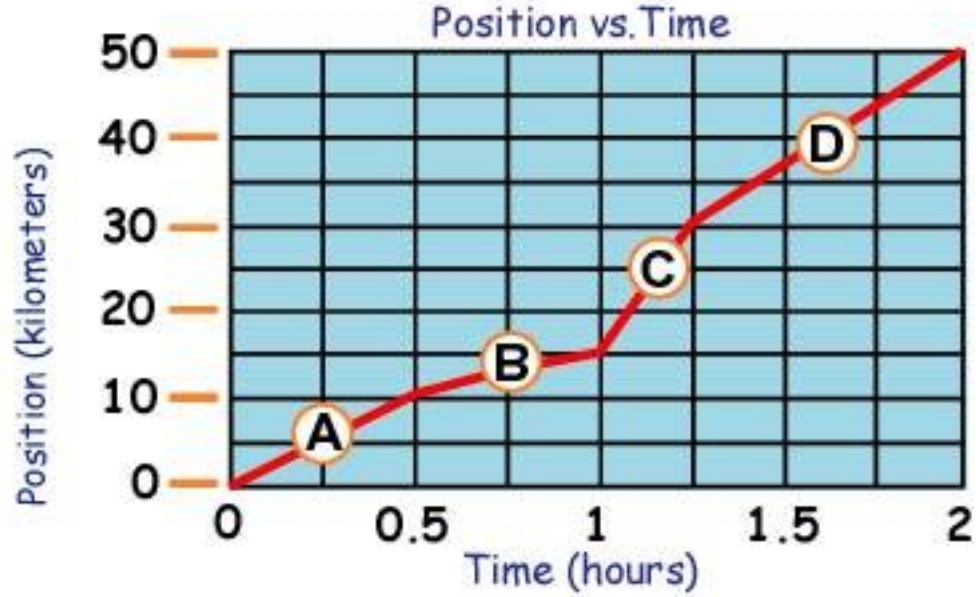
- Usain Bolt a Jamaican sprinter ran the 100 meter dash in a record setting time of 9.58 seconds. What was his speed? Convert to mi/hr.

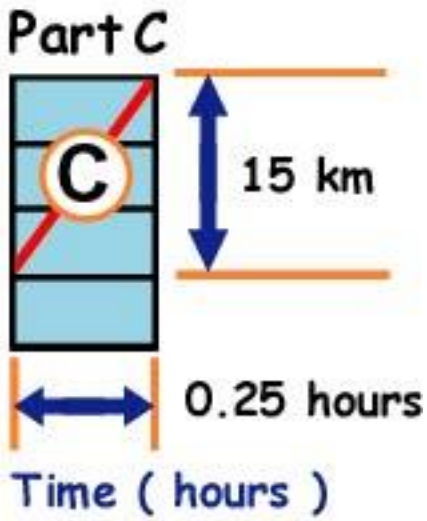
$$\text{average speed} = \frac{\text{total distance covered}}{\text{time interval}}$$

- Answer: 100 meters / 9.58 seconds = **10.4 m/s**
- Convert to mi/hr
- Answer: 10.4 m/s x 1mi/1609.34m x 3600sec/1hr = **23.3 mi/hr**

Position vs.Time Graph

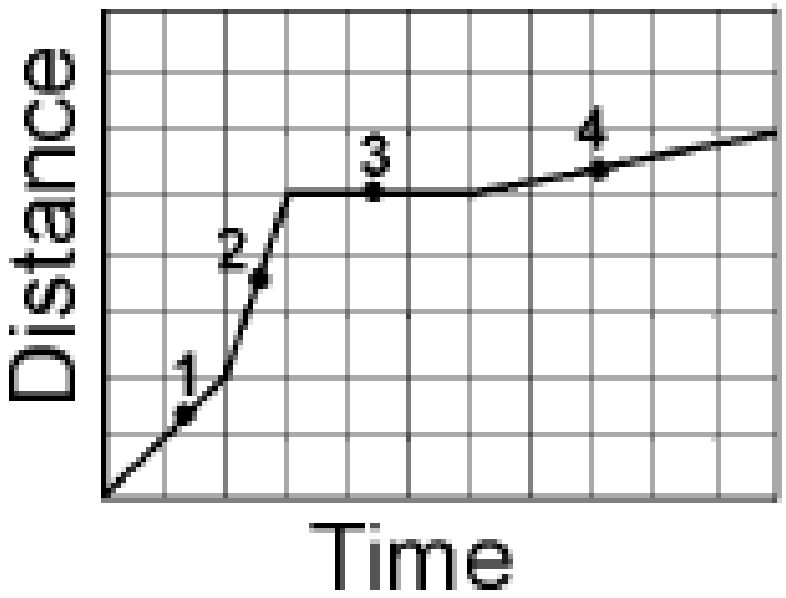






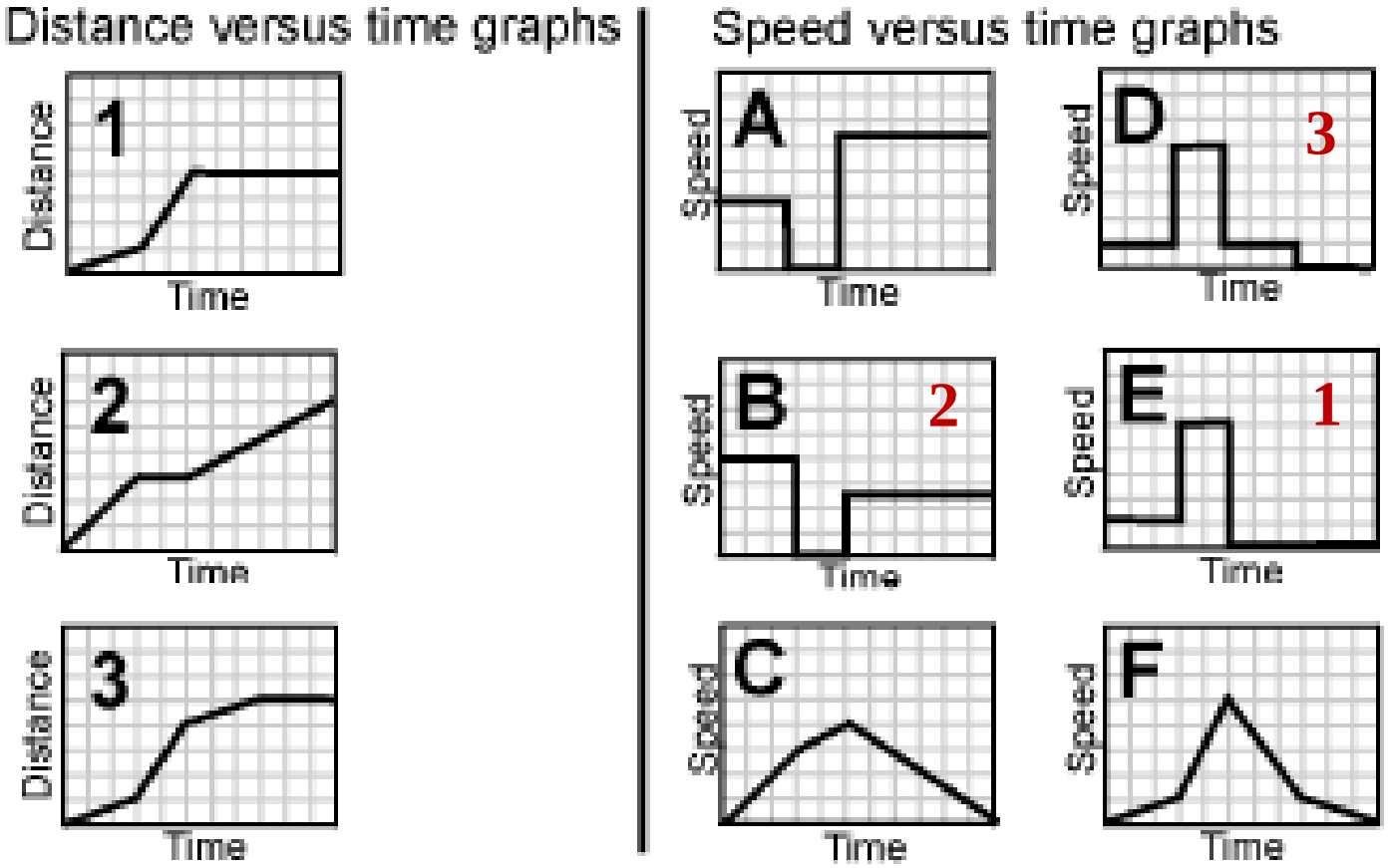
$$\text{Average speed for Part } C = \frac{15 \text{ km}}{0.25 \text{ hours}} = 60 \text{ km/h}$$

Determine the greatest speed on a graph



Fastest
a)
b)
c)
d)
Slowest

Match each of the three distance vs. time graphs with the corresponding speed vs. time graph.



Instantaneous Speed vs. Average Speed

- The speed at any instant is called instantaneous.
- A car's speedometer will always give you your instantaneous speed

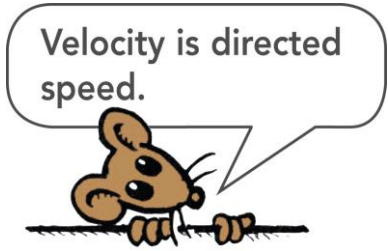
- Average is looks at the total distance covered divided by the time.

Think

- If a cheetah can maintain a constant speed of 25 m/s, it will cover 25 meters every second. At this rate, how far will it travel in 10 seconds? In 1 minute?
- *Answer:* In 10 s the cheetah will cover 250 m, and in 1 min (or 60 s) it will cover 1500 m.

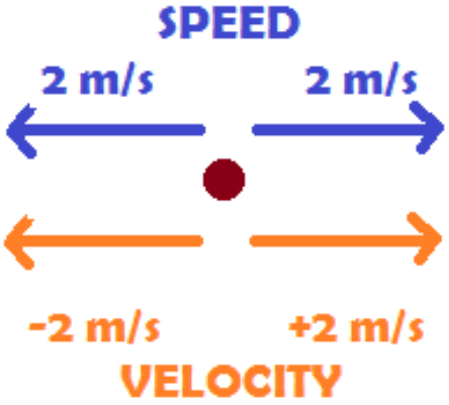
$$\text{average speed} = \frac{\text{total distance covered}}{\text{time interval}}$$

Velocity (vector)



- Velocity is speed in a given direction
- Units
  - m/s
- Equation
  - $$\text{Velocity} = \frac{\text{displacement}}{\text{time interval}}$$
- Example:
  - 20 mi/hr up
  - +15 m/s

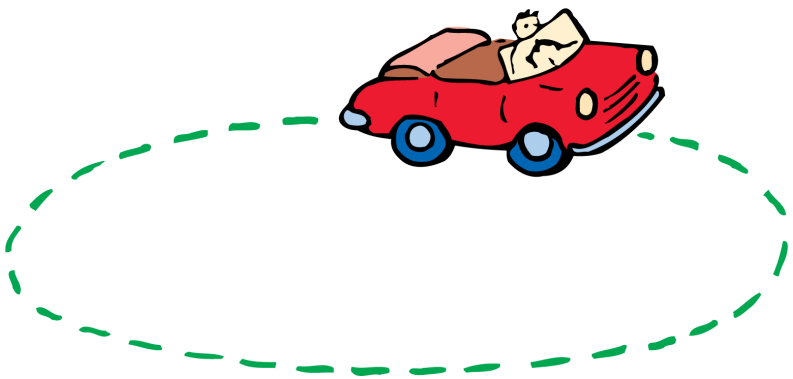
- Speed is a description of how fast an object moves; velocity is how fast and in what direction it moves.



Changing Velocity

If *either* the speed *or* the direction (or both) is changing, then the velocity is changing.

- Constant speed and constant velocity are not the same.
- A body may move at constant speed along a curved path but it does not move with constant velocity, because its direction is changing every instant.



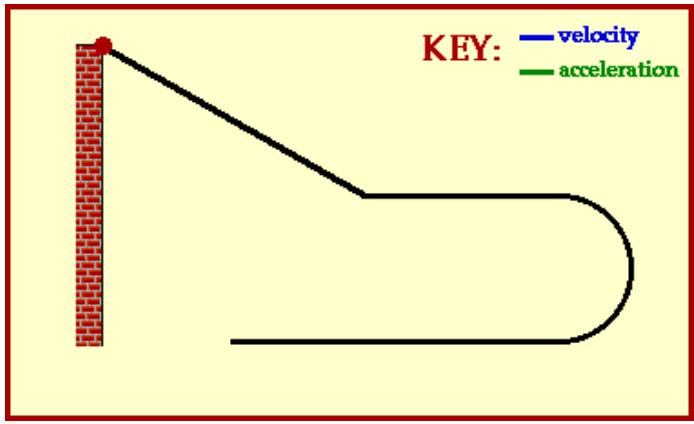
think!

- The speedometer of a car moving northward reads 60 km/h. It passes another car that travels southward at 60 km/h. Do both cars have the same speed? Do they have the same velocity?
- *Answer:* Both cars have the same speed, but they have opposite velocities because they are moving in opposite directions.

Acceleration (Vector)

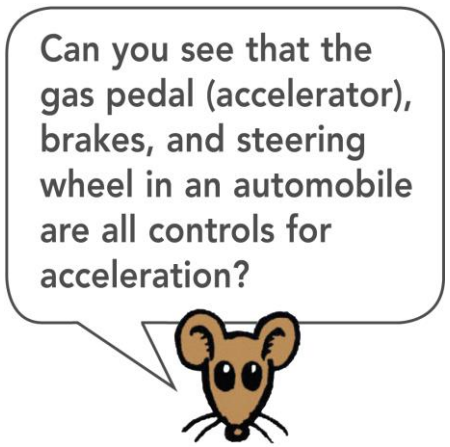
- Acceleration – is the rate of change in the velocity of an object.
  - Change the state of motion of an object by changing its speed, its direction of motion, or both.
  - Zero acceleration if your traveling at constant velocity (same direction & and speed)
- Units:
  - m/s^2
- Equation: Acceleration =

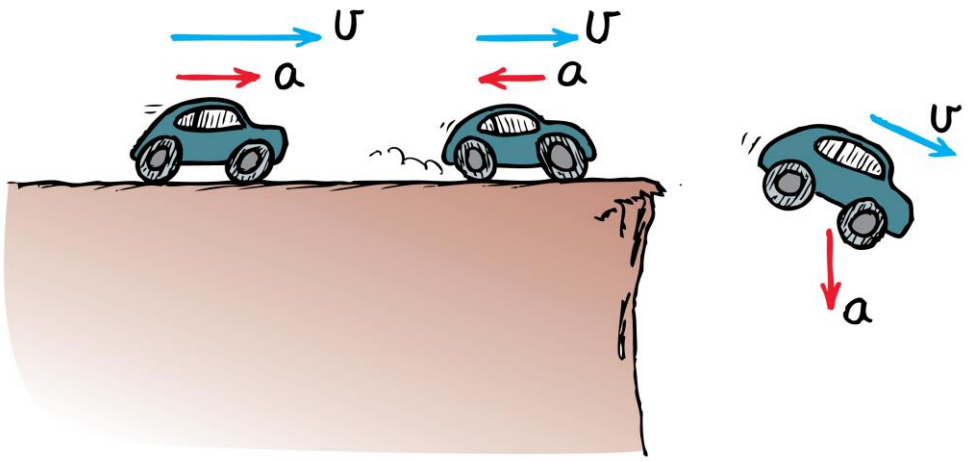
$$\text{acceleration} = \frac{\text{change of velocity}}{\text{time interval}}$$



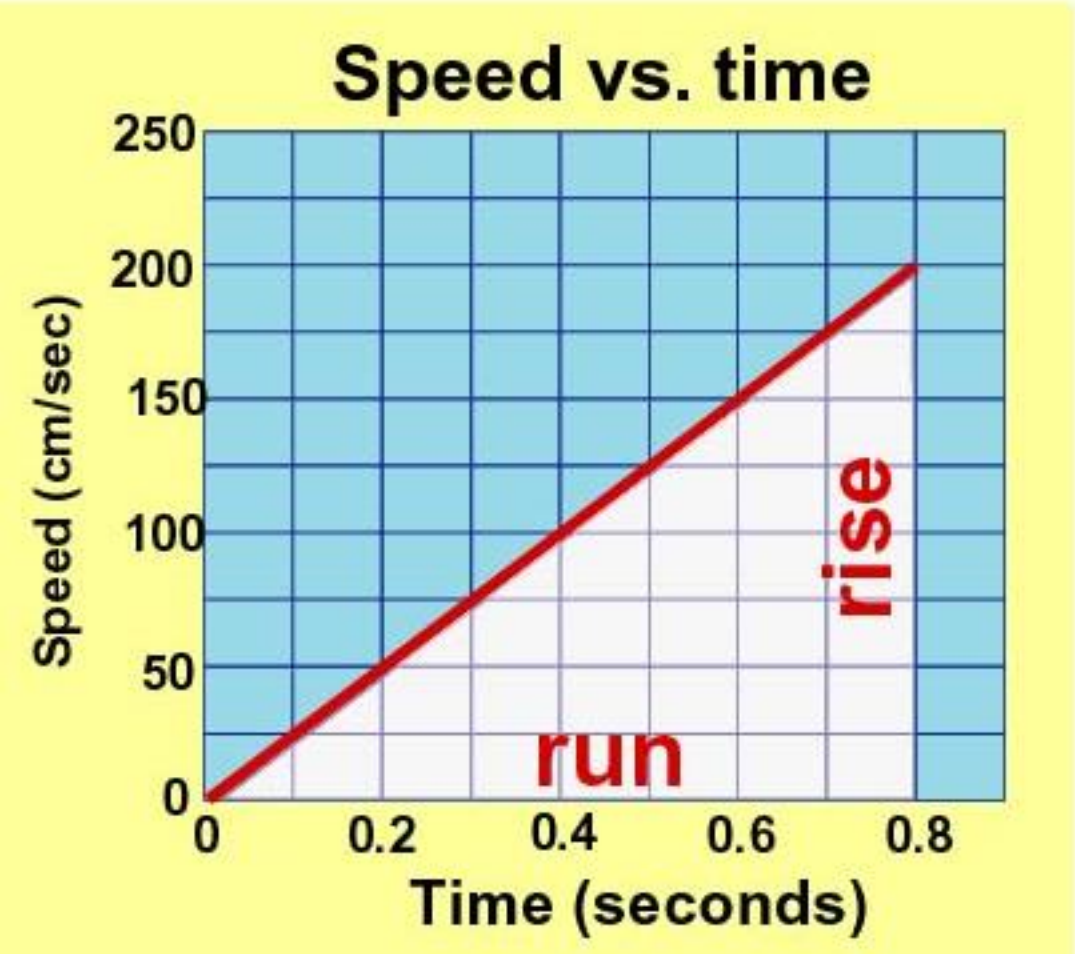
Acceleration

- Accelerate in the direction of velocity–speed up
- Accelerate against velocity–slow down
  - This is also called *deceleration*
- Accelerate at an angle to velocity–change direction





Acceleration is the slope of the speed vs. time graph.

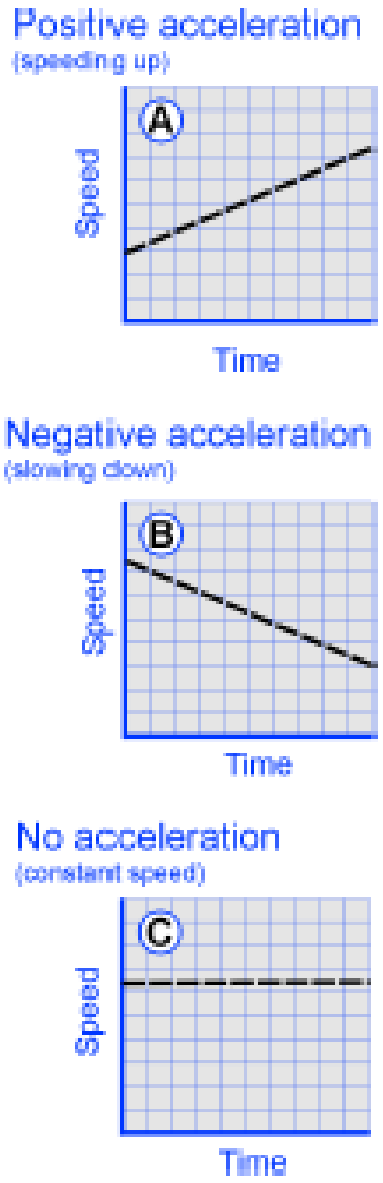


$$\text{Slope} = \frac{\text{rise}}{\text{run}}$$

$$= \frac{200 \text{ cm/sec}}{0.8 \text{ seconds}}$$

$$= 250 \text{ cm/sec}^2$$

11) Seeing acceleration on a graph.



Think

- Suppose a car moving in a straight line steadily increases its speed each second, first second from 35 to 40 km/h, then from 40 to 45 km/h, then from 45 to 50 km/h. What is its acceleration?

$$\text{acceleration} = \frac{\text{change in speed}}{\text{time interval}}$$

- *Answer:* The speed increases by 5 km/h during each 1-s interval in a straight line. The acceleration is therefore
  5 km/h•s during each interval.

Think

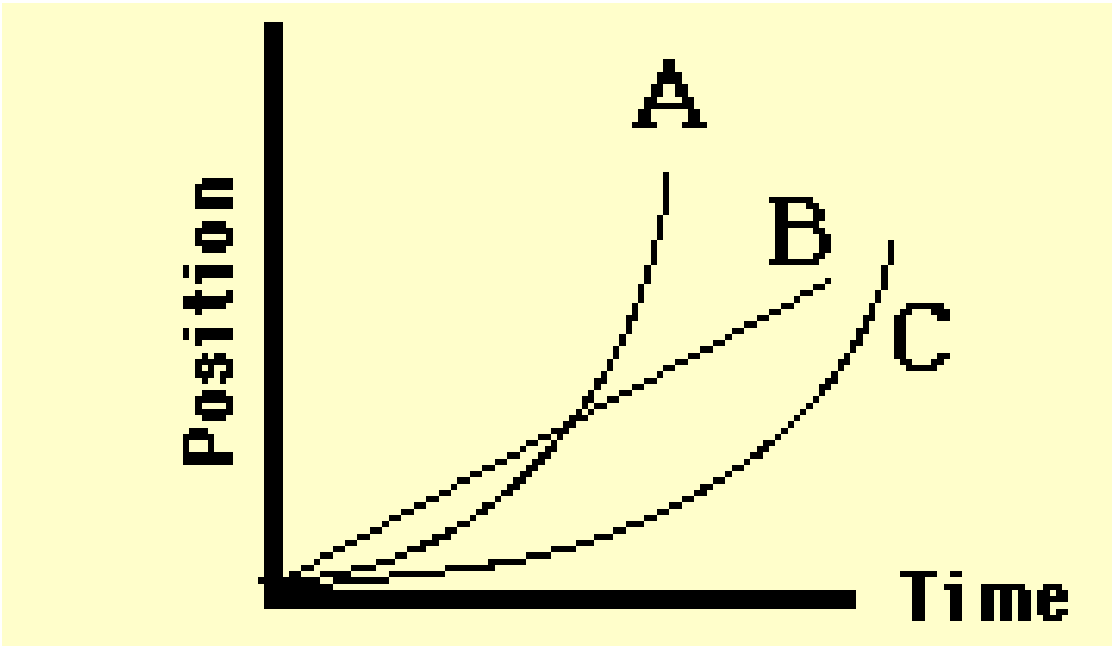
- In 5 seconds a car moving in a straight line increases its speed from 50 km/h to 65 km/h, while a truck goes from rest to 15 km/h in a straight line. Which undergoes greater acceleration? What is the acceleration of each vehicle?

$$\text{acceleration} = \frac{\text{change in speed}}{\text{time interval}}$$

- *Answer:* The car and truck both increase their speed by
  15 km/h during the same time interval, so their acceleration is the same.

Which car or cars is under acceleration?

- Match the line to the correct car.



- What is the acceleration for 4 seconds

$$\text{Acceleration} = \frac{\text{Change in speed}}{\text{Change in time}}$$

Example A

Time (s)	Velocity (m/s)
0	0
1	2
2	4
3	6
4	8

- Accel = (8-0)/4
- Accel = 2 m / sec / sec

$$\text{Acceleration} = \frac{\text{Change in speed}}{\text{Change in time}}$$

Example A

Time (s)	Velocity (m/s)
0	0
1	2
2	4
3	6
4	8

Problem

- You are driving your car and the speed goes from 10 mph to 50 mph in 4 sec. What is the acceleration of your car?

$$\text{Acceleration} = \frac{\text{Change in speed}}{\text{Change in time}}$$

- You are driving your car and the speed goes from 20 mph to 60 mph in 4 sec. What is the acceleration of your car?
  - *Change in speed = 60 – 20 =* ***40 mph***
  - *Change in time =* ***4 sec***
  - *Acceleration = 40 mph / 4 sec*
  - ***= 10 mph / sec*** *or 10 m / hr/ sec*

$$\text{Acceleration} = \frac{\text{Change in speed}}{\text{Change in time}}$$