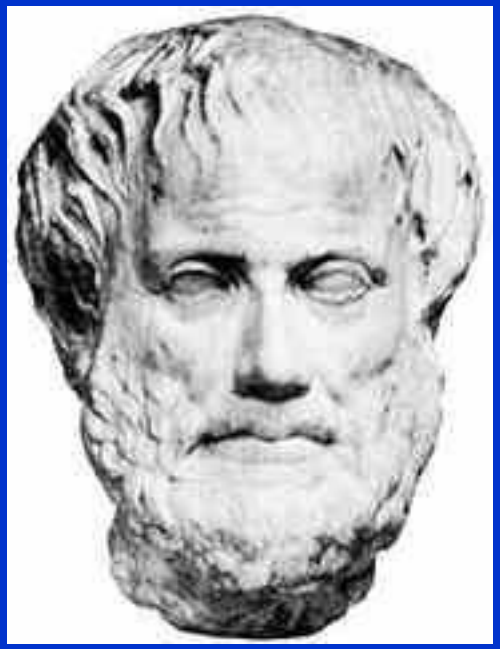
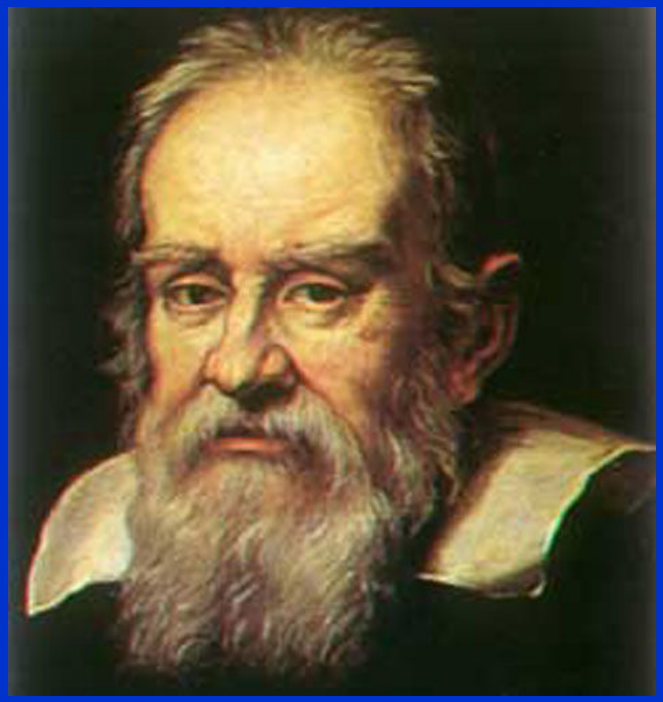
Linear Motion 1



Aristotle

384 B.C. - 322 B.C.



Galileo

1564 - 1642

Scalars and Vectors

- The motion of objects can be described by words such as
  - distance, displacement, speed, velocity, and acceleration.

Scalars

Vectors

Scalars & Vectors

Scalars: fully described by magnitude (or size) alone. That is, direction is not involved.

- o distance, speed, mass, temperature
- o 3m, 5 m/s, 60 kg, 5°C

- **Vectors** are quantities fully described by both magnitude (size) and direction.
  - o displacement, velocity
  - o 3m, right; 5 blocks south; -2 m (the sign is the direction); 2 m/s, up

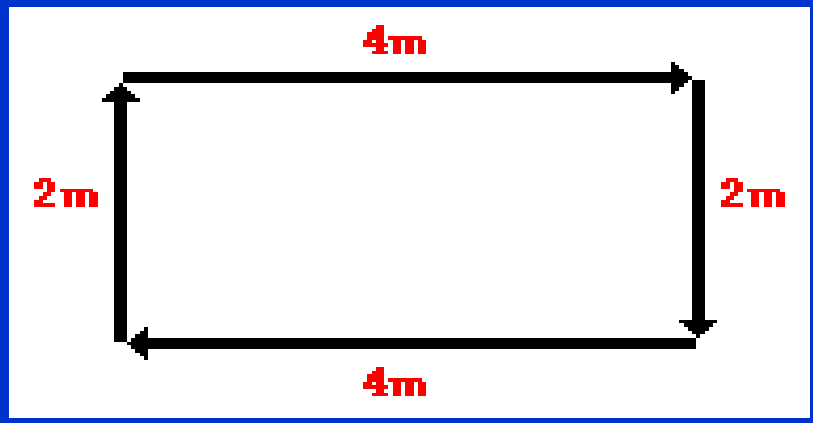
Distance and Displacement

- **Distance** is a scalar quantity referring to how far an object or person has traveled. It is the reading on a pedometer or on an odometer.

- **Displacement** is a vector quantity referring to the object's change in position. Displacement is calculated by subtracting the initial position from the final position: $X_{final} - X_{initial}$

Displacement Example

A physics teacher walks 4 meters East, 2 meters South, 4 meters West, and finally 2 meters North.

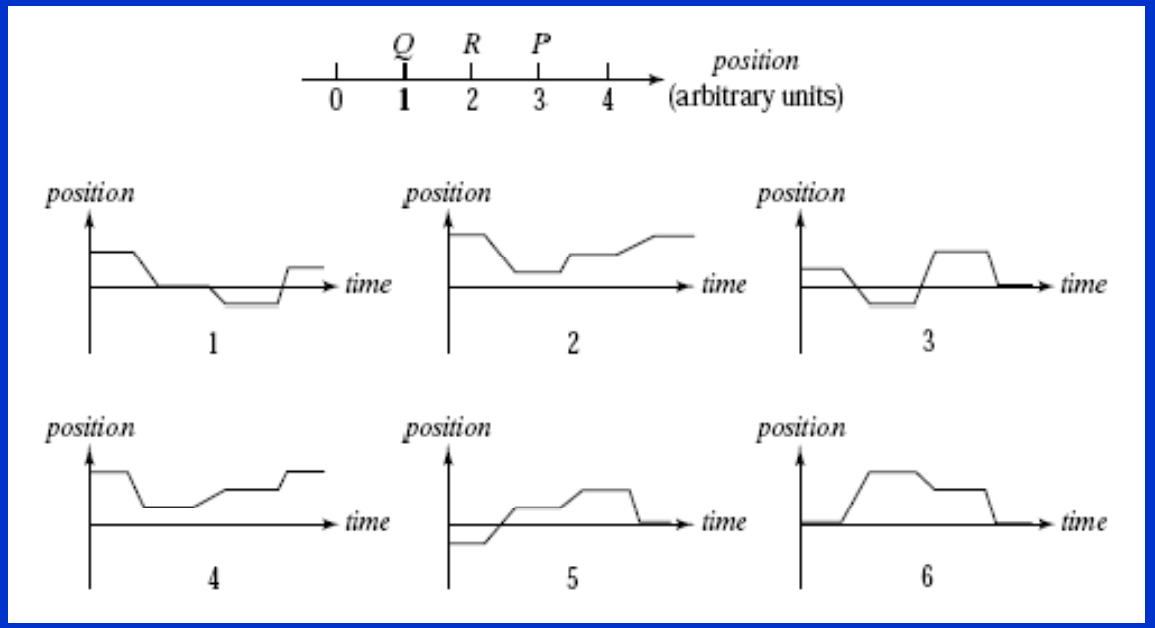


- The physics teacher has walked a total distance of

- The physics teacher's displacement is

Concept Test #1

A person initially at point *P* in the illustration stays there a moment and then moves along the axis to *Q* and stays there a moment. She then runs quickly to *R*, stays there a moment, and then strolls slowly back to *P*. Which of the position vs. time graphs below correctly represents this motion?



Concept Test #2

An object goes from one point in space to another. After it arrives at its destination, its displacement is:

1. either greater than or equal to
2. always greater than
3. always equal to
4. either smaller than or equal to
5. always smaller than
6. either smaller or larger than the distance it traveled.

Speed and Velocity

- **Speed** is a scalar quantity referring to how fast an object is moving. Direction is irrelevant.

- **Velocity** is a vector quantity referring to how fast an object changes its position.

- Imagine a person moving rapidly - one step forward and one step back - always returning to the original starting position. This motion results in zero average velocity.

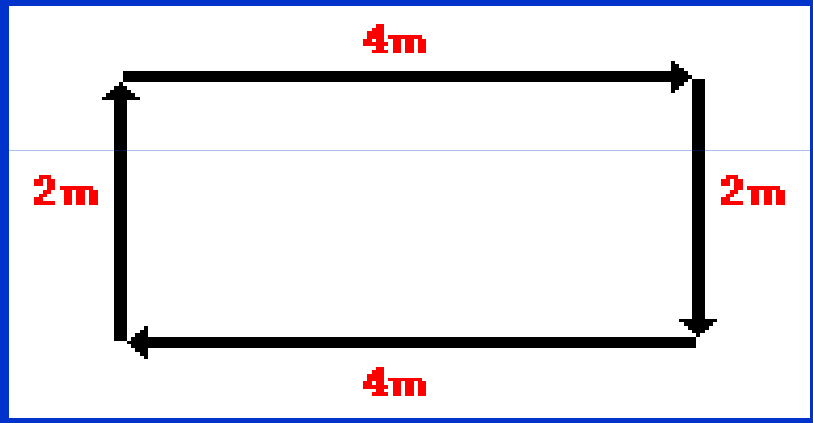
Speed & Velocity

$$\text{Average Speed} = \frac{\text{Distance Traveled}}{\text{Time of Travel}}$$

$$\text{Average Velocity} = \frac{\Delta\,\text{position}}{\text{time}} = \frac{\text{displacement}}{\text{time}}$$

Velocity & Speed

- The physics teacher walks 4 meters East, 2 meters South, 4 meters West, and finally 2 meters North. The entire motion lasts 24 seconds. Determine her average speed and average velocity.



The physics teacher walked a distance of 12 meters in 24 seconds; thus, her average speed was 0.50 m/s. However, since her displacement is 0 meters, her average velocity is 0 m/s.

Instantaneous and Average

- **Instantaneous Speed** - speed at any given instant in time
  - speedometer reading

- **Average Speed** – total distance divided by total time of travel
  - rate you would have to travel constantly to cover the same distance in the same time

Constant and Changing Speed

An object moving with a constant speed of 6 m/s

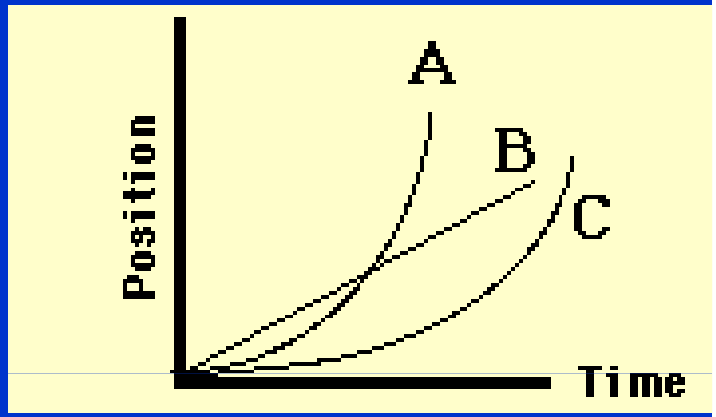
Time (s)	Position (m)
0	0
1	6
2	12
3	18
4	24

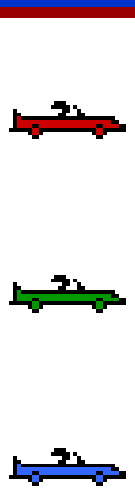
An object moving with a changing speed

Time (s)	Position (m)
0	0
1	1
2	4
3	9
4	16

Acceleration

- **Acceleration** is a vector quantity defined as the rate at which an object changes its velocity. An object is accelerating if it is changing its velocity.





Accelerating Objects

Accelerating Objects are Changing Their Velocity ...

... by a constant amount each second ...

Time (s)	Velocity (m/s)
0	0
1	4
2	8
3	12
4	16

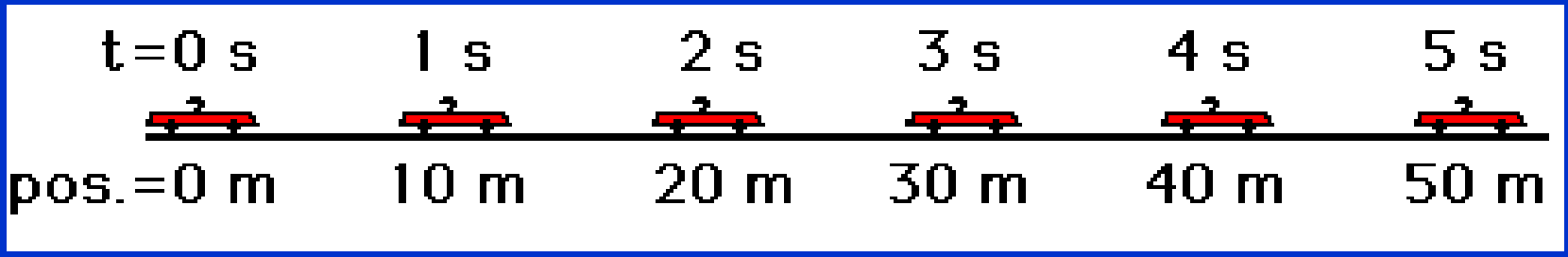
...in which case, it is referred to as a constant acceleration.

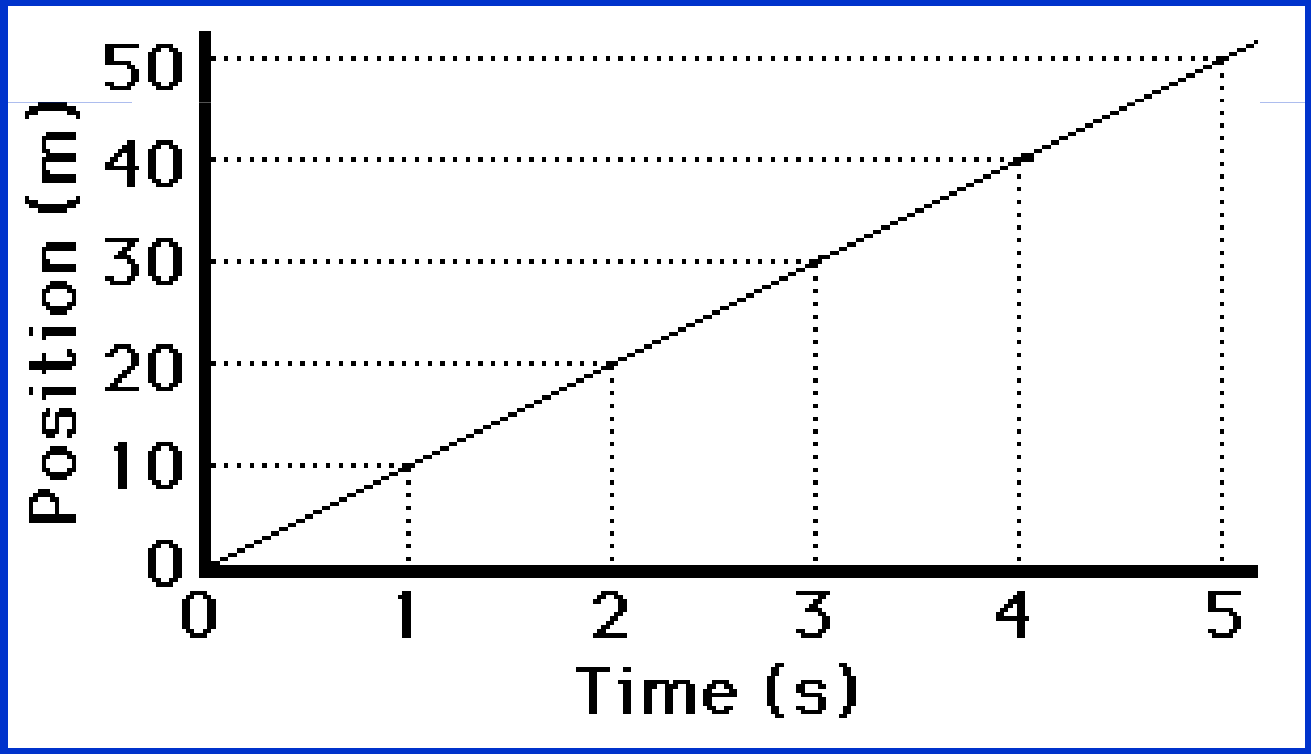
... or by a changing amount each second ...

Time (s)	Velocity (m/s)
0	0
1	1
2	4
3	5
4	7

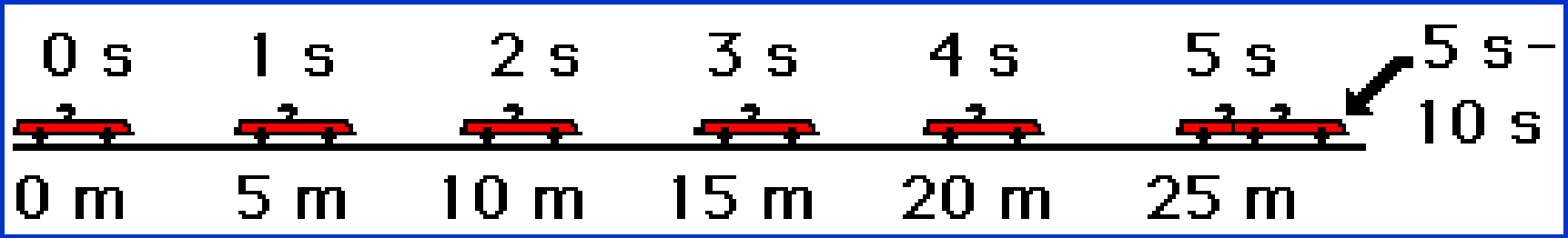
...in which case, it is referred to as a non-constant acceleration.

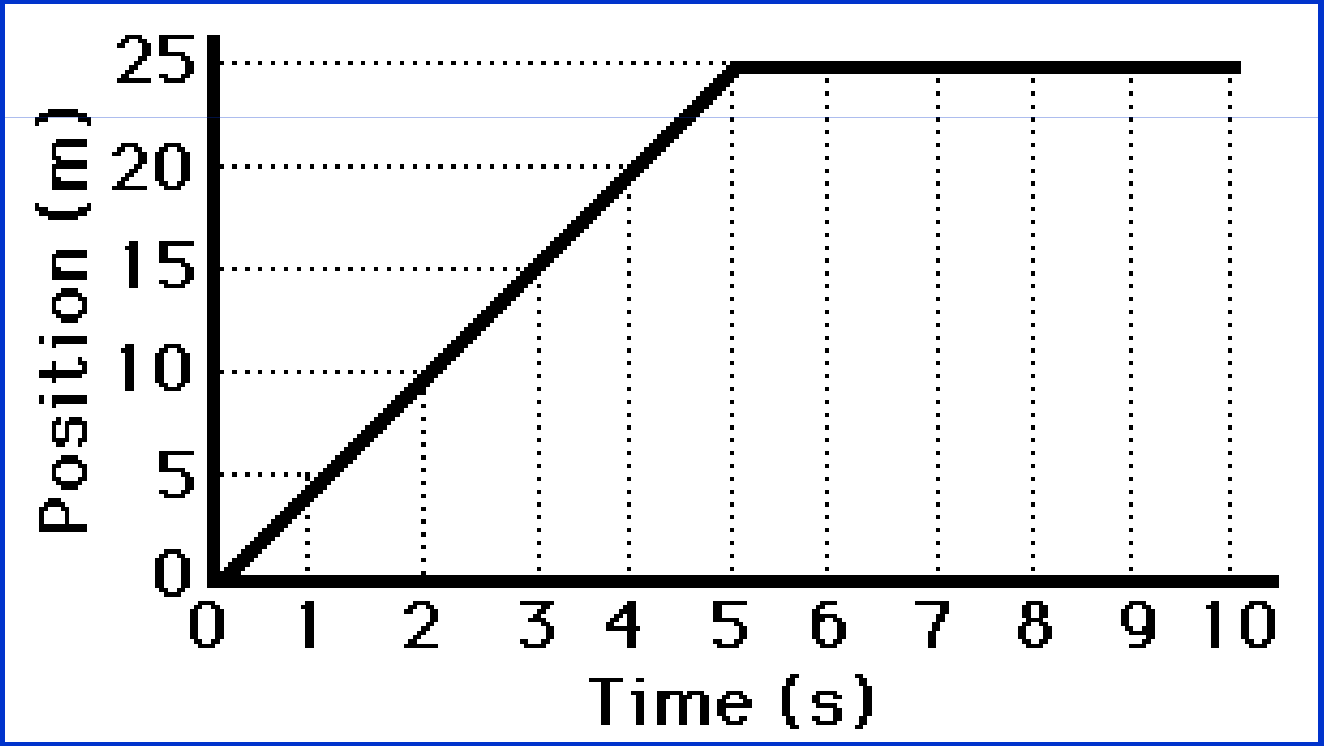
Position - Time for Constant Velocity





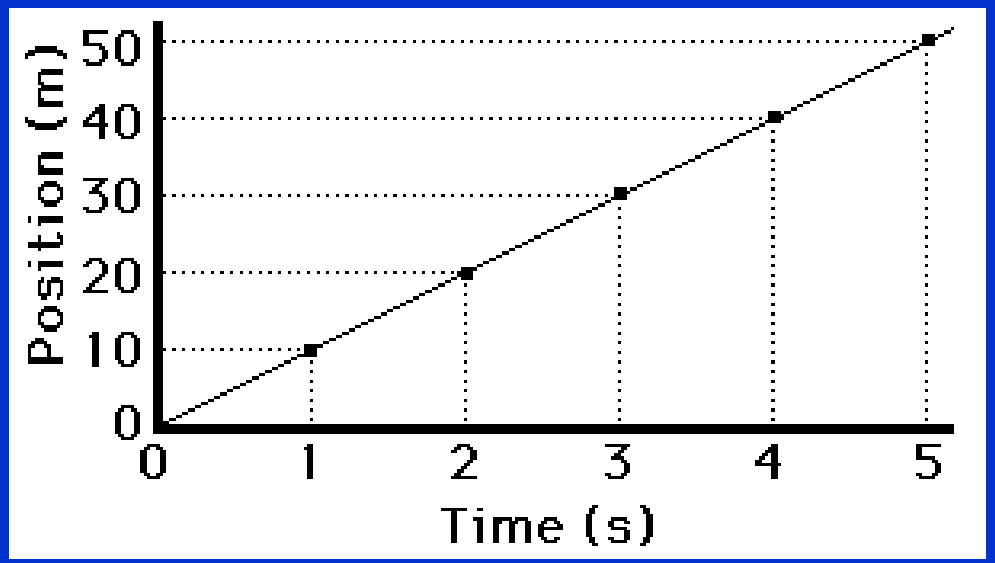
Slope of Position-Time





Slope of Position-Time
Velocity

$$\text{slope} = \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{\text{rise}}{\text{run}}$$



For points (5 s, 50 m) and (0 s, 0 m):

$$\text{slope} = \frac{50\,\text{m} - 0\,\text{m}}{5\,\text{s} - 0\,\text{s}} = 10\ \text{m/s}$$

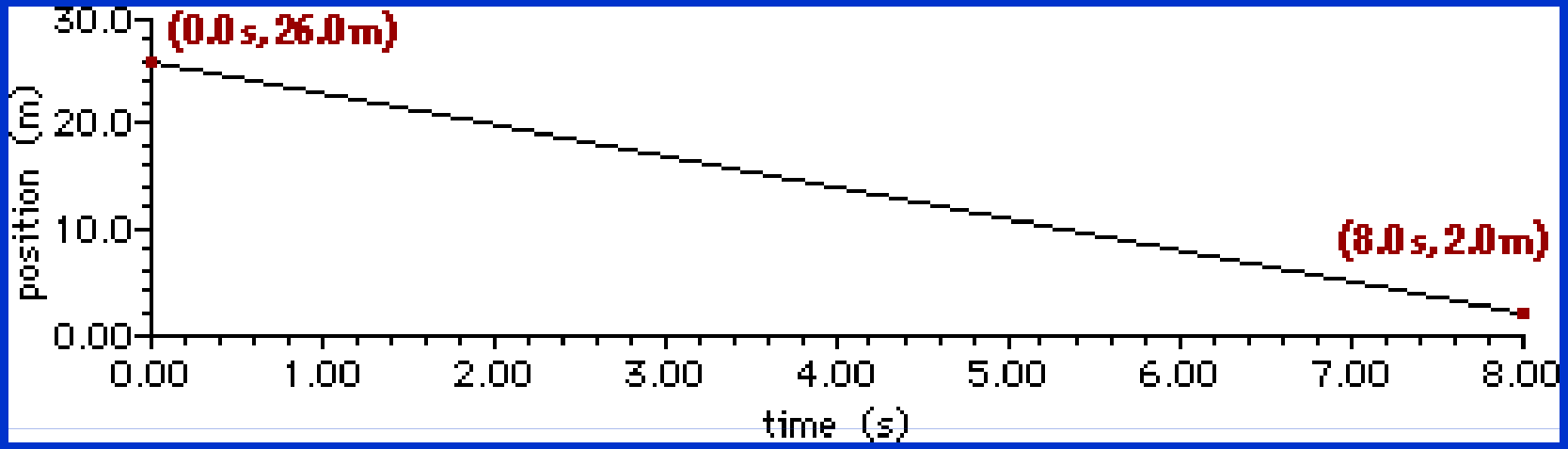
For points (5 s, 50 m) and (2 s, 20 m):

$$\text{slope} = \frac{50\,\text{m} - 20\,\text{m}}{5\,\text{s} - 2\,\text{s}} = 10\ \text{m/s}$$

For points (4 s, 40 m) and (3 s, 30 m):

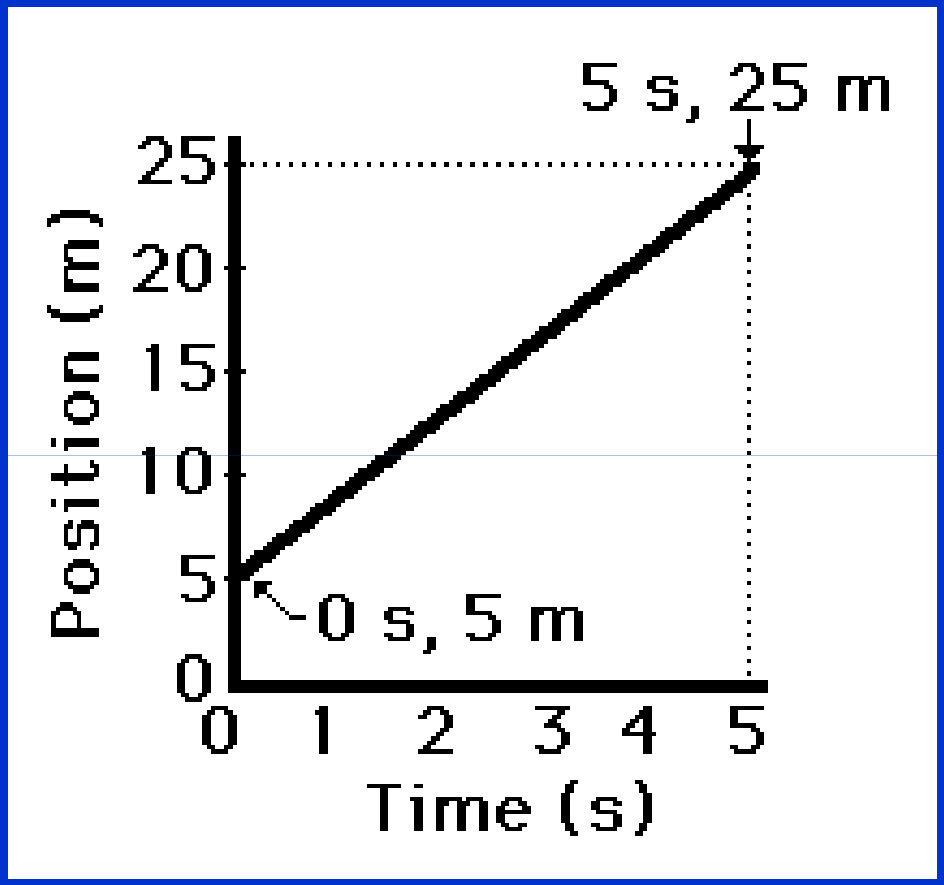
$$\text{slope} = \frac{40\,\text{m} - 30\,\text{m}}{4\,\text{s} - 3\,\text{s}} = 10\ \text{m/s}$$

Slope Practice 1



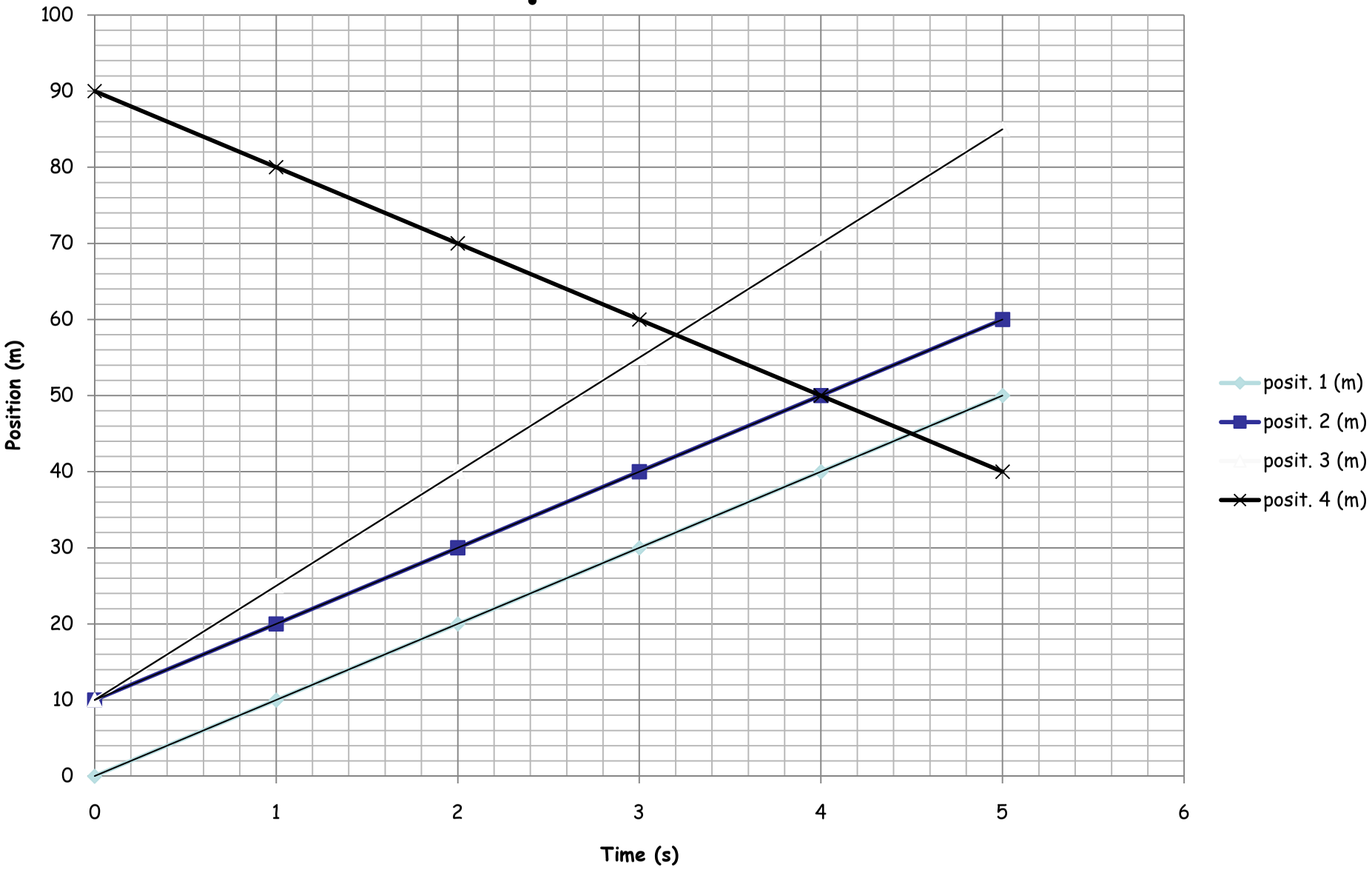
- Calculate the velocity of the object whose graph is shown above.
- -24m/8s = -3 m/s

Slope Practice 2

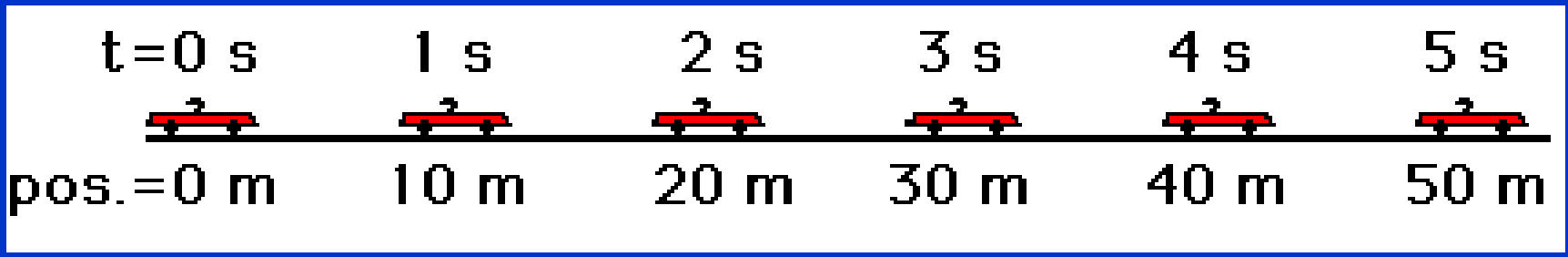


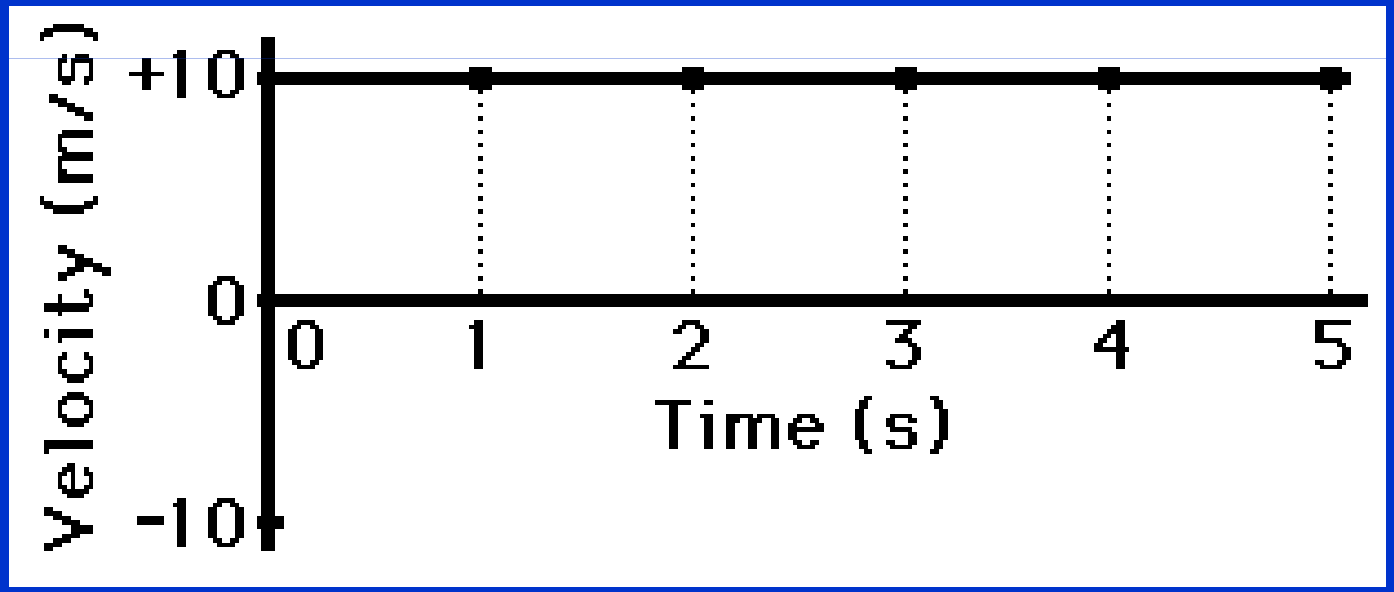
- Determine the velocity of the object whose motion is graphed at the left.
- 20m/5s = 4 m/s

Slope Practice



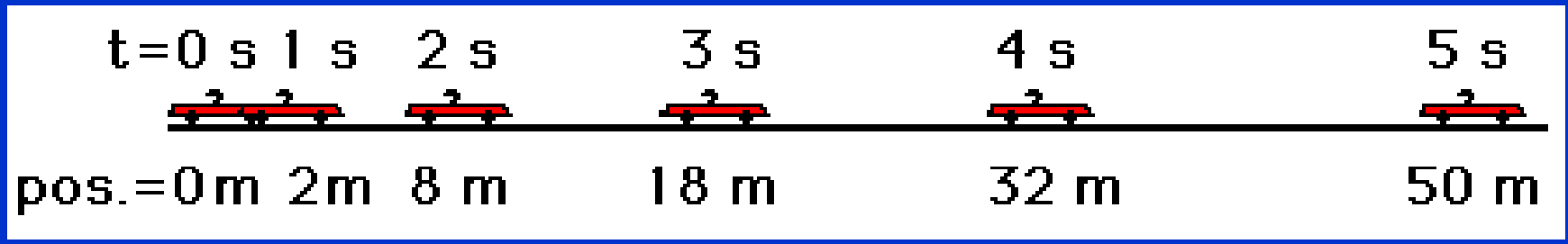
Velocity - Time Graph -- 1

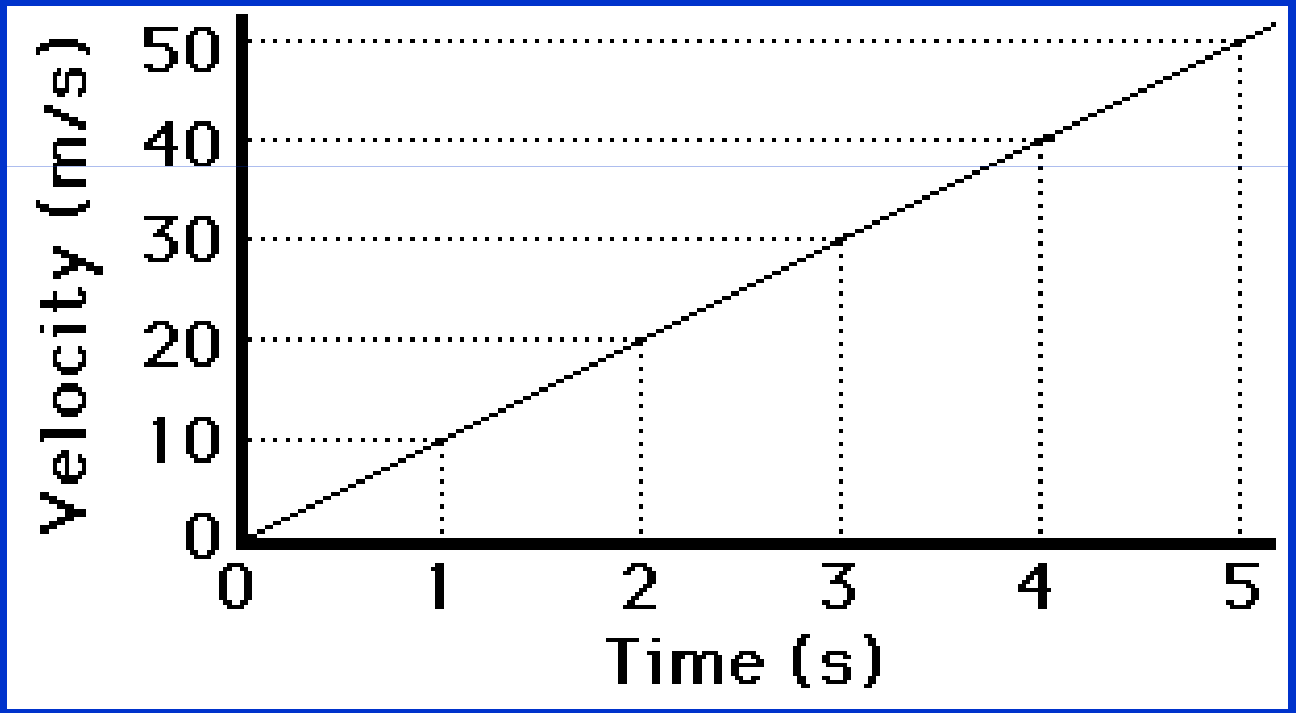




Graphics from Minds On Physics

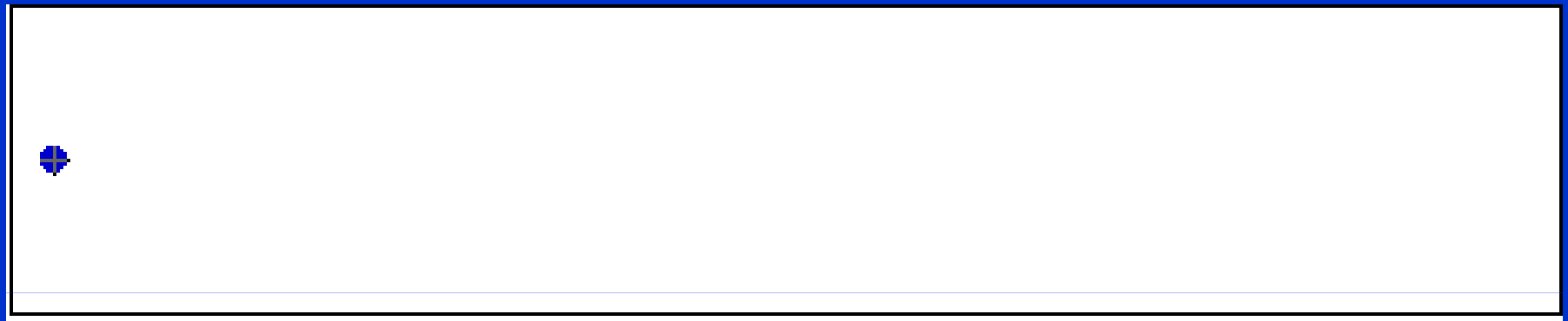
Velocity - Time Graph - 2



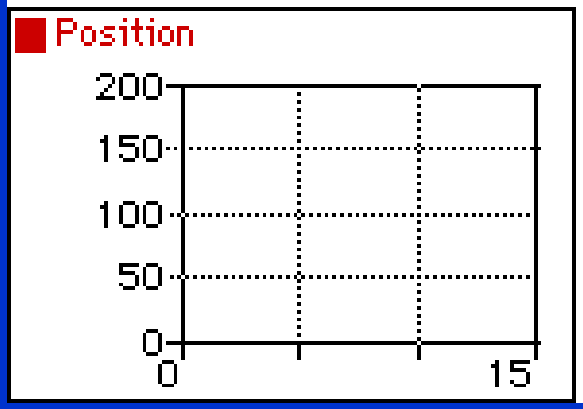


Graphics from Minds On Physics

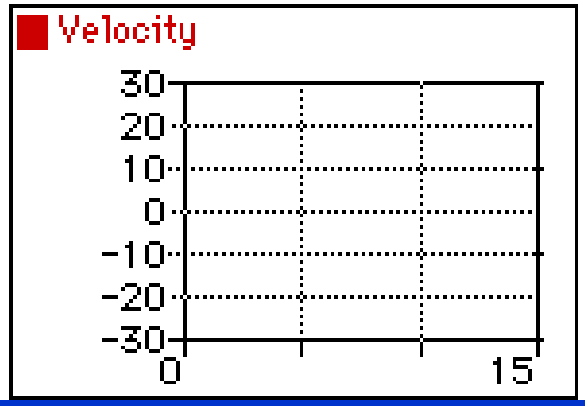
Constant Positive Velocity



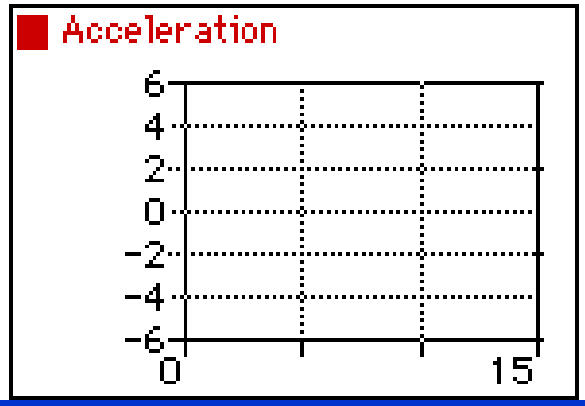
Position-Time Graph



Velocity-Time Graph

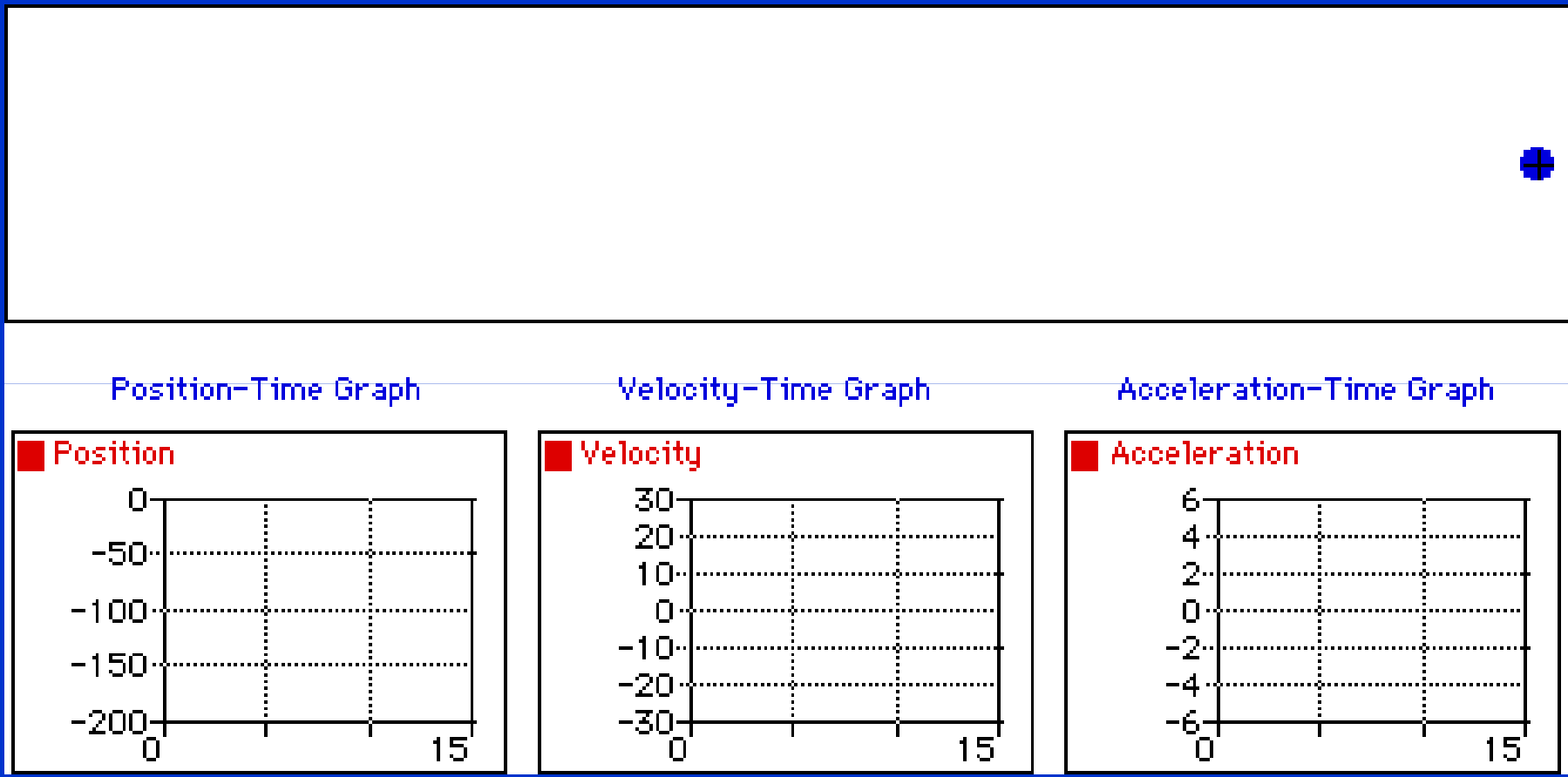


Acceleration-Time Graph



Graphics from Minds On Physics

Constant Negative Velocity



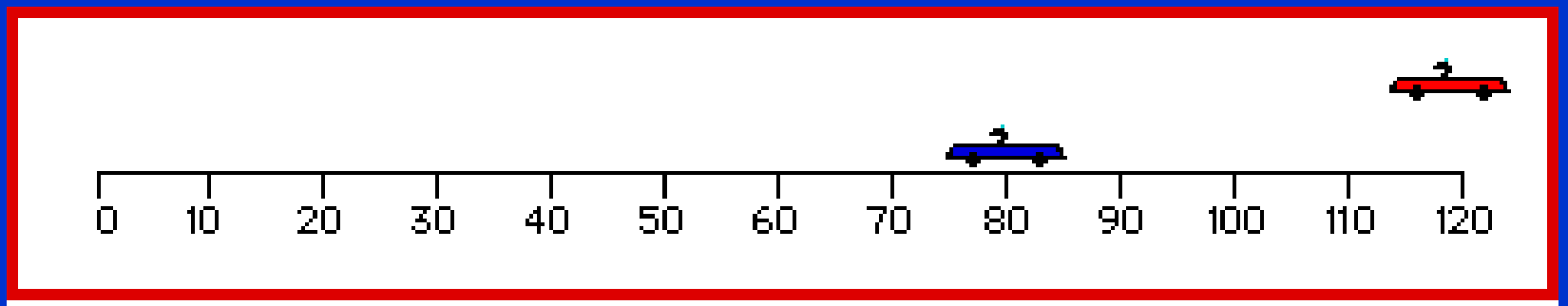
Graphics from Minds On Physics

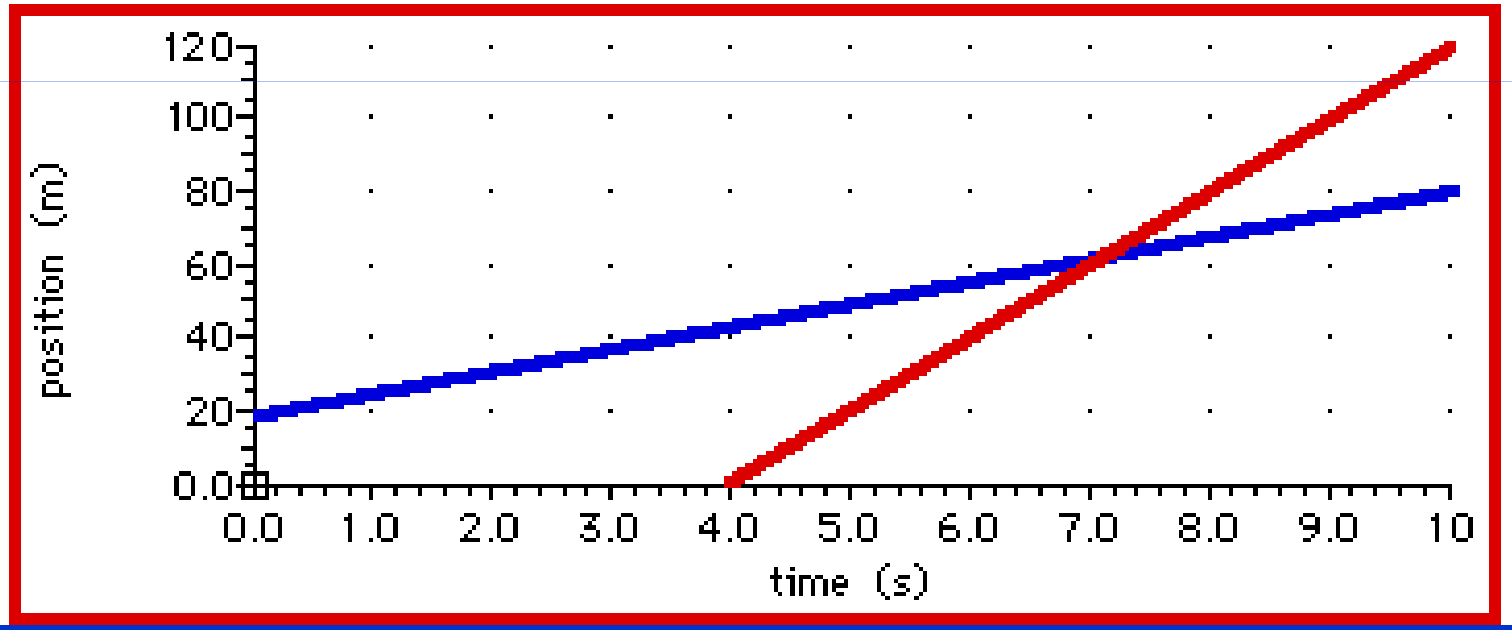
Average Speed Practice

Complete the table below.

ANIMAL	DISTANCE	TIME	SPEED
CHEETAH	75 m	3 s	25 m/s
GREYHOUND	160 m	10 s	
GAZELLE	1 km		100 km/h
TURTLE		30 s	1 cm/s

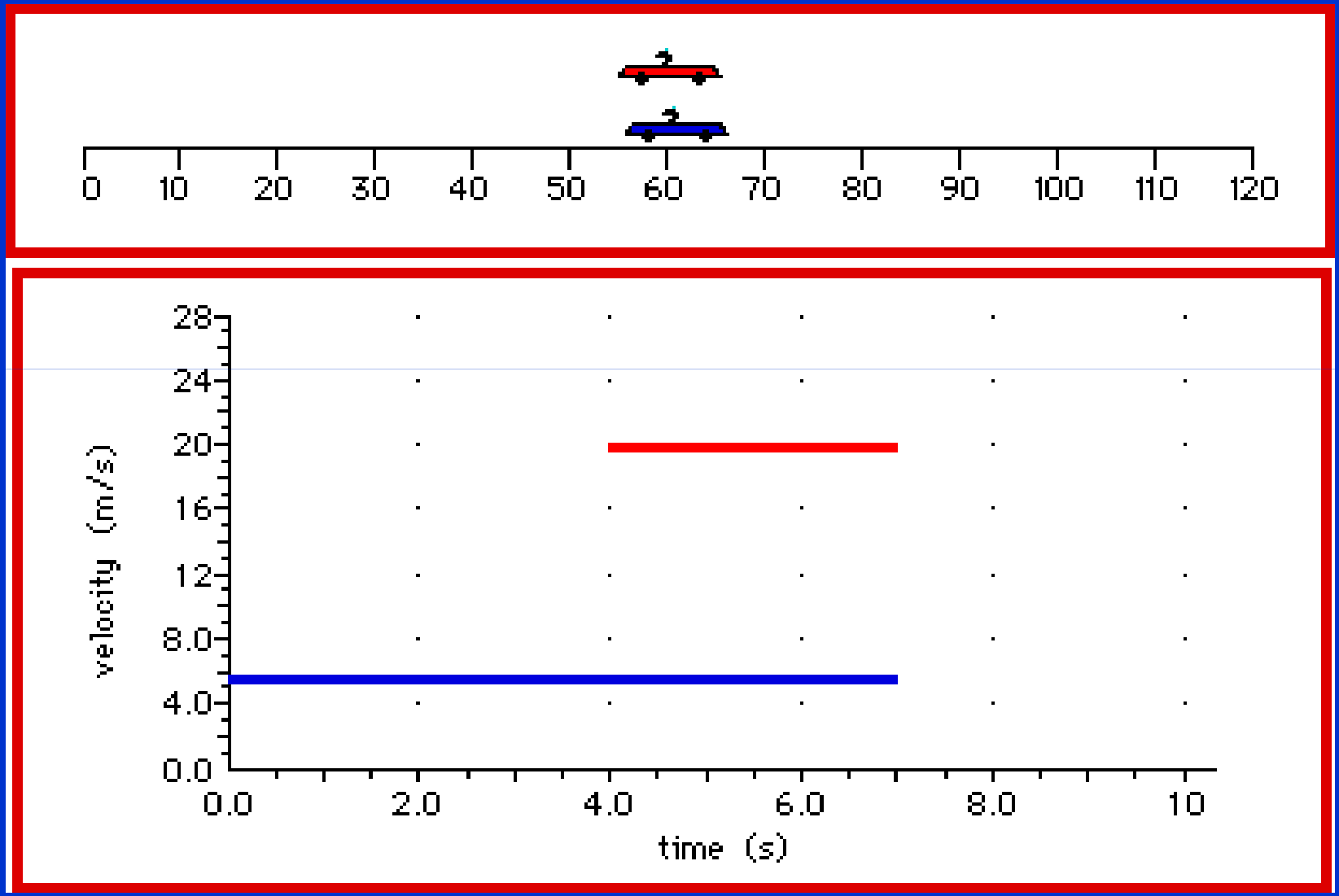
Passing Lane - Position-Time





Graphics from Minds On Physics

Passing Lane - Velocity-Time



Graphics from Minds On Physics