Unit-4

DYNAMICS OF PARTICLES

Particle Kinematics

Dynamics = Kinematics + Kinetics

Kinematics: The *description* of motion (position, velocity, acceleration, time) without regard to forces.

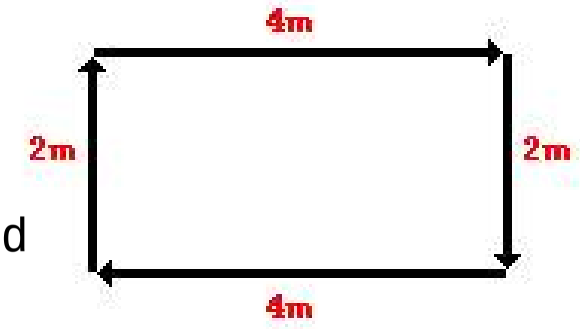
Kinetics: Determining the *forces* (based on F=ma) associated with motion.

Distance and Displacement

Distance is a scalar quantity that refers to "how much ground an object has covered" during its motion.

Displacement is a vector quantity that refers to "how far out of place an object is"; it is the object's overall change in position.

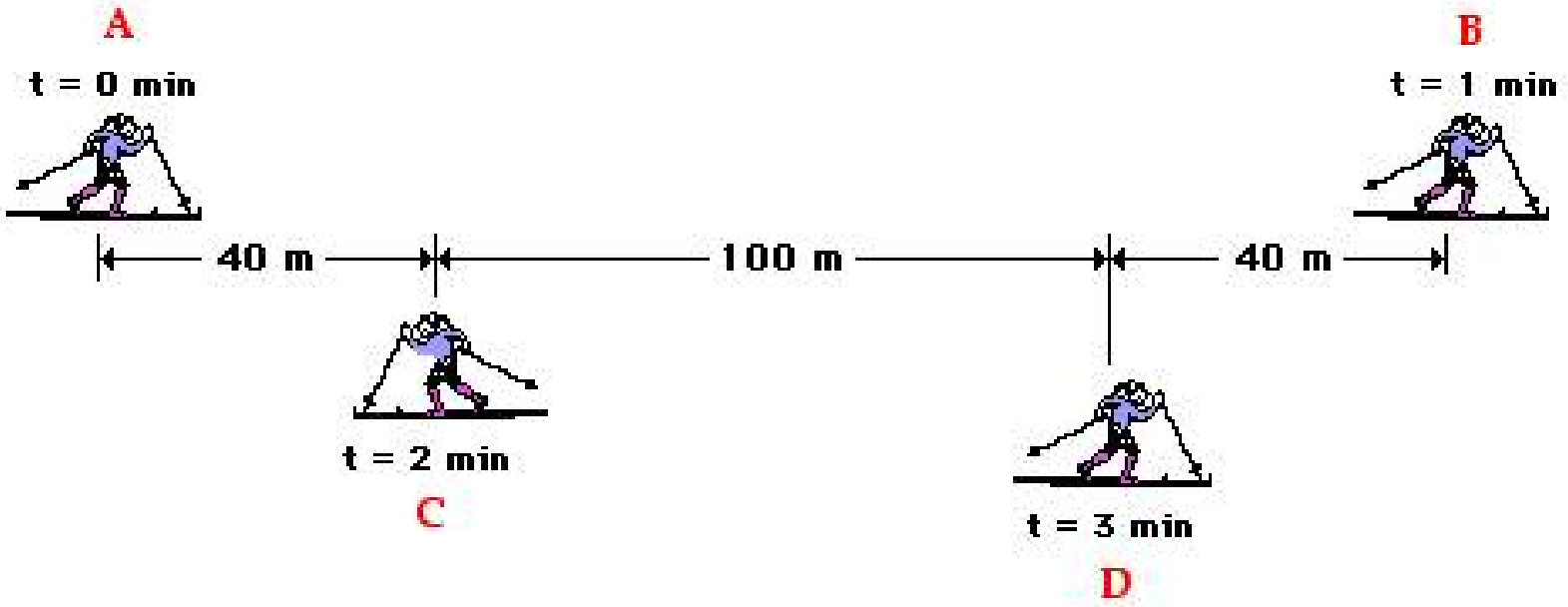
To test your understanding of this distinction, consider the motion depicted in the diagram below. A person walks 4 meters East, 2 meters South, 4 meters West, and finally 2 meters North.



He covered 12 meters of ground
(distance = 12 m)

There is no displacement for his motion
(displacement = 0 m)

Use the diagram to determine the resulting displacement and the distance traveled by the skier during these three minutes.



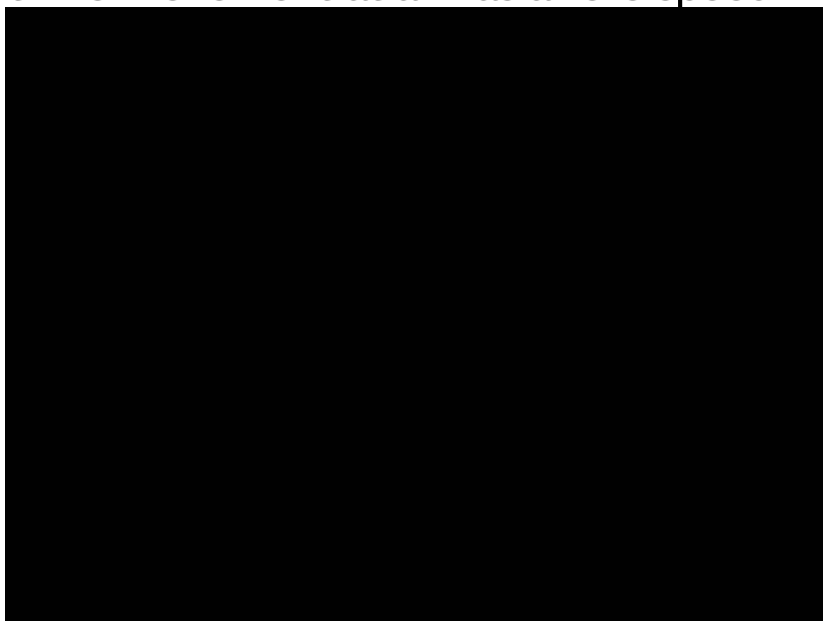
The skier covers a distance of

(180 m + 140 m + 100 m) = **420 m**

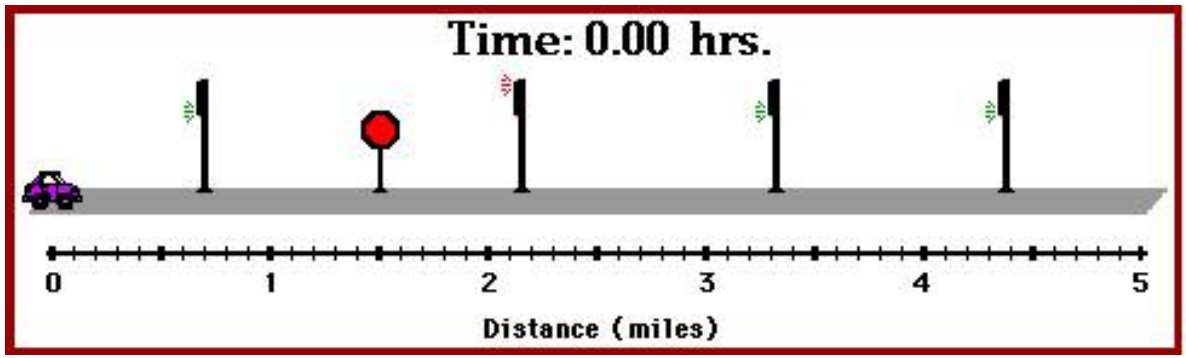
has a displacement of **140 m, rightward**.

Speed and Velocity

- **Speed** is a scalar quantity that refers to "how fast an object is moving."
- Speed can be thought of as the rate at which an object covers distance.
- A fast-moving object has a high speed and covers a relatively large distance in a short amount of time.
- Contrast this to a slow-moving object that has a low speed; it covers a relatively small amount of distance in the same amount of time.
- An object with no movement at all has a zero speed.



- **Velocity** is a vector quantity that refers to "the rate at which an object changes its position."
- Imagine a person moving rapidly - one step forward and one step back - always returning to the original starting position.
- While this might result in a frenzy of activity, it would result in a zero velocity.
- Because the person always returns to the original position, the motion would never result in a change in position.
- Since velocity is defined as the rate at which the position changes, this motion results in zero velocity.



The average speed during the course of a motion is often computed using the following formula:

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

In contrast, the average velocity is often computed using this formula

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

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

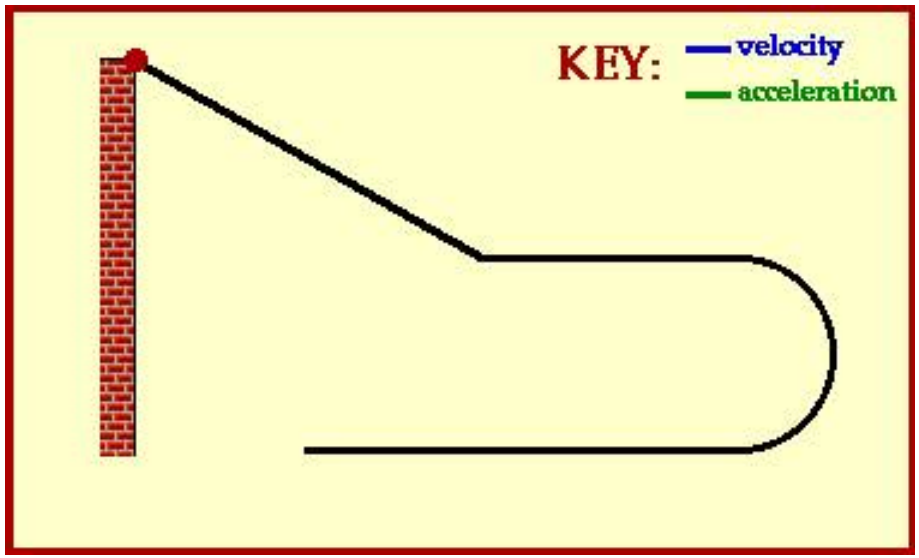
Time (s)	Position (m)
0	0
1	1
2	4
3	9
4	16

v=ds/dt

Acceleration

Acceleration is a vector quantity that is defined as the rate at which an object changes its velocity. An object is accelerating if it is changing its velocity. **a=dv/dt**

1. Which car or cars (red, green, and/or blue) are undergoing an acceleration?
2. Which car (red, green, or blue) experiences the greatest acceleration?



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Kinematic Variables

Particle kinematics involves describing a particle's position, velocity and acceleration versus time.

Kinematic Variables		
Description	**Vector**	**Scalar**
Position	$\vec{r}$	s
Velocity	$\vec{v}$	v
Acceleration	$\vec{a}$	a
Time	t	t