General

Physics 101

Motion in One Dimension

Prepared By

Prof. Rashad Badran

One Dimensional Motion:☹Kinematics

By Prof. Rashad Badran

MOTION ALONG A STRAIGHT LINE

The state of motion of a particle can be described by the , position, velocity, and accelerationwhich are all dependent on time

One Dimensional Motion:

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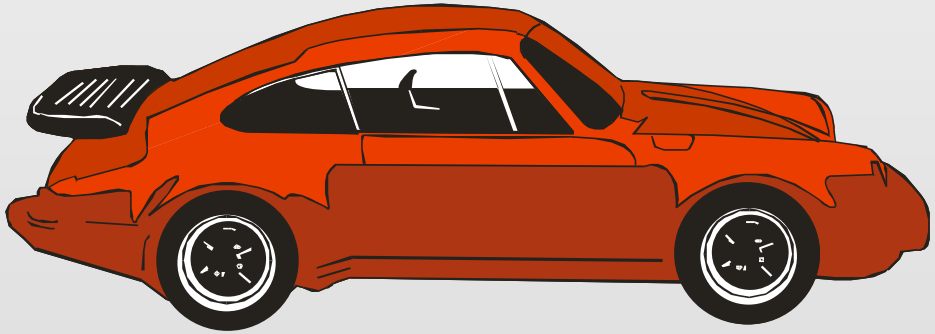
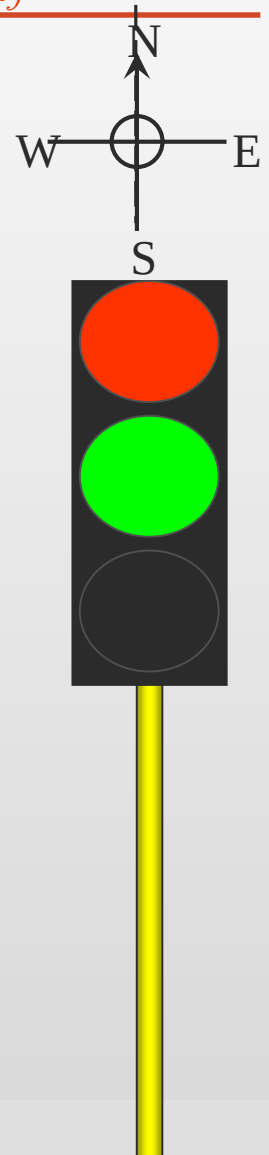
Position of an Object





What is the position of the car with respect to the traffic light?

One Dimensional Motion:

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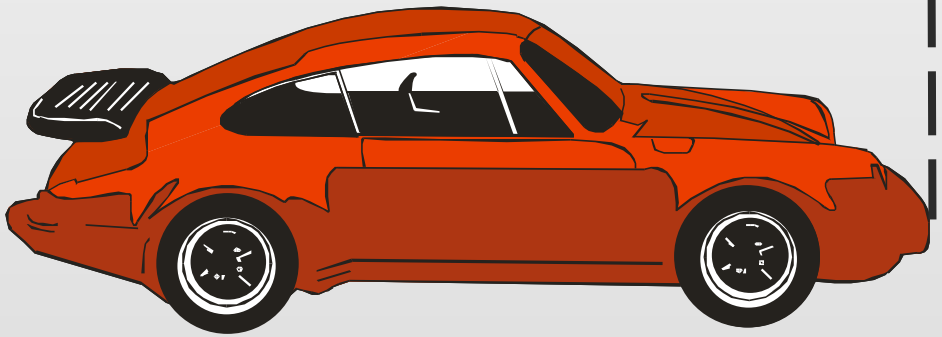
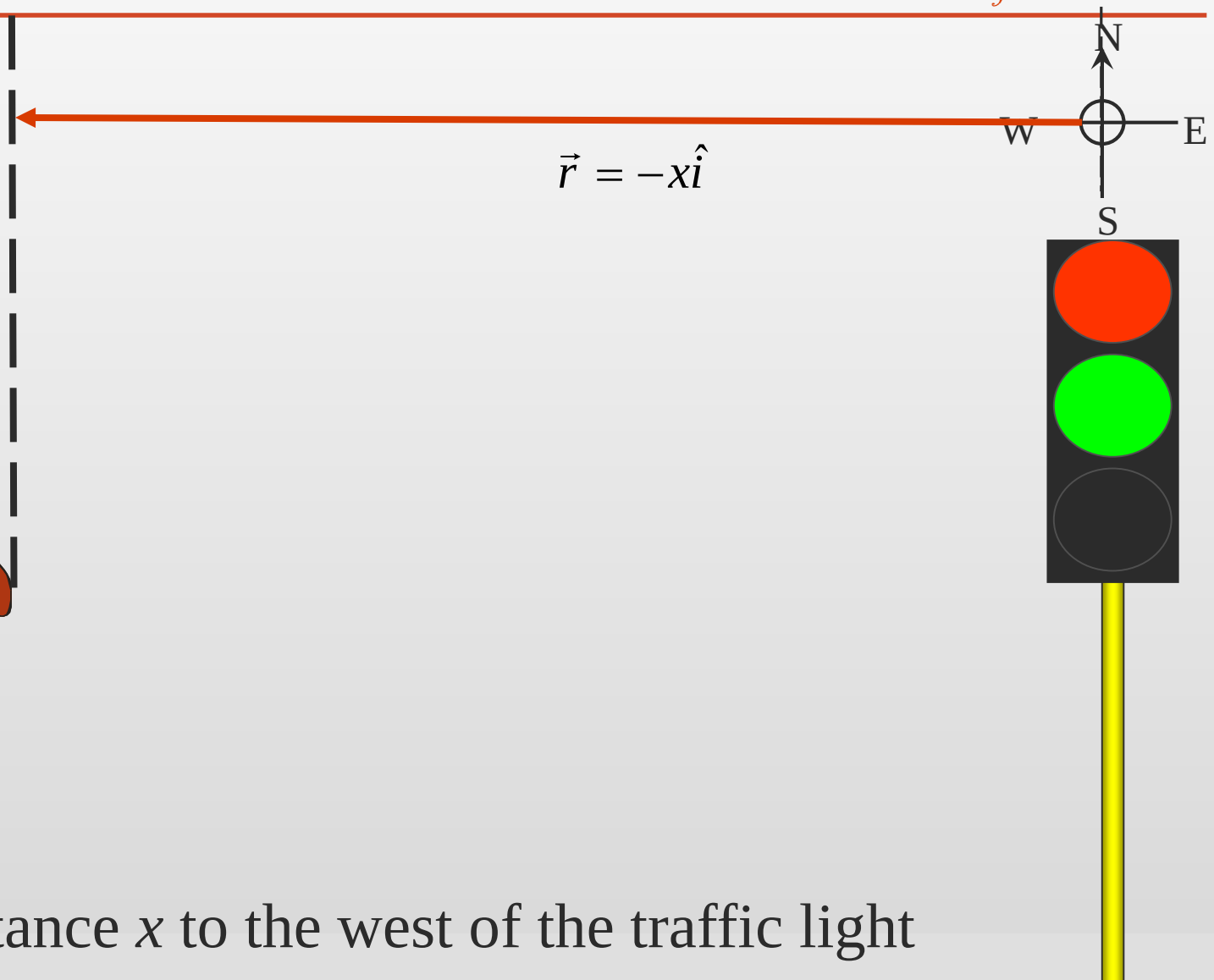
Position of an Object





The position of the car is at a distance x to the west of the traffic light

One Dimensional Motion:

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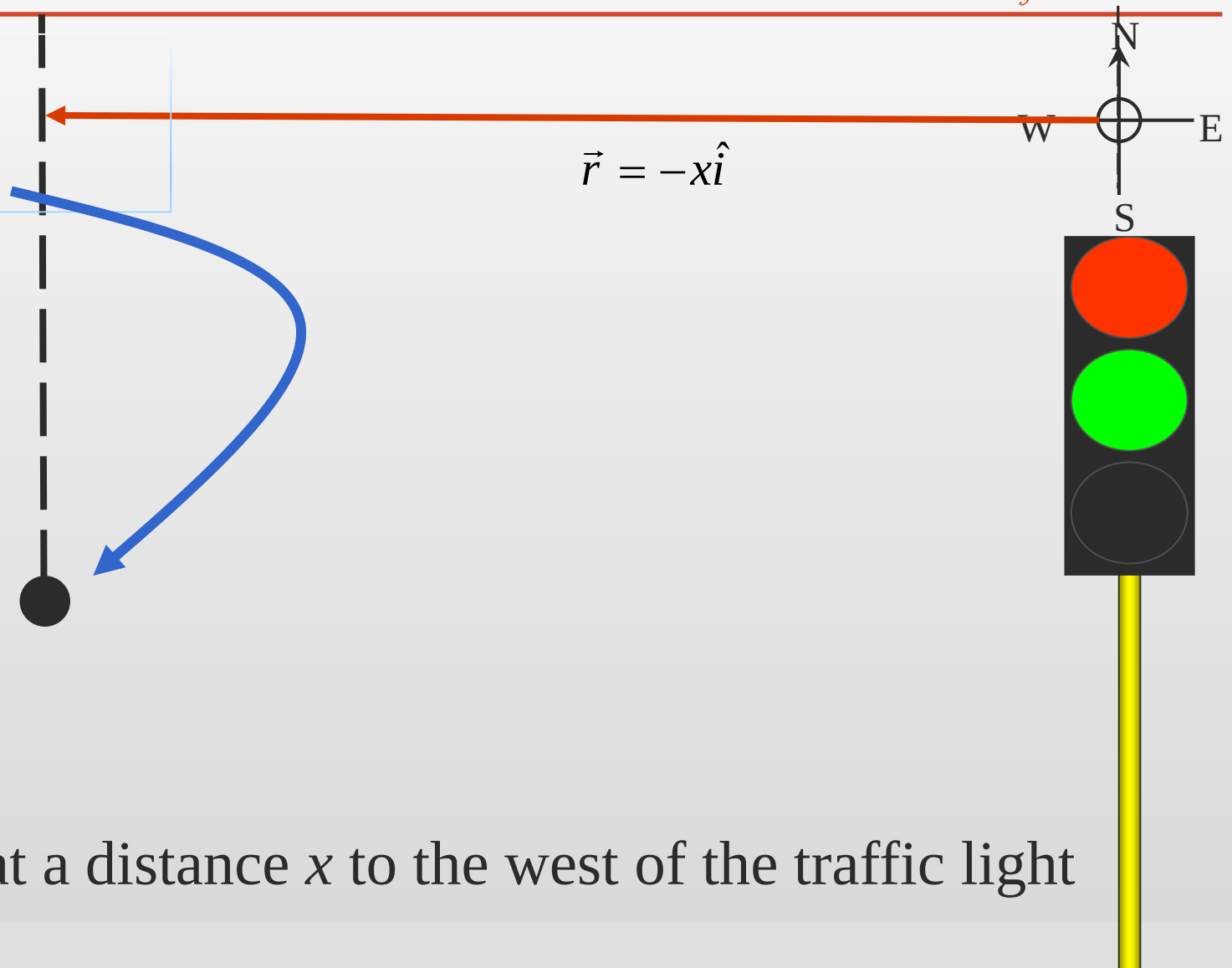
An object (car) can be idealized as a particle



The position of the particle is at a distance *x* to the west of the traffic light

One Dimensional Motion:

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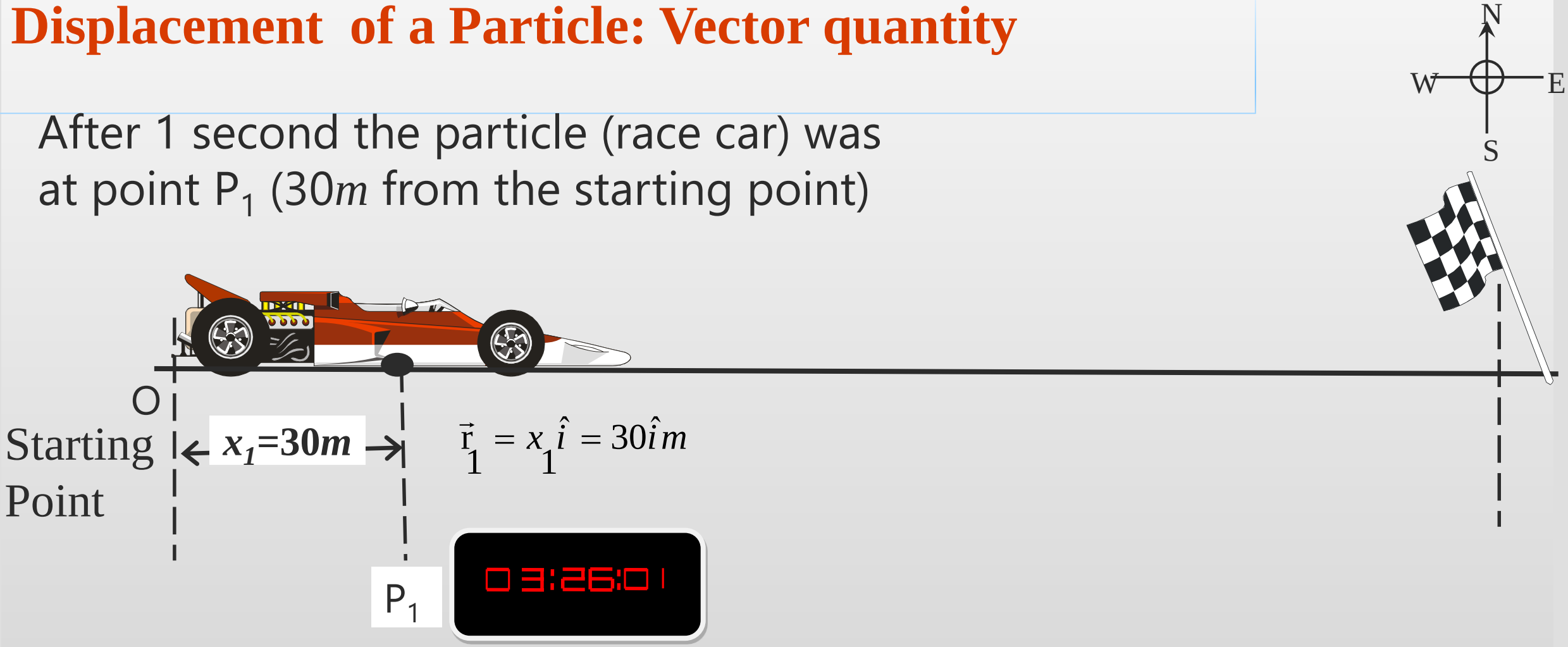
Displacement of a Particle: Vector quantity

After 1 second the particle (race car) was at point P_1 ($30m$ from the starting point)



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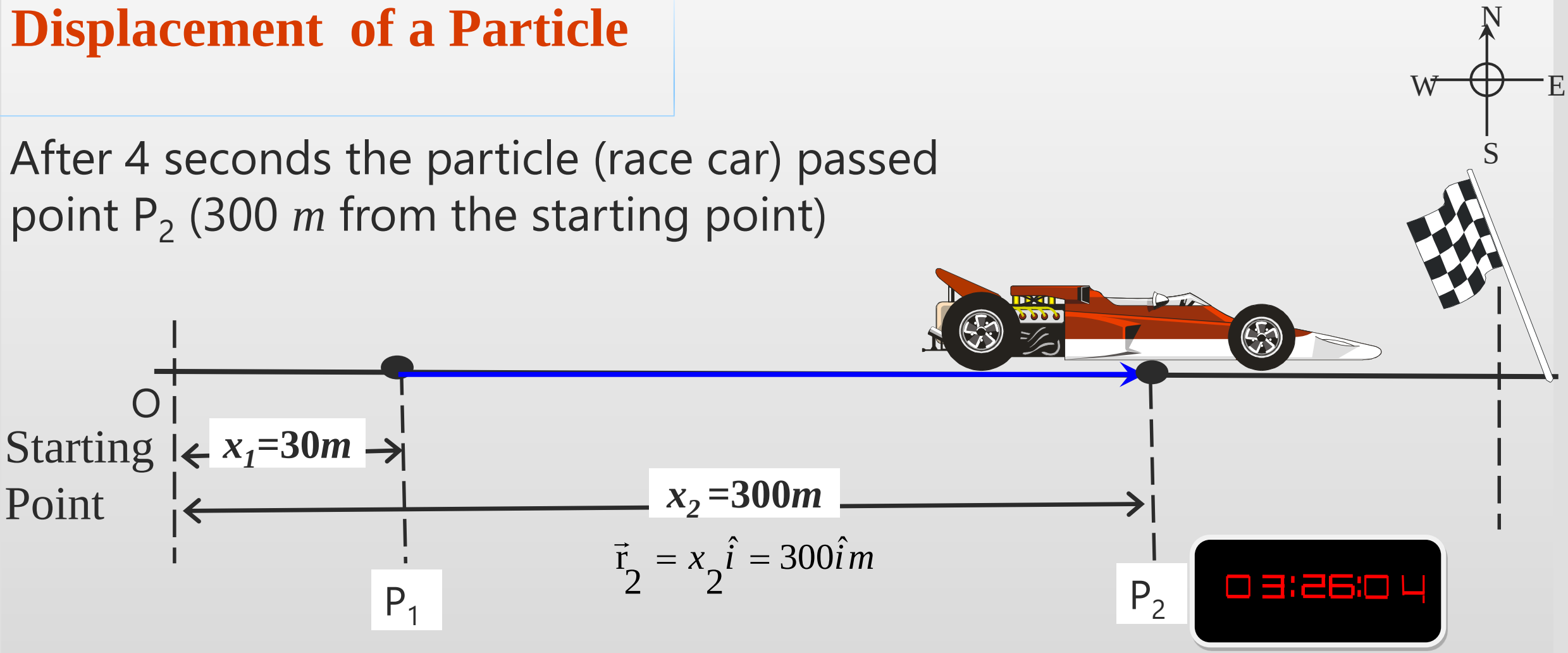
Displacement of a Particle

After 4 seconds the particle (race car) passed point P_2 (300 m from the starting point)



One Dimensional Motion:

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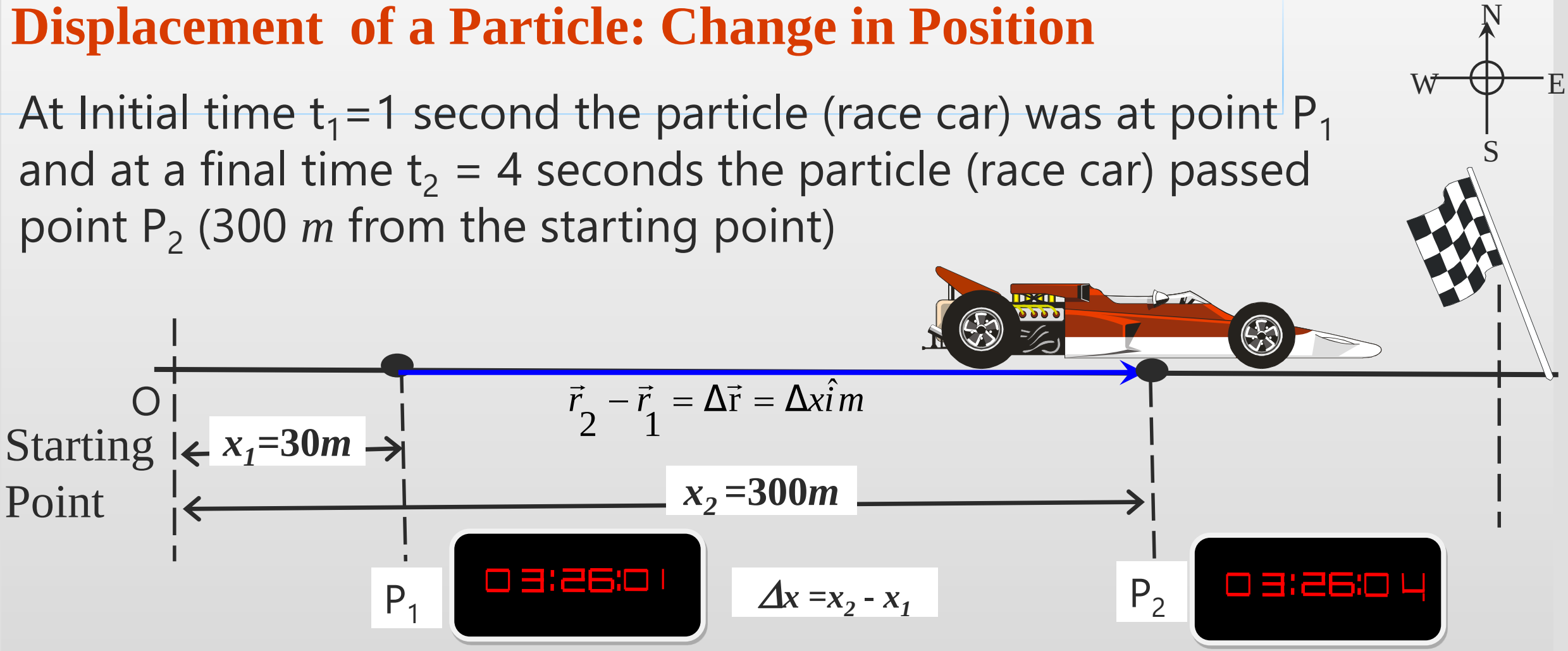
Displacement of a Particle: Change in Position

At Initial time t_1=1 second the particle (race car) was at point P_1 and at a final time t_2 = 4 seconds the particle (race car) passed point P_2 (300 *m* from the starting point)



One Dimensional Motion:

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Displacement of a Particle

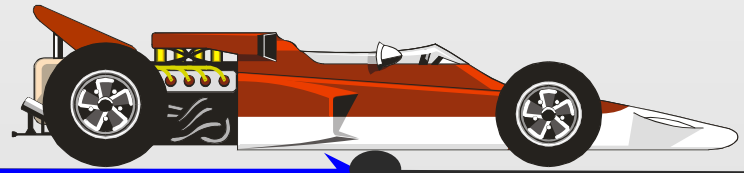
Displacement = $\Delta x = x_2 - x_1$

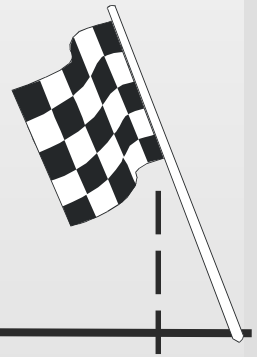
$= 300\ m - 30\ m = 270\ m$

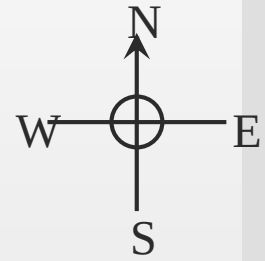
magnitude

direction

$(+\hat{i})$ or due to east







O

Starting Point

$x_1 = 30m$

$\Delta\vec{r} = 270\hat{i}\,m$

$x_2 = 300m$

P_1

$\Delta x = x_2 - x_1$

P_2

Note: The magnitude of displacement is called distance

One Dimensional Motion:

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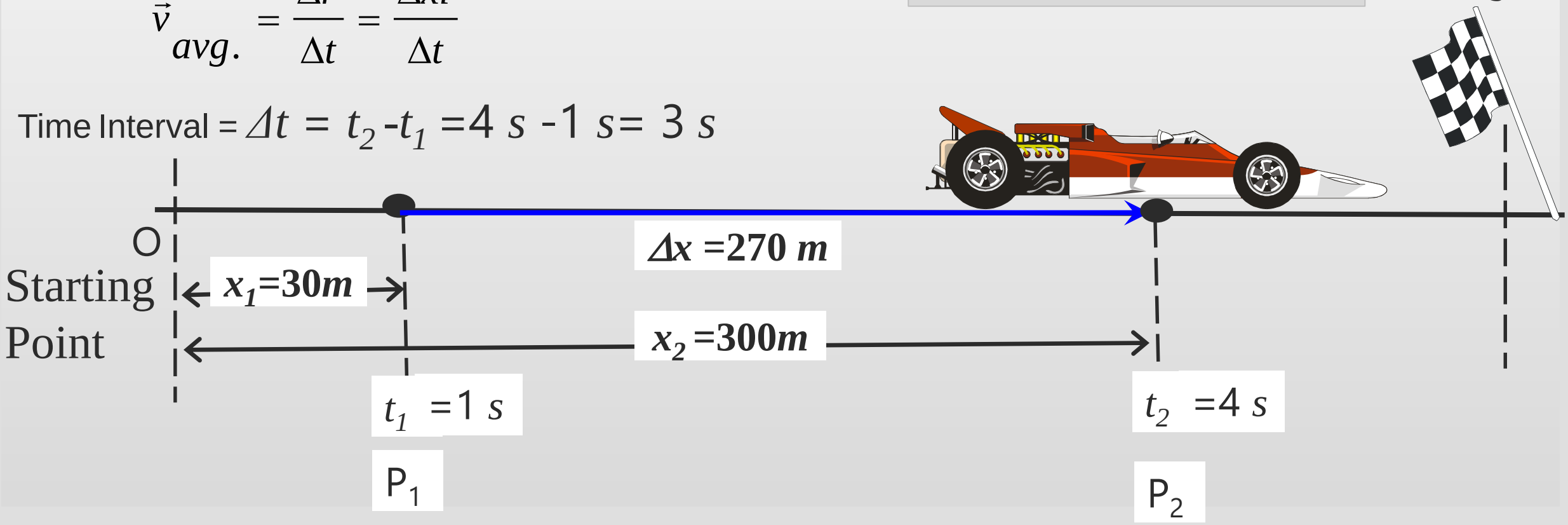
Average Velocity of a Particle $\vec{v}_{avg.}$ = $\frac{\text{Displacement}}{\text{Time Interval}}$

$$\vec{v}_{avg.} = \frac{\Delta\vec{r}}{\Delta t} = \frac{\Delta x\hat{i}}{\Delta t}$$

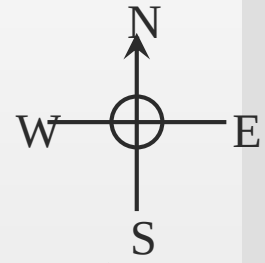
Time Interval = $\Delta t = t_2 - t_1 = 4\ s - 1\ s = 3\ s$



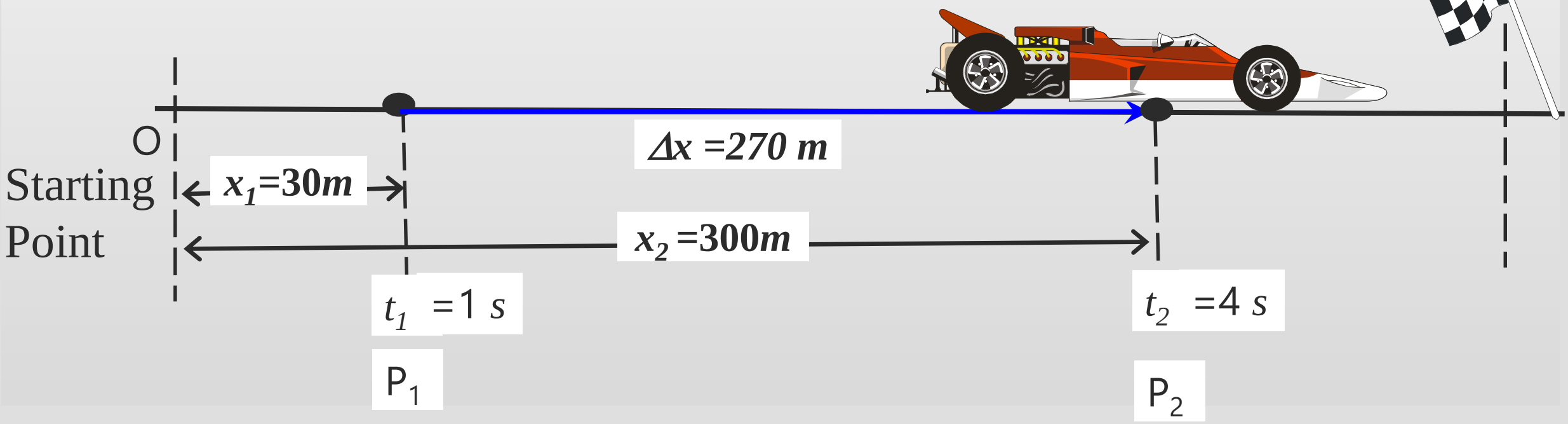
One Dimensional Motion:

Average Velocity of a Particle

$$\vec{v}_{avg.} = \frac{270\hat{i}\,m}{3s} = 90\hat{i}\ \ m/s$$



Average velocity is a vector quantity which has a magnitude of 90 *m/s* and direction due east (or towards *+ve x*-axis)

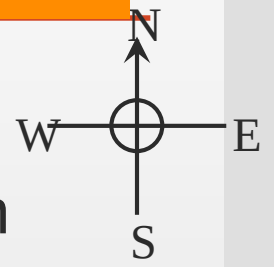


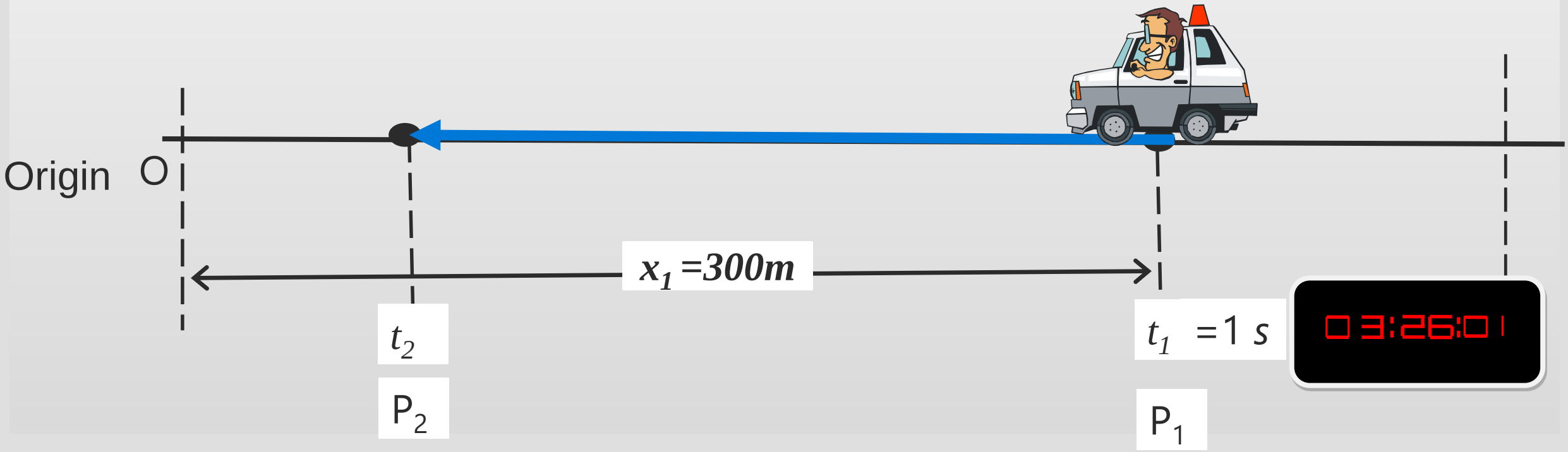
One Dimensional Motion:

Example

Average Velocity of a Particle

A service car was at point P_1 which is located 300 m from the shown origin after one second of its motion it passed point P_2 which is 30 m far away from the same origin at time 4 seconds of its motion. What is its average velocity?



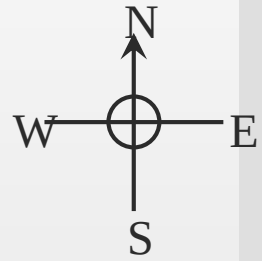


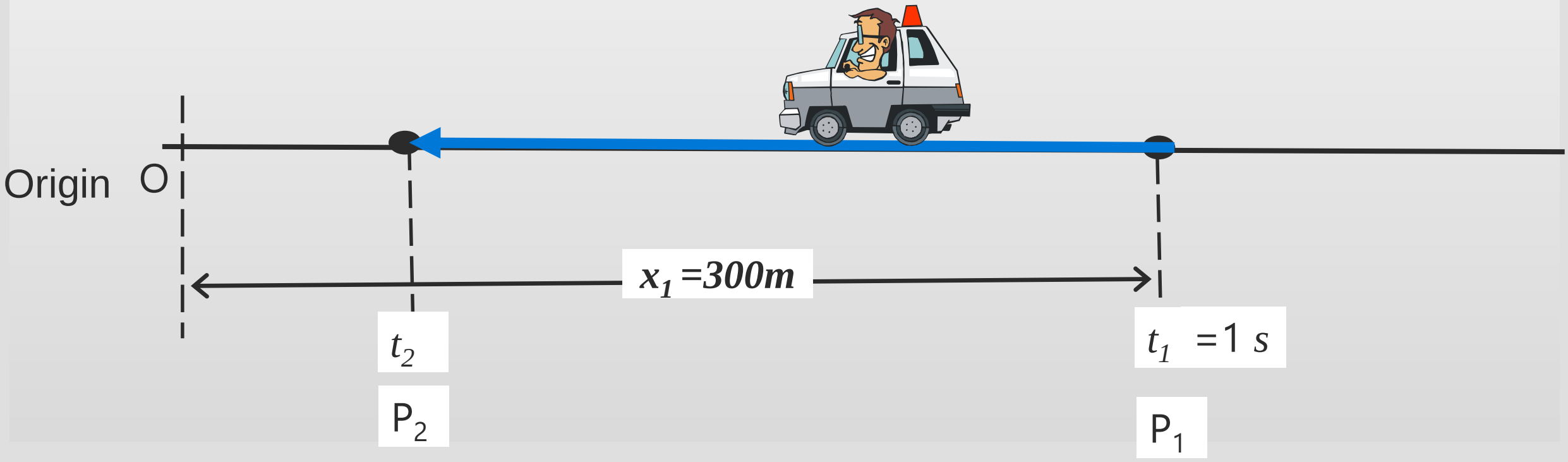
One Dimensional Motion:

Solution:

Average Velocity of a Particle

$$\vec{v}_{avg.} = \frac{\Delta \vec{r}}{\Delta t} \qquad m/s$$





One Dimensional Motion:

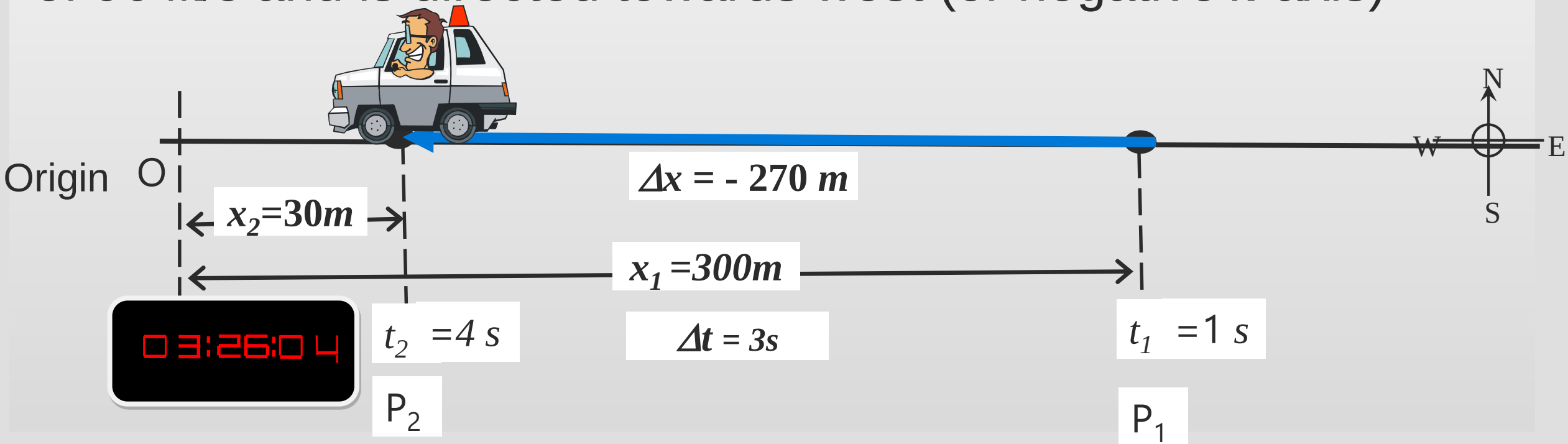
Solution:

$\Delta x = x_2 - x_1 = 30\ m - 300\ m = -270\ m$

$\Delta t = t_2 - t_1 = 3\ s$

$$\Rightarrow \vec{v}_{avg.} = \frac{\Delta x \hat{i}}{\Delta t} = \frac{-270 \hat{i}\, m}{3s} = -90\hat{i}\ \ m/s$$

This result means that the average velocity has a magnitude of 90 *m/s* and is directed towards west (or negative *x*-axis)



Distance and Average Speed: From Irbid to Amman

Average Speed=Total Distance/Total time

Driving Distance (orange path)= 92km. But driving distance via Al Mafraq (blue path)=111km

Direct flying Distance (by plane)=67km=The shortest distance between Amman and Irbid is the straight line (**dark path**) which is the magnitude of displacement.

Average Speed = 67km/0.2h for the **dark path** with time of trip equals 0.2h.

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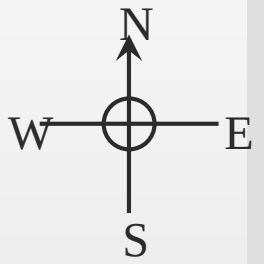
Finding Average Velocity

Position of a car at different times

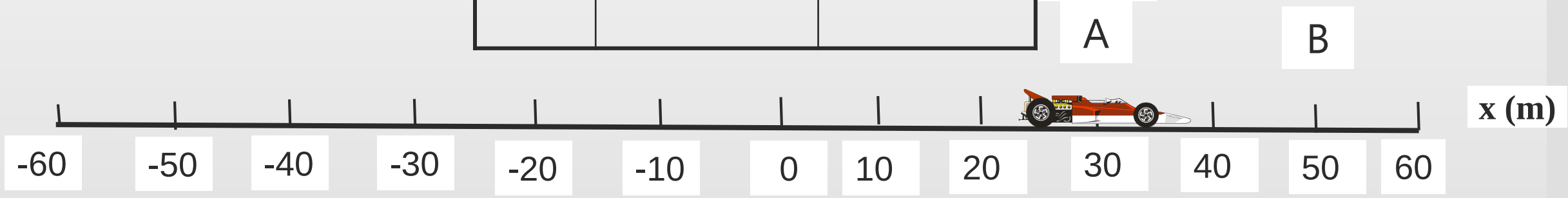
Position	t (s)	x (m)
A	0	30

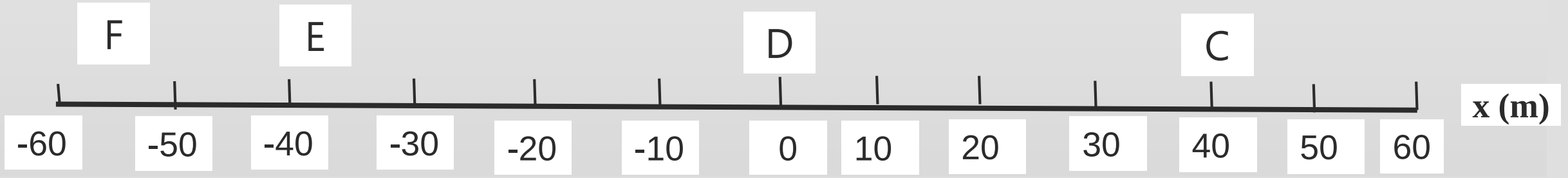
Example

The car moves to the east from position A to B



$t_A = 0$





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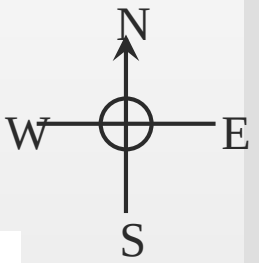
Finding Average Velocity

Position of a car at different times

Position	t (s)	x (m)
A	0	30
B	10	52

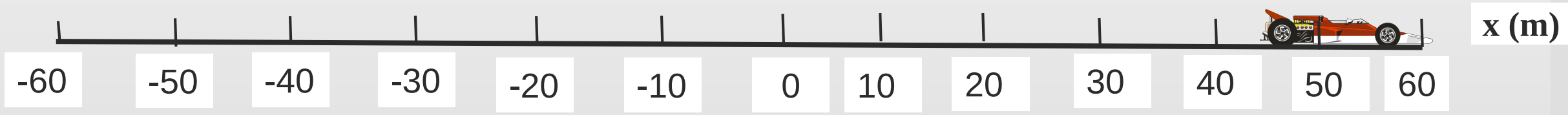
Example

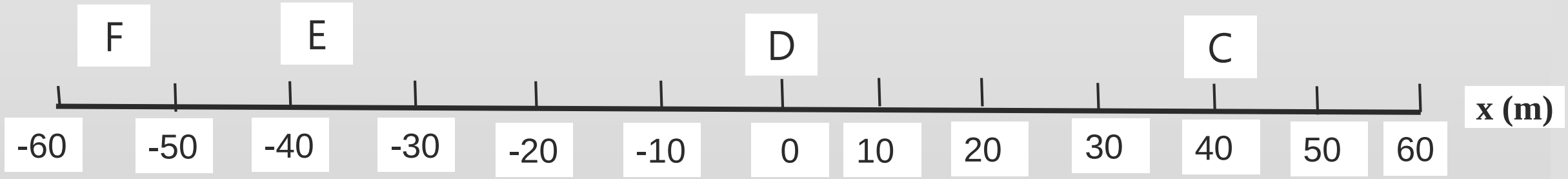
The car moves to the east from position A to B



$t_A = 0$ $t_B = 10$ s

A B





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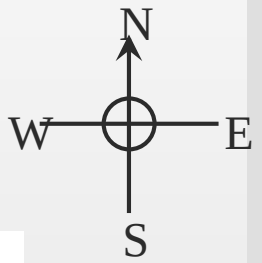
Finding Average Velocity

Position of a car at different times

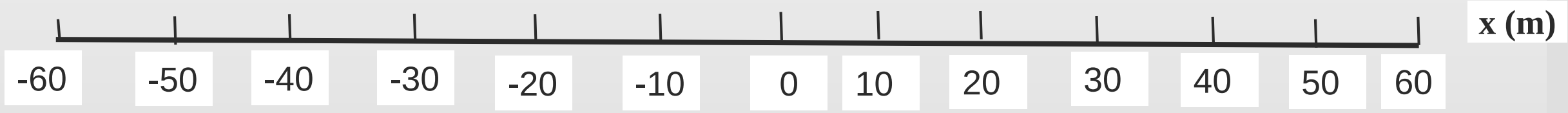
Position	t (s)	x (m)
A	0	30
B	10	52
C	20	38

Example



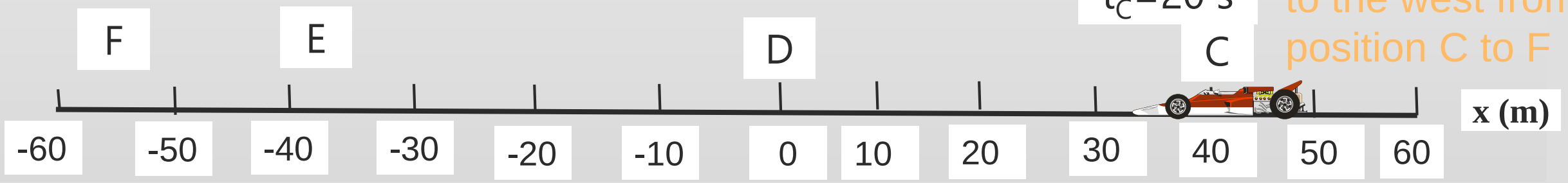
$t_A = 0$ A

$t_B = 10$ s B



$t_C = 20$ s C

The car moves to the west from position C to F



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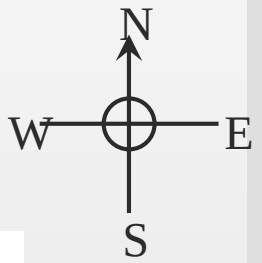
Finding Average Velocity

Position of a car at different times

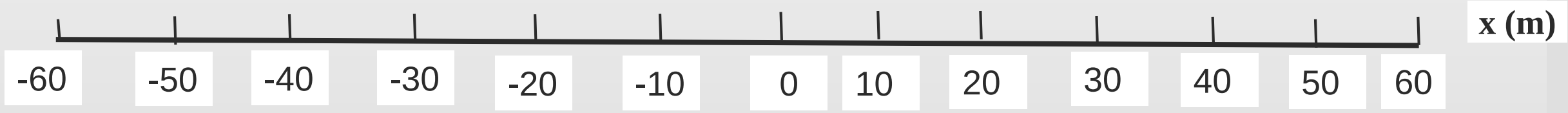
Position	t (s)	x (m)
A	0	30
B	10	52
C	20	38
D	30	0

Example



$t_A = 0$ A

$t_B = 10$ s B



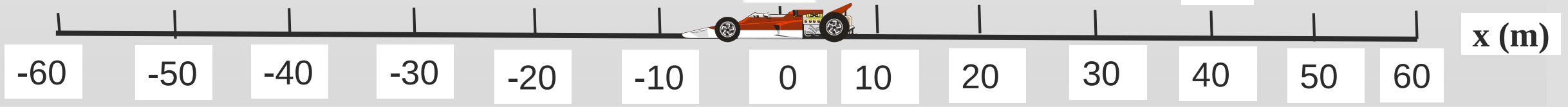
$t_D = 30$ s D

$t_C = 20$ s C

F

E

The car moves to the west from position C to F



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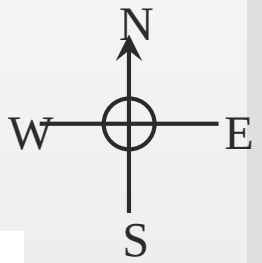
Finding Average Velocity

Position of a car at different times

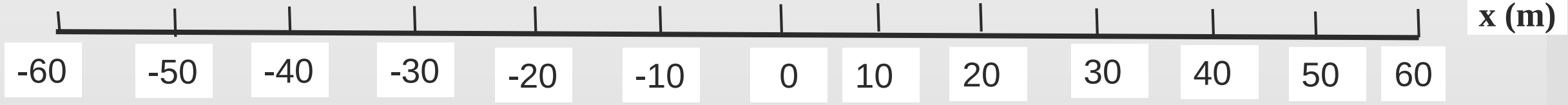
Position	t (s)	x (m)
A	0	30
B	10	52
C	20	38
D	30	0
E	40	-37

Example



$t_A = 0$ A

$t_B = 10$ s B



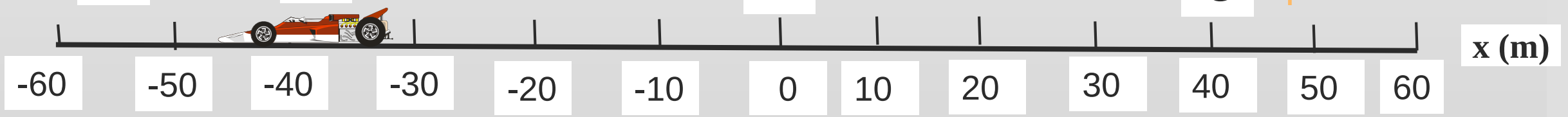
$t_E = 40$ s E

F

$t_D = 30$ s D

$t_C = 20$ s C

The car moves to the west from position C to F



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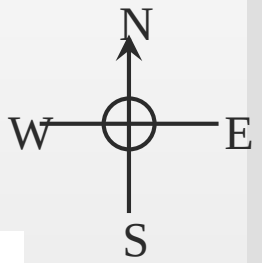
Finding Average Velocity

Position of a car at different times

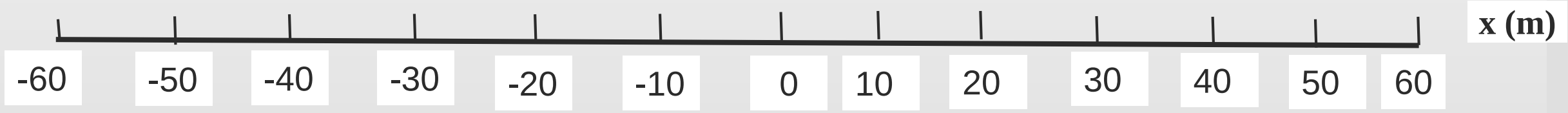
Position	t (s)	x (m)
A	0	30
B	10	52
C	20	38
D	30	0
E	40	-37
F	50	-53

Example



$t_A = 0$ A

$t_B = 10$ s B



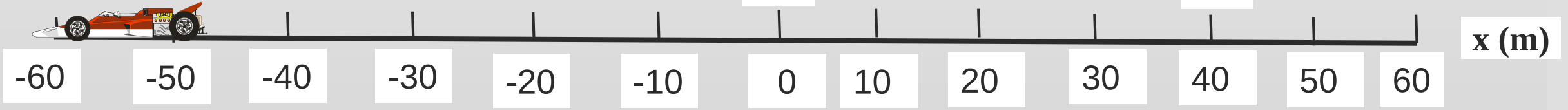
$t_F = 50$ s F

$t_E = 40$ s E

$t_D = 30$ s D

$t_C = 20$ s C

The car moves to the west from position C to F



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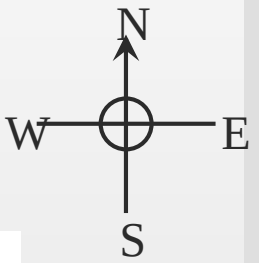
Finding Average Velocity

Position of a car at different times

Position	t (s)	x (m)
A	0	30
B	10	52
C	20	38
D	30	0
E	40	-37
F	50	-53

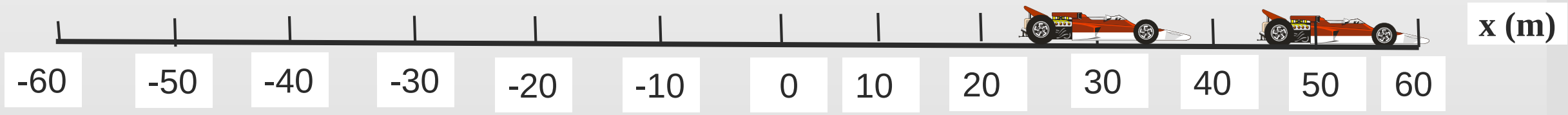
Example

The car moves to the east from position A to B



$t_A = 0$ A

$t_B = 10$ s B



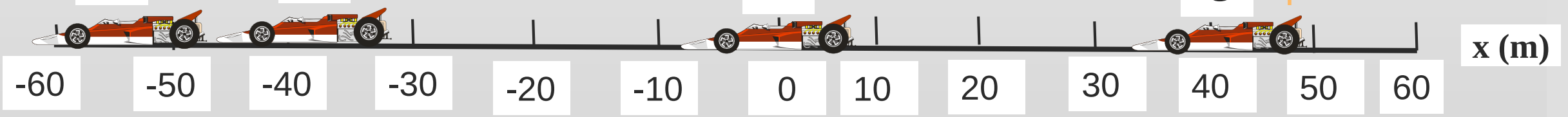
$t_F = 50$ s F

$t_E = 40$ s E

$t_D = 30$ s D

$t_C = 20$ s C

The car moves to the west from position C to F

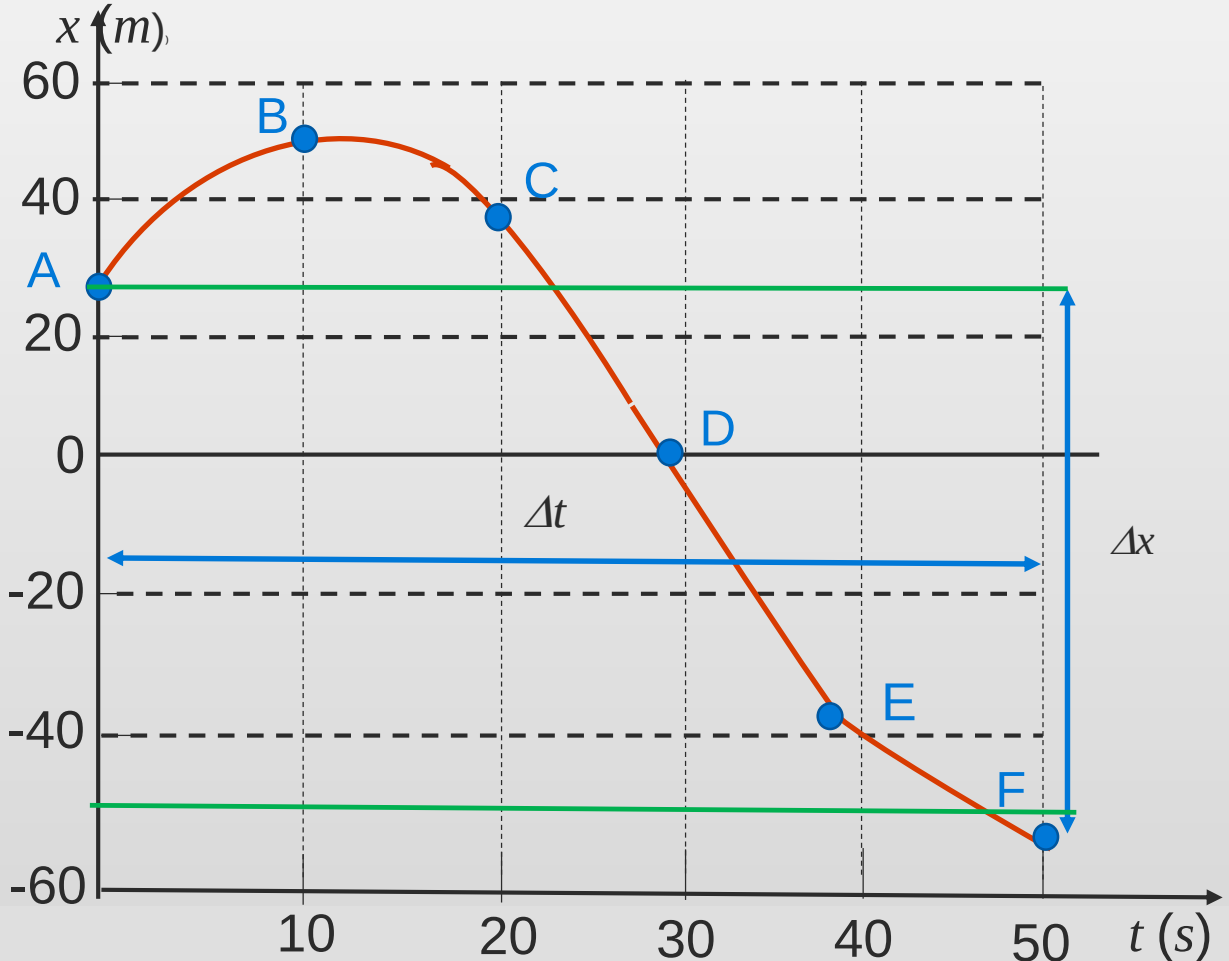


Finding Average Velocity

(a) Find the displacement between positions A and F.

(b) Find the average velocity between positions A and F.

Position	$t\ (s)$	$x\ \ (m)$
A	0	30
B	10	52
C	20	38
D	30	0
E	40	-37
F	50	-53



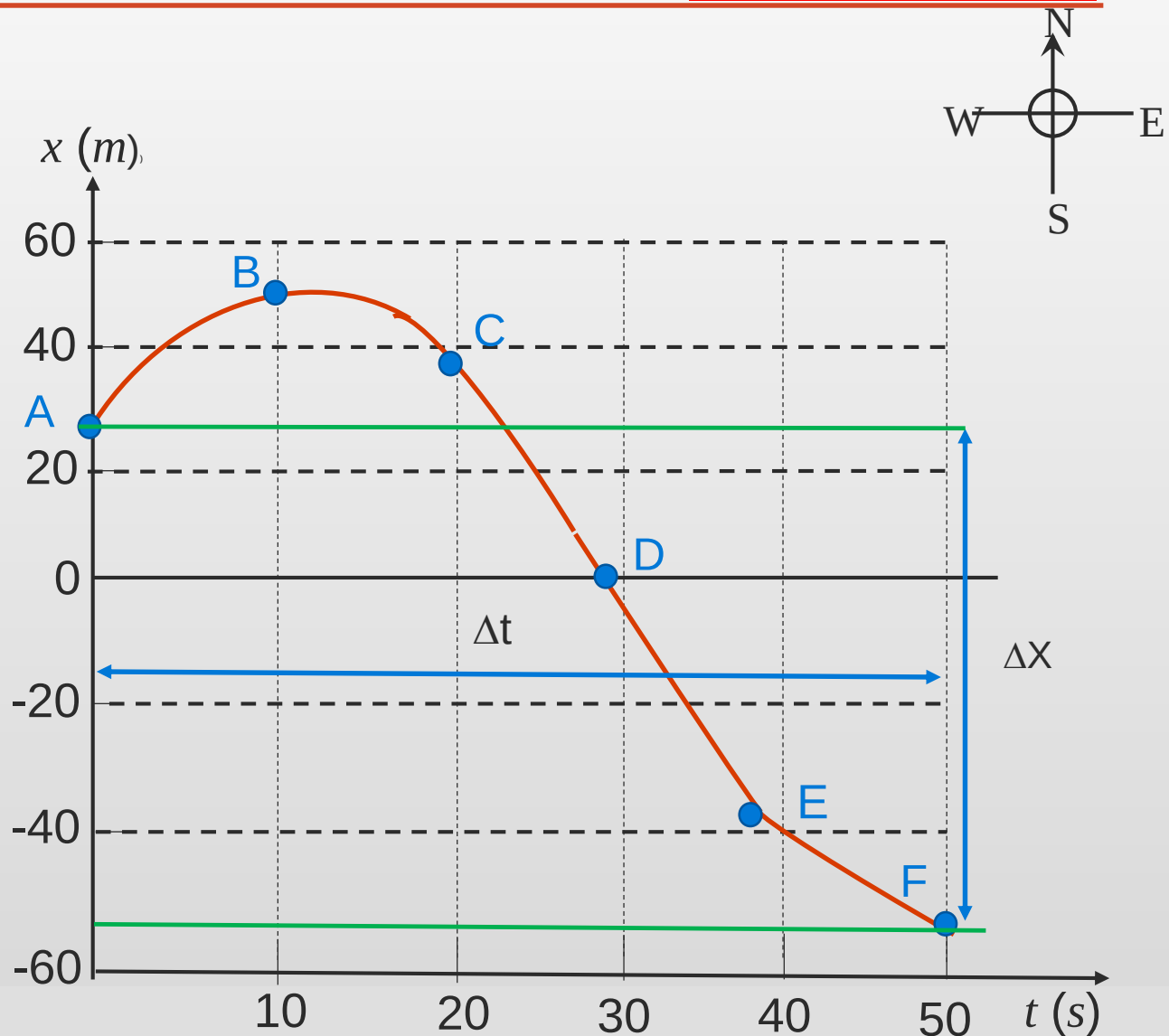
Finding Displacement

Solution:

(a) $\Delta x = x_F - x_A = -53-30 = -83\ m$

i.e. Magnitude of displacement is 83 m and its direction is due west

Position	t (s)	x (m)
A	0	30
B	10	52
C	20	38
D	30	0
E	40	-37
F	50	-53



Finding Average Velocity

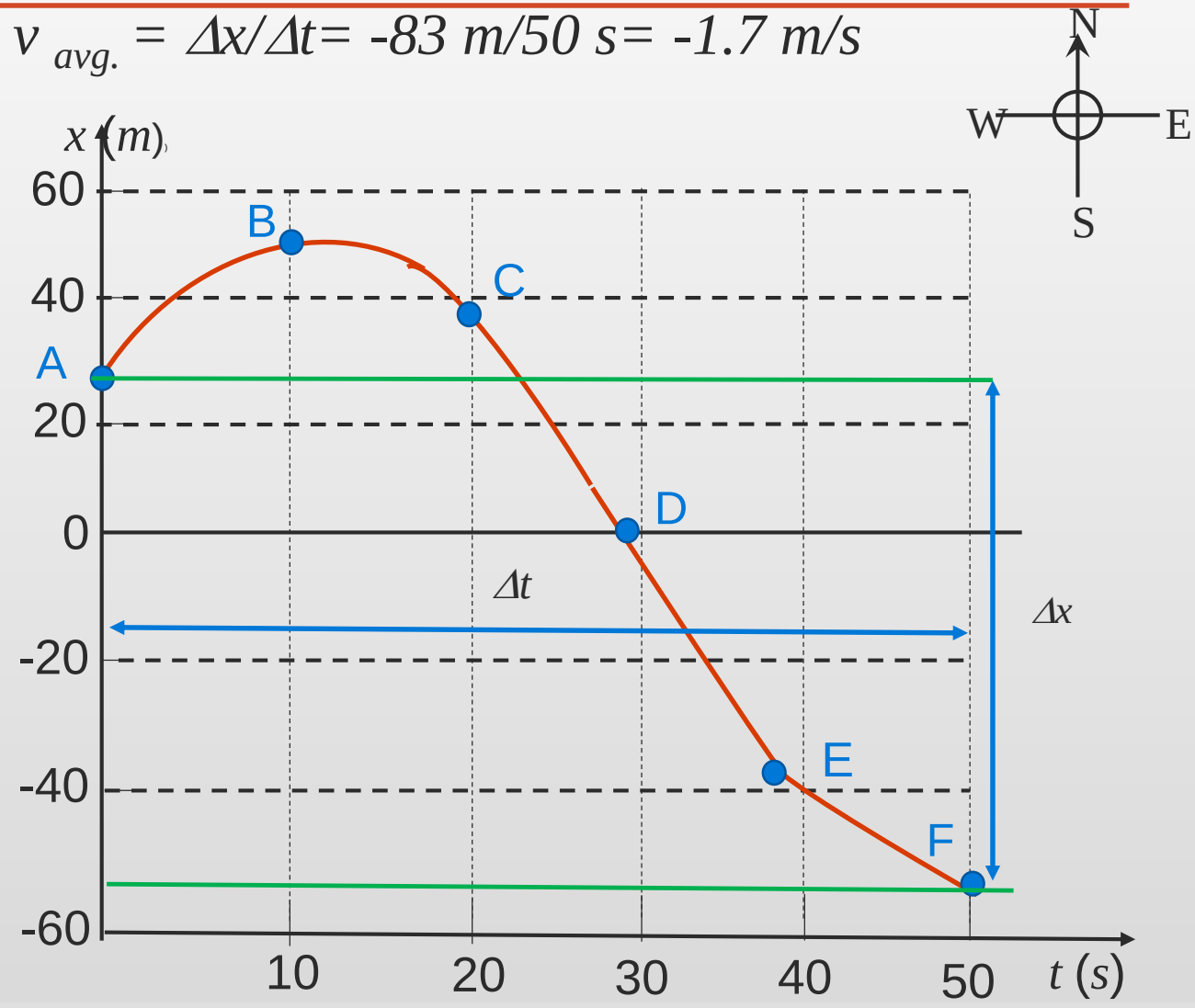
Solution:

(b) $\Delta t = t_F - t_A = 50\text{-}0 = 50\ s$ ⟹ $v_{avg.} = \Delta x/\Delta t = -83\ m/50\ s = -1.7\ m/s$

i.e. Magnitude of $v_{avg.}$ is **1.7** *m/s* and its direction is due west

Position	$t\ (s)$	$x\ (m)$
A	0	30
B	10	52
C	20	38
D	30	0
E	40	-37
F	50	-53

Note: The average velocity between any two positions for a given time interval is a vector quantity that has a magnitude and direction



One Dimensional Motion:

Conceptual Question

If the average velocity of an object is zero in some time interval. Which of the following statements is correct?

(a) The displacement is constant

(b) The initial and final positions are the same

(c) The velocity is zero at each instant of the time interval

(d) The answers in (a) and (b) are correct

(e) The answers in (b) and (c) are correct

By Prof. Rashad Badran

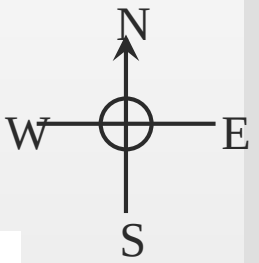
Finding Average speed

Position of a car at different times

Position	t (s)	x (m)
A	0	30
B	10	52
C	20	38
D	30	0
E	40	-37
F	50	-53

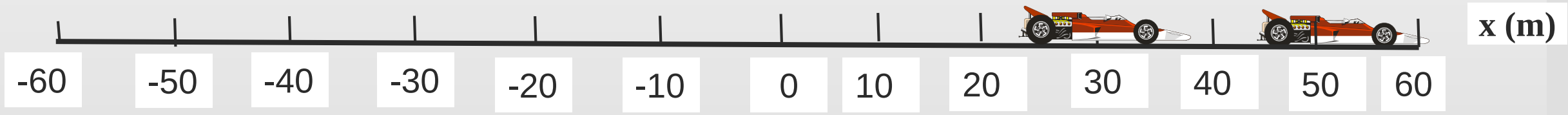
Example

The car moves to the east from position A to B



$t_A = 0$ A

$t_B = 10$ s B



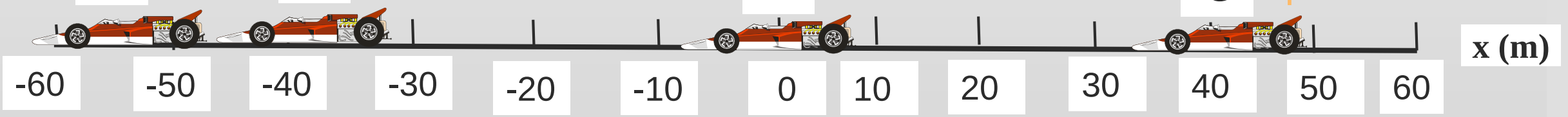
$t_F = 50$ s F

$t_E = 40$ s E

$t_D = 30$ s D

$t_C = 20$ s C

The car moves to the west from position C to F

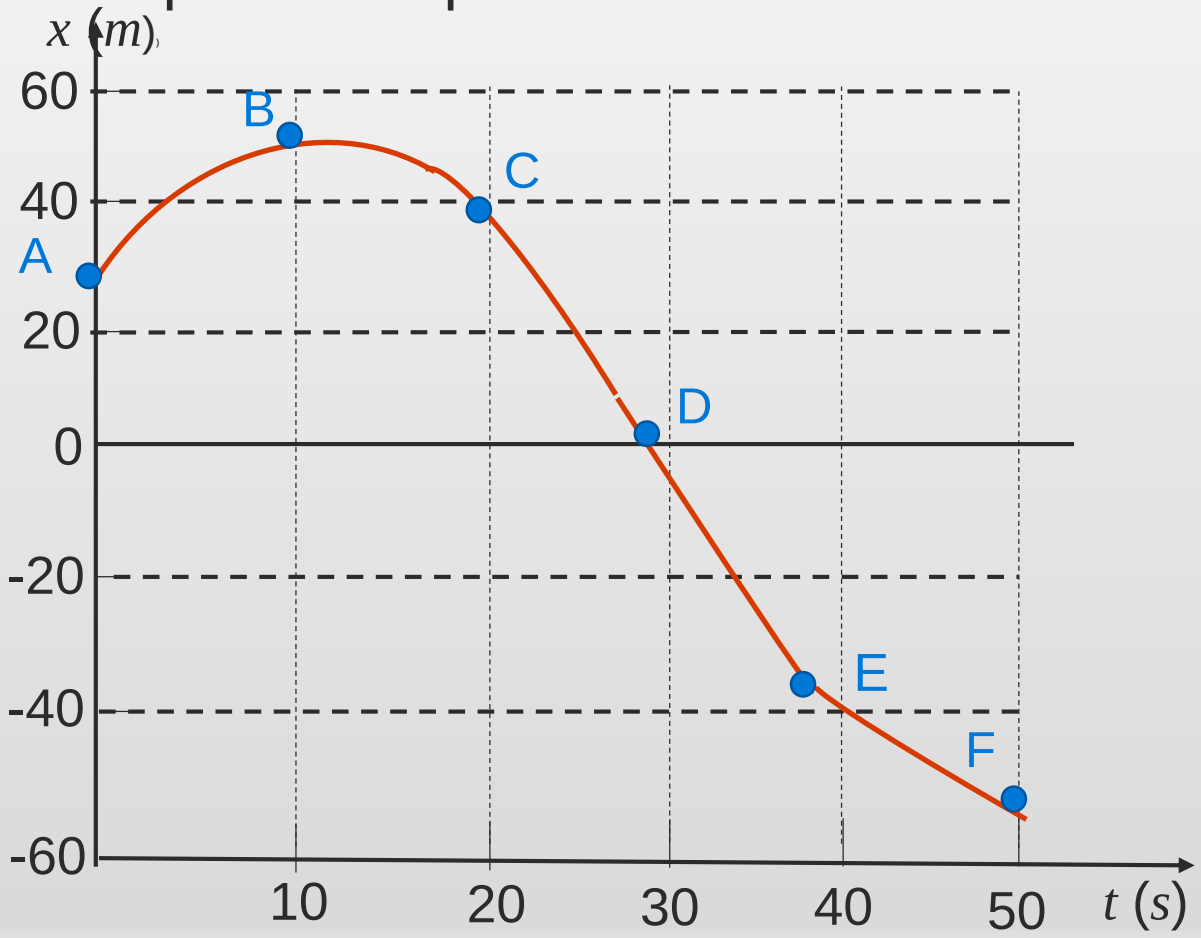


Finding Distance and Average Speed

(a) Find the distance from point A to point F.

(b) Find the average speed as car moves from point A to point F.

Position	$t\ (s)$	$x\ \ (m)$
A	0	30
B	10	52
C	20	38
D	30	0
E	40	-37
F	50	-53



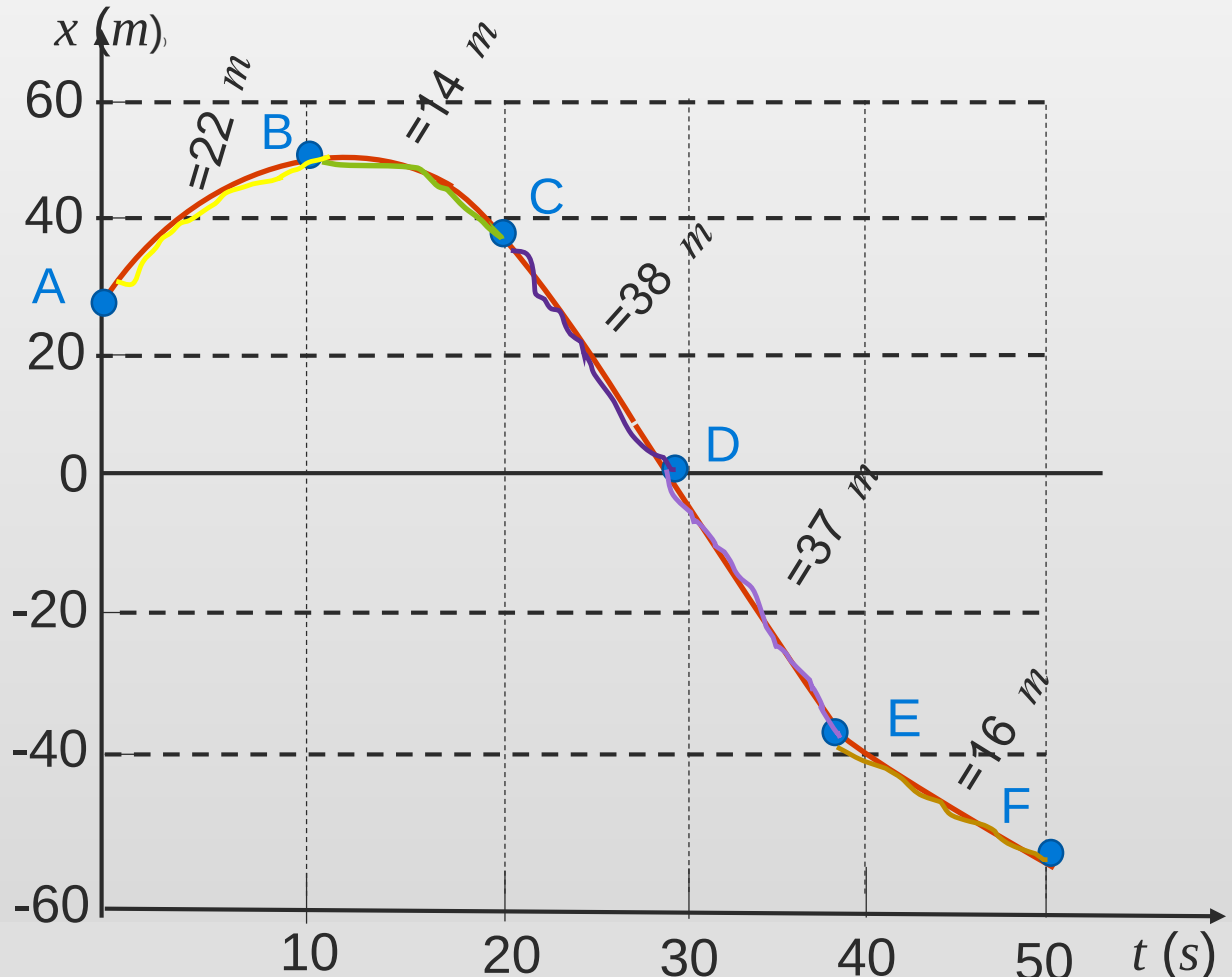
Finding Distance and Average Speed

Solution:

(a) The distance from point A to point F is the sum of distances shown in the figure

$=22 + 14 + 38 + 37 + 16 = 127\ m$

Position	t (s)	x(m)	*distance* ,m
A	0	30	
B	10	52	AB=22
C	20	38	BC=14
D	30	0	CD=38
E	40	-37	DE=37
F	50	-53	EF=16



Note: The total distance from A to F (127 m) is different from the magnitude of displacement (83 m) from A to F. This is because the latter represents the shortest distance (straight line) between A and F.

Finding Distance and Average Speed

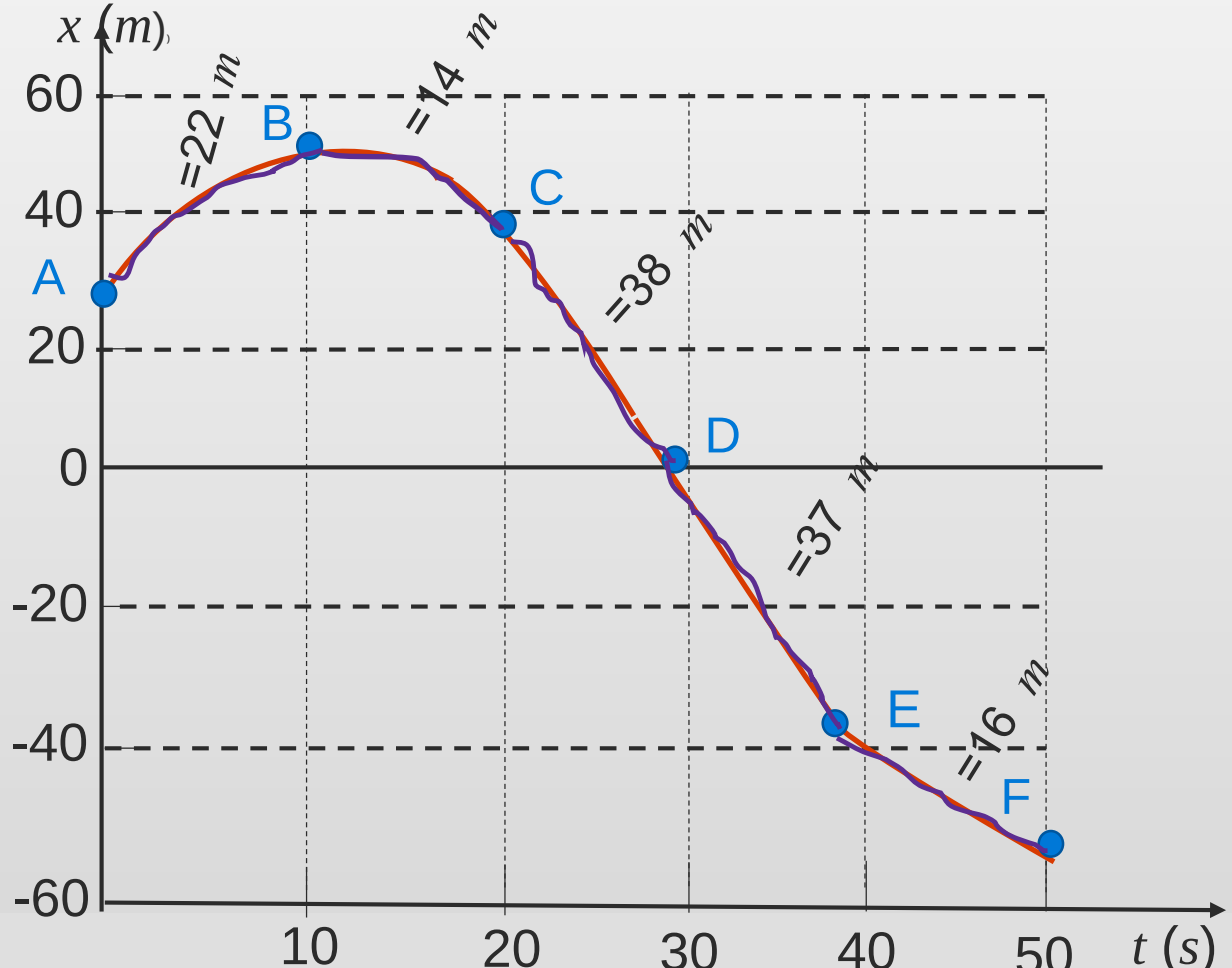
Solution:

(b) The average speed from point A to point F is total distance (127 m) divided by the total time interval needed to travel this distance (50 s)

$= 127\ m/50\ s = 2.5\ m/s$

Position	$t\ (s)$	$x\ \ (m)$
A	0	30
B	10	52
C	20	38
D	30	0
E	40	-37
F	50	-53

Note: The average speed between any two positions for a given time interval is a scalar quantity that has a magnitude ONLY.



One Dimensional Motion:

Objective Question

One drop of oil falls down onto the road from the engine of a moving car every 5 s. The figure shows the pattern of the drops left behind on the pavement. What is the average speed of the car over this part of its motion?

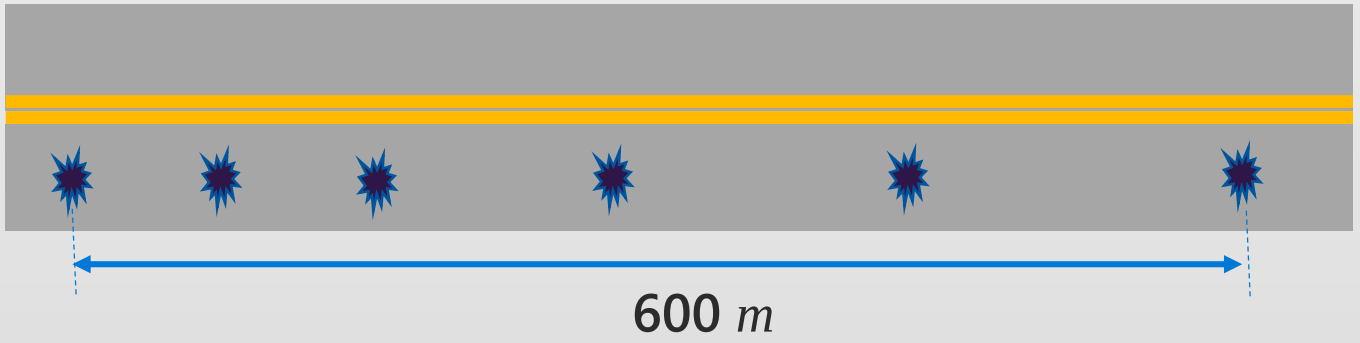
(a) 20 m/s

(b) 24 m/s

(c) 30 m/s

(d) 100 m/s

(e) 120 m/s



One Dimensional Motion:

Objective Question

A car travels from point A to point B a distance of 1500 m and then comes back to point A in a trip with time interval of 250 s. The average speed and average velocity of the car have the values

(a) zero and 6 *m/s*, respectively,

(b) 12 *m/s* and zero, respectively

(c) 12 *m/s* and 6 *m/s*, respectively.

(d) Zero and 12 *m/s*, respectively.

(e) 6 *m/s* and 12 *m/s*, respectively.