"What one man calls God, another calls the laws of physics."

-Nikola Tesla

TOPIC 2: KINEMATICS

THE ABOUT

CHAPTER ANALYSIS

TIME

- 4 **key** concepts
- Displacement, Velocity, Average Speed, Acceleration
- 2 **advanced** concepts
- Graphical Analysis, Free Fall + Terminal Velocity

EXAM

- Tested in both MCQ and Section A or B
- Important chapter that is closely linked to chapters like Force, Work Energy Power.

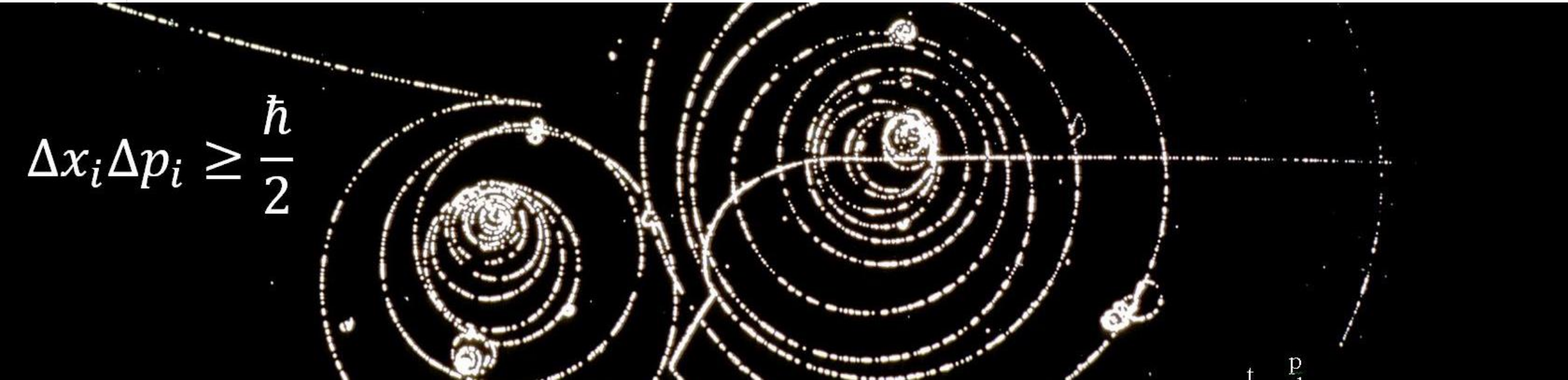
WEIGHTAGE

- Medium overall weightage
- Constitute to around **3.5%** of marks for past 5 year papers

KEY CONCEPT

TWO PHYSICAL QUANTITIES
DISTANCE
DISPLACEMENT

$$\Delta x_i \Delta p_i \geq \frac{\hbar}{2}$$



DISTANCE

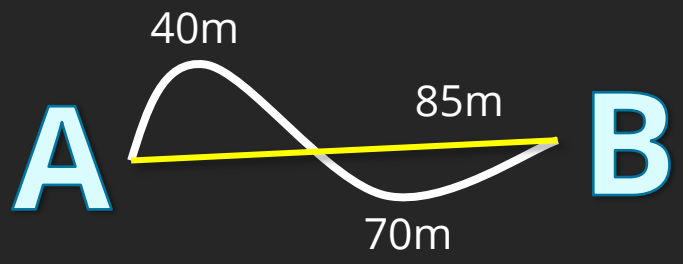
Distance is defined as the **total length travelled**, regardless of the direction of the motion.

Distance is a **scalar** quantity.

A scalar is a physical quantity that has **magnitude only**.

Unit: m

If a man walk along the curved path from point A to point B,



Total Distance:
40m + 70m = 110 m

DISPLACEMENT

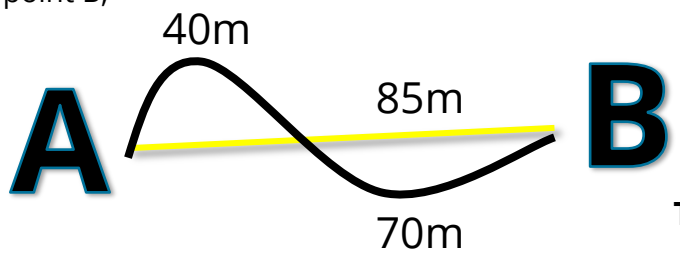
Displacement is defined as total length between the **start point** and the final **end point** of the object, taking into account the direction of the motion.

Displacement is a **vector** quantity.

A vector quantity is a physical quantity that have both **magnitude & direction.**

Unit: m

If a man walk along the same curved path from point A to point B,

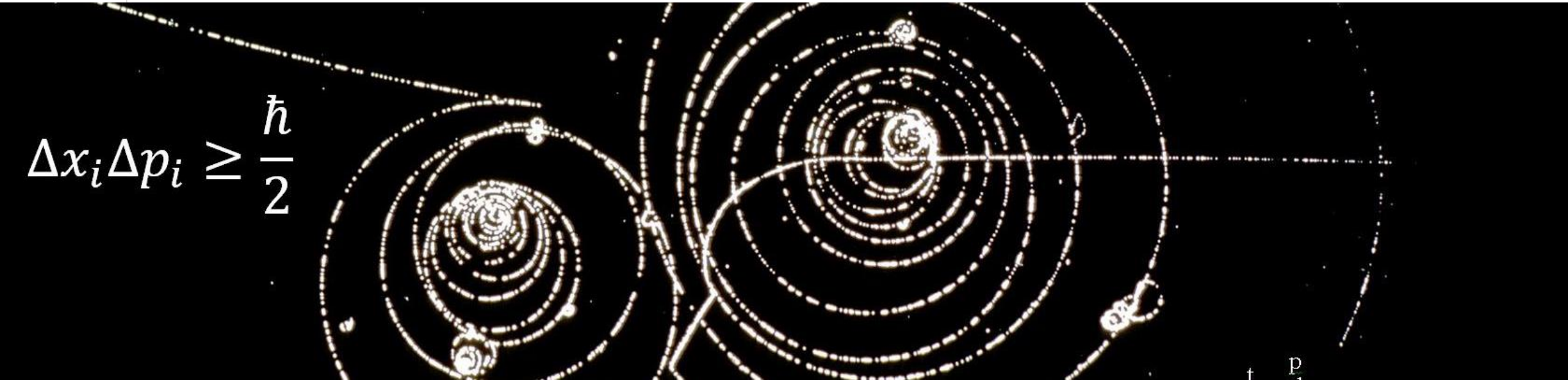


Total Displacement:
85 m

So even though the man had travelled 110m, his displacement is only effectively 85m.

KEY CONCEPT

TWO PHYSICAL QUANTITIES
SPEED
VELOCITY



SPEED

Speed is defined as the **rate of change of distance** with respect to time.

Speed is a **scalar** quantity & has no direction.

Unit: ms^{-1}

VELOCITY

Velocity is defined as the **rate of change of displacement** with respect to time.

Velocity is a **vector** quantity, that have both **magnitude & direction.**

Unit: ms^{-1}

EXAMPLE

Amy & David walk towards each other. Taking the direction to the left as positive,

Amy, 25s

Amy's speed:
100m / 25s = 4 ms^{-1}

Amy's velocity:
100m / 25s = **4 ms^{-1}**

David, 30s

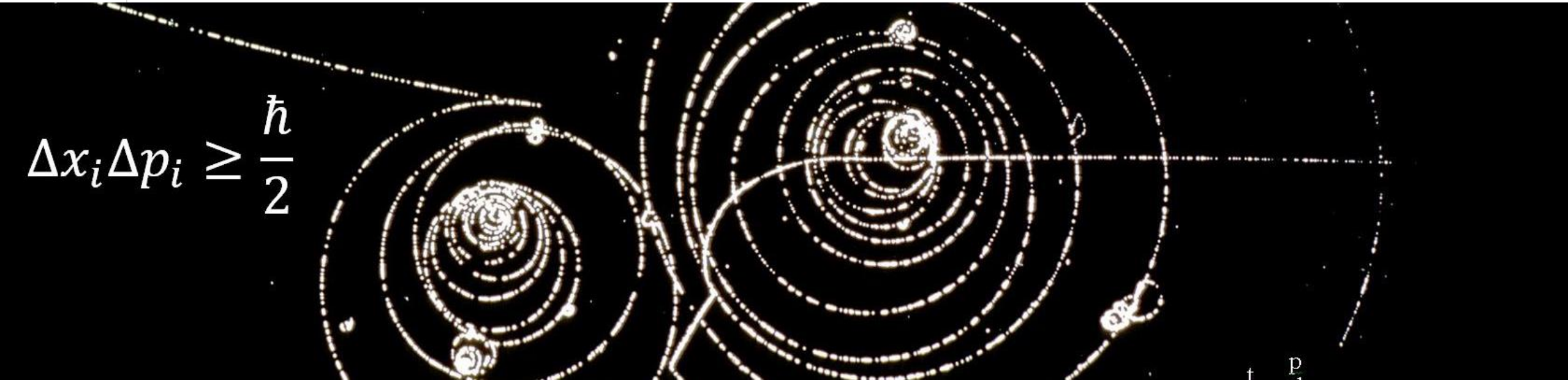
David's speed:
120m / 30s = 4 ms^{-1}

David's velocity:
-120m / 30s = **-4 ms^{-1}**

When calculating velocity, always take into account the direction!

ADVANCED CONCEPT

AVERAGE SPEED ACCELERATION



Average Speed

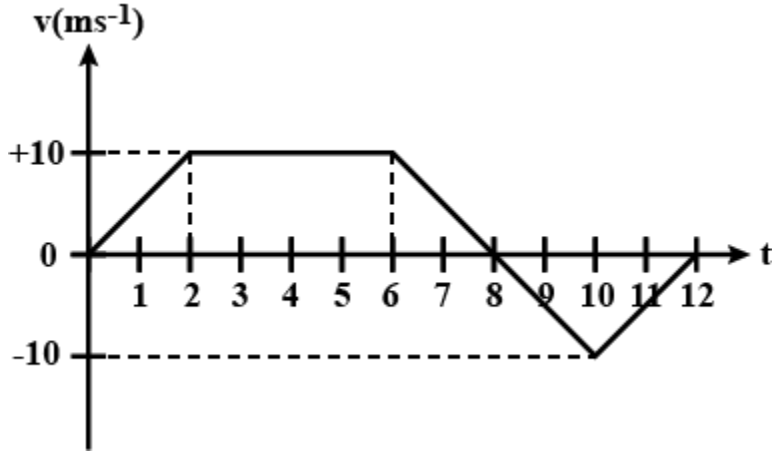
Average speed is the total distance travelled over a period of time.

Formula:

Average Speed = Total Distance / Total Time

Instantaneous speed is the speed at a specific point in time.

Average Speed Question



What is the average speed of the car?

Total Distance = Area under graph
= (½ x 2 x 10) + (4 x 10) + (½ x 2 x 10) + (½ x 4 x 10)
= 80m

Average speed = 80m / 12s
= 6.67 ms^{-1}

*Area of graph in negative region is in the **reverse direction**!

What is the average velocity of the car?

Total Displacement = area under graph
= (½ x 2 x 10) + (4 x 10) + (½ x 2 x 10) - (½ x 4 x10)
= 40m

Average velocity = 40m / 12s
= 3.33 ms^{-1}

What is the instantaneous speed of the car at 1s?

The instantaneous speed of the car at 1s is 5 ms^{-1} .

Acceleration

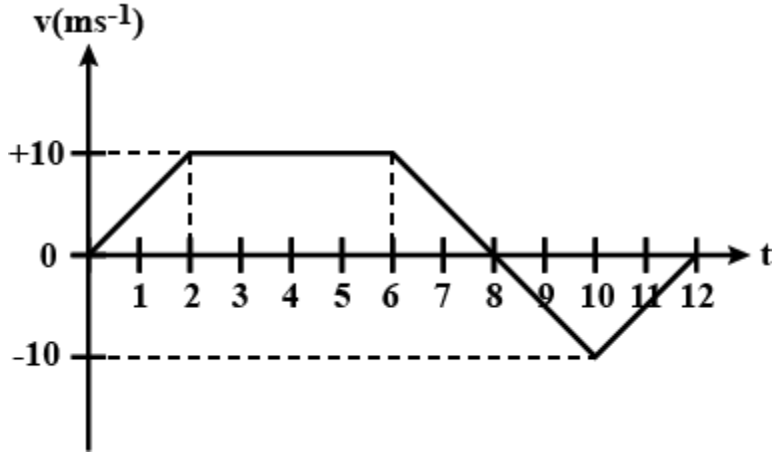
Acceleration is the **rate of change of velocity** with respect to time.

Formula:

Acceleration = Change in velocity / time

a = (v-u) / t

Acceleration Question



What is the acceleration of the car in the first 2 seconds?

Acceleration = (v-u) / t
= (10-0) / 2
= 5.0 ms^{-2}

What is the acceleration of the car between 2s - 6s?

The car is travelling at constant velocity, hence there is no acceleration.

Describe what is happening to the car from 6s to 12s.

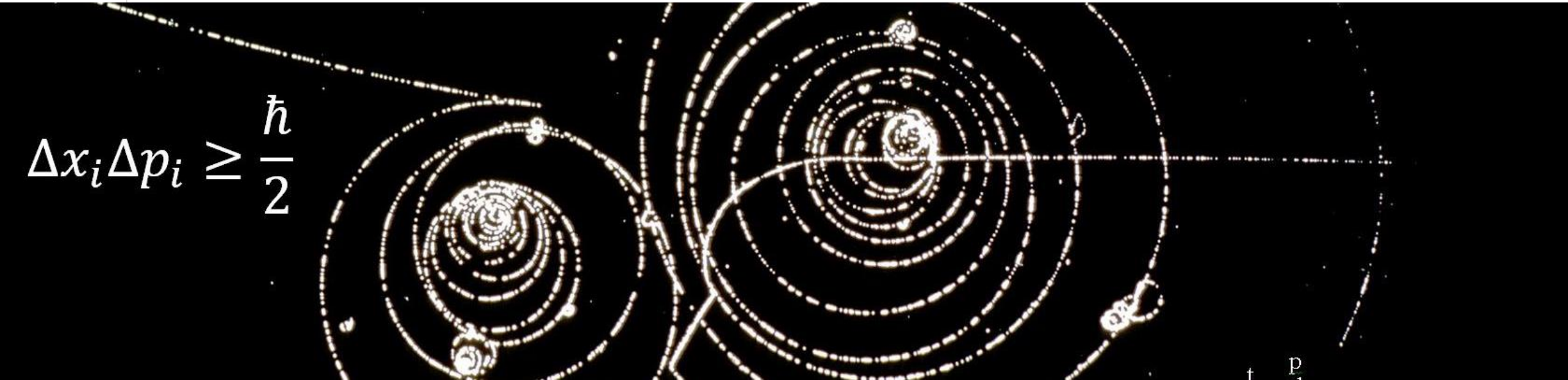
From 6s to 8s, the car starts to decelerate, reducing its velocity from 10ms^{-1} to 0ms^{-1}.

At the 8s mark, the car is at rest momentarily before moving in the opposite direction. As it is reversing, it speeds up to reach -10ms^{-1}.

At 10s, the car slows down while traveling in the opposite direction before coming to rest at 12s.

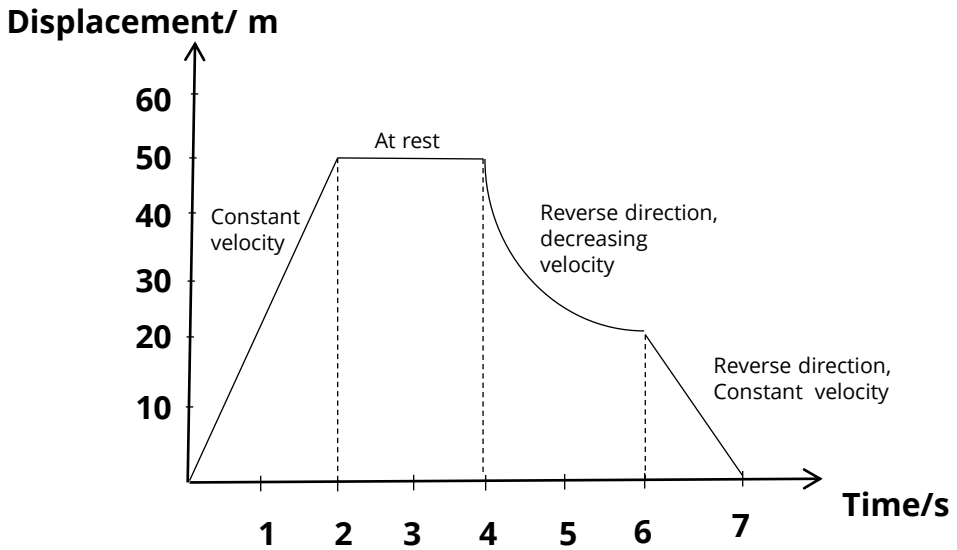
KEY CONCEPT

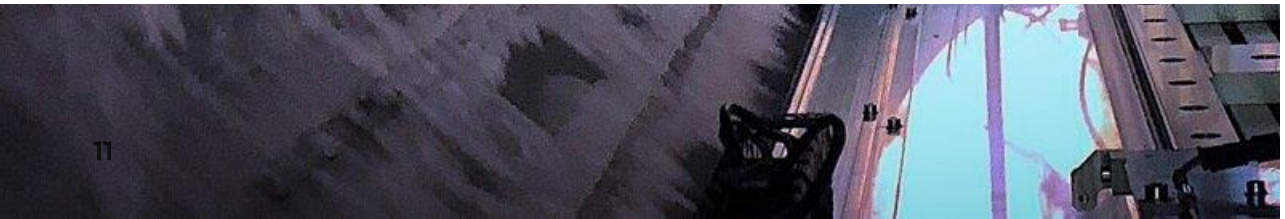
GRAPHICAL ANALSIS
DISPLACEMENT-TIME GRAPH
VELOCITY-TIME GRAPH



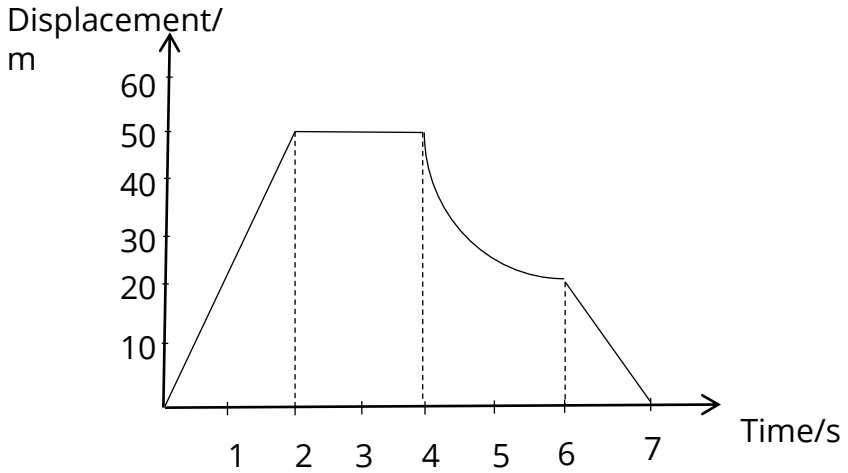
Displacement-time graph

Gradient represents **velocity** (change in displacement per unit time).





Displacement-Time Graph Question



What is the velocity of the car in the first 2s?

Velocity = gradient
= (50-0) / 2
= 25 ms^{-1}

What is the average speed of the car?

Average speed = Total Distance / Total Time
= (50m + 50m) / 7s
= 14.29 ms^{-1}

What is the average velocity of the car?

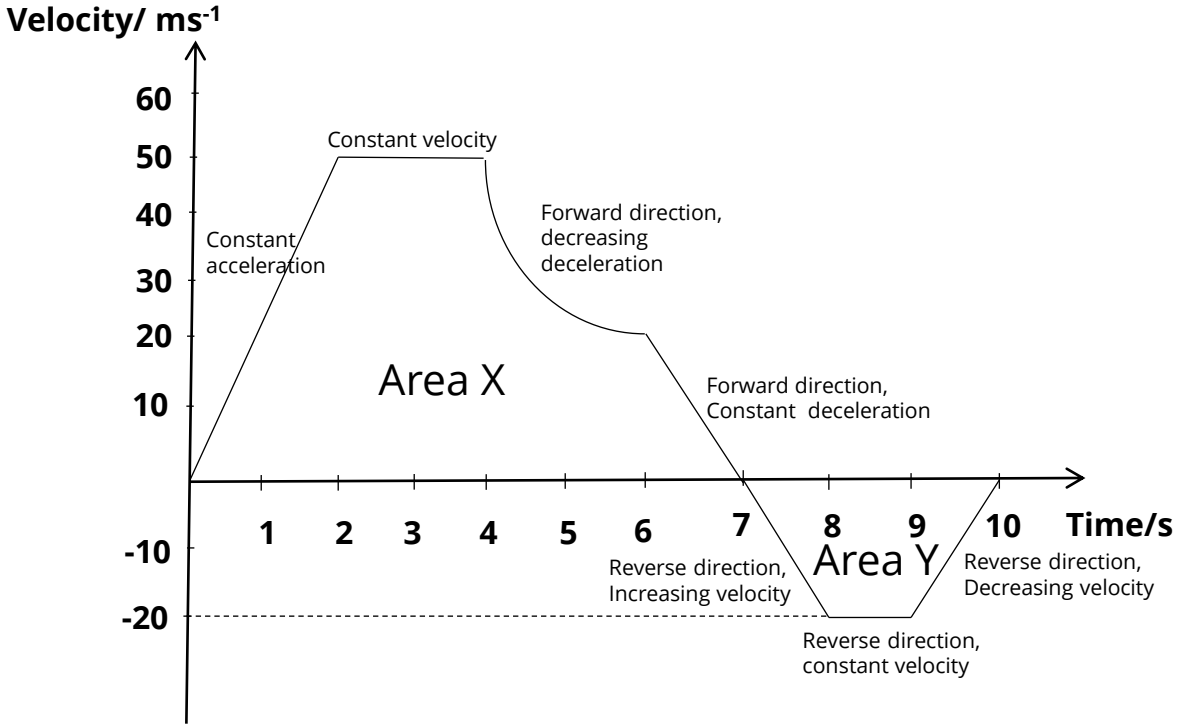
Average speed = Total Displacement / Total Time
= 0m / 7s
= 0 ms^{-1}

By referring to the Y-axis, at the end of the journey at 7s, the car's displacement is at 0m.

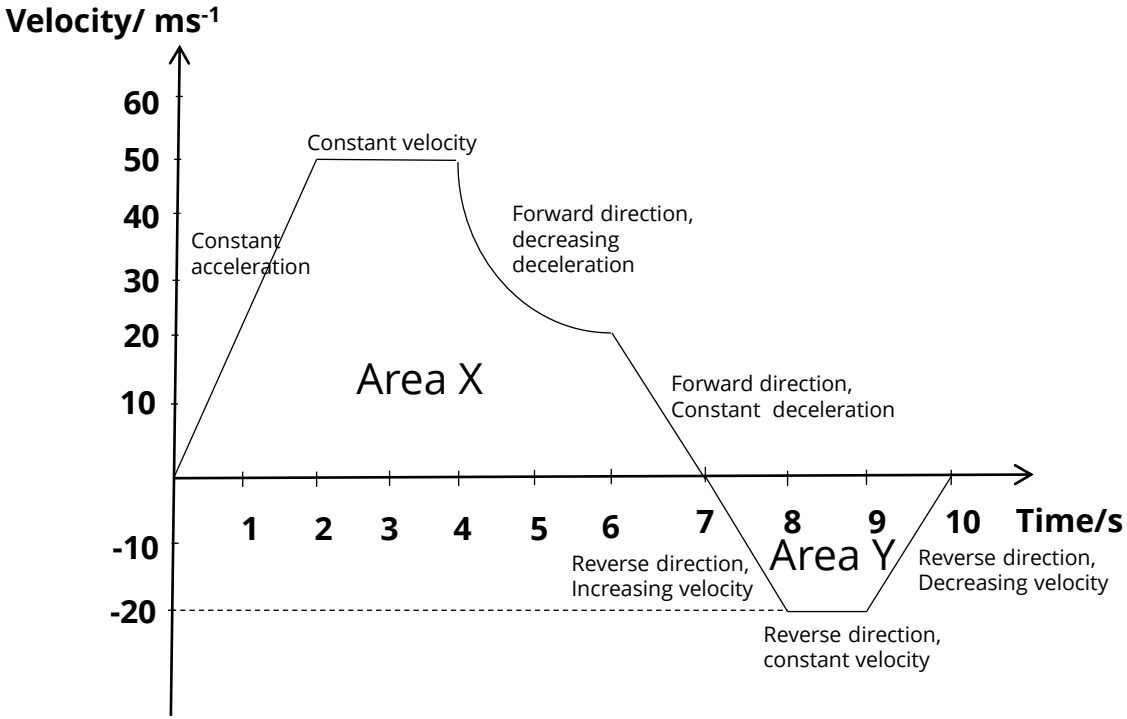
Velocity-time graph

Gradient represents **acceleration** (change in velocity per unit time).

Area underneath velocity-time graph represents **displacement.**



Velocity-Time Graph Question



What is the average velocity of the car?

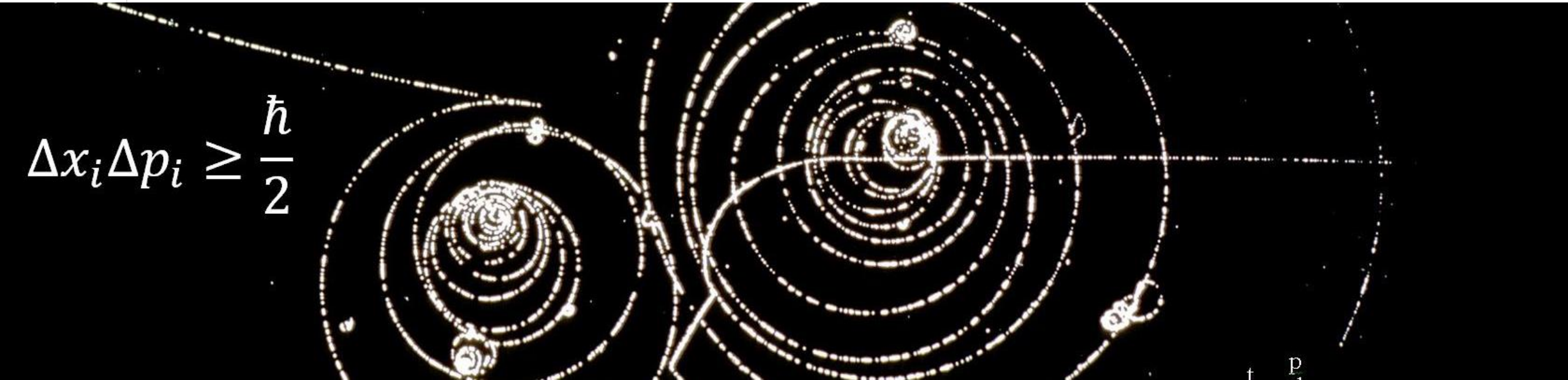
Average velocity = Total Displacement / Total time
= *Area X* – *Area Y* / time

What is the average speed of the car?

Average speed = Total Distance / Total Time
= *Area X* + *Area Y* / time

ADVANCED CONCEPT

Acceleration of free fall, g
Air Resistance

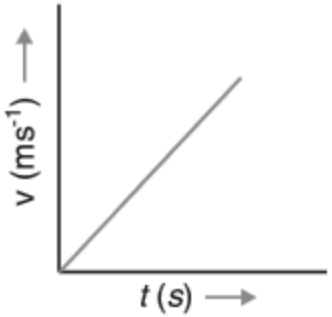


Acceleration of free fall

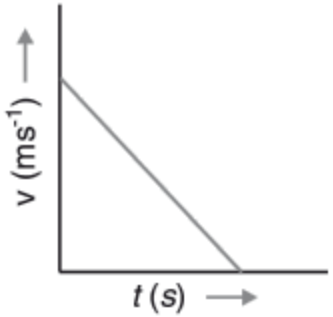
As all objects have mass, they will experience a **gravitational force**. Free fall occurs when an object falls under the sole influence of gravity (no air resistance).

$g = 10 ms^{-2}$

For object falling in mid-air,



For object thrown vertically upwards,



Air Resistance

Air resistance is a **frictional force** that **opposes the motion** of moving objects due to collision with air particles present in the air.

For any object travelling in a non-vacuum, it will experience air resistance as the object will collide with air particles.

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