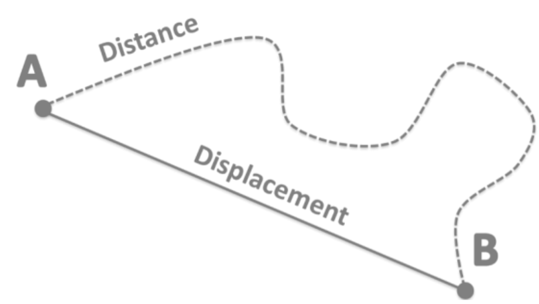
SUPER PHYSICS

Chapter 2 Notes

Kinematics

Physical Quantities

- **Scalars**
    - Has only magnitude (length, mass, time, speed, distance, etc.)
    - Kinematics: Only positive values are possible
- **Vector**
    - Has both magnitude and **direction** (velocity, displacement, acceleration, etc.)
    - Requires a defined origin and a defined positive direction
- **Distance**
    - Scalar
    - SI Unit: Meter
    - Length covered by a moving body
- **Displacement**
    - Vector
    - SI Unit: Meter
    - Straight-line distance covered by a moving body measured from a **reference point** in a stated direction



Difference between **speed** and **velocity**:

Speed

- Scalar
- SI Unit: Meter per second
- Distance moved per unit time

Velocity

- Vector
- SI Unit: Meter per second
- Rate of change of displacement
- Direction of Motion (arrows!)

Chapter 2: Kinematics

Quantities	Type	Symbol	Unit
Distance	Scalar	d	m
Displacement	Vector	s	m
Speed	Scalar	v	$m\ s^{-1}$
Velocity	Vector	u (initial), v (final)	$m\ s^{-1}$
Acceleration	Vector	a	$m\ s^{-2}$
Time	Scalar	t	s

Average Speed

- Total distance divided by total time taken

Average Velocity

- Change in **displacement** (final - initial) divided by change in time (final minus initial)
- $\triangle s$ represents change in position (length and direction from origin to final position)

Chapter 2: Kinematics

Cheryl runs once around a 0.25km track in 2.0min and comes back to her starting position. What is the magnitude of her average speed?

Average Speed
= d/t

= 0.25km/2min

= 250m/120s

= 2.08m s^{-1} [write out if using later]

= 2.1m s^{-1} (2 s.f.)

Acceleration

- Vector
- SI Unit: Meter per second per second (ms^{-2})
- Rate of change of velocity (final minus initial speed, and time)
- $\triangle v/\triangle t$ or $v_f - v_i/t_f - t_i$
- $v = u + at$ where a = acceleration, v = final velocity, u = initial velocity

Velocity of a body changes from 2.50m s^{-1} to 6.75m s^{-1} in 3.00s. Determine its acceleration.

Acceleration
= $\triangle v/\triangle t$

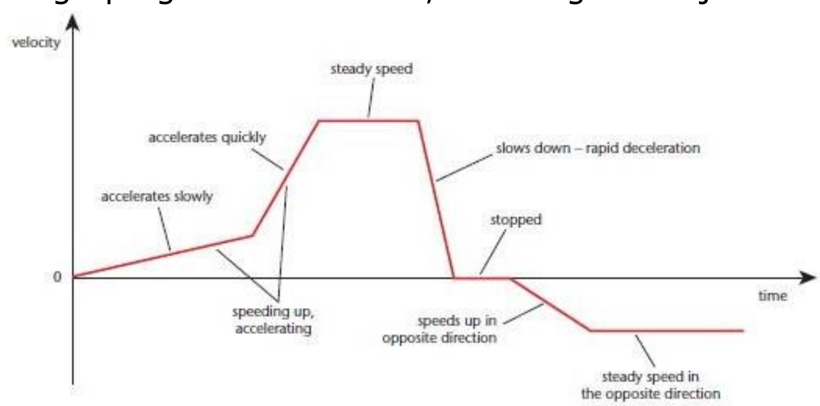
= (6.75 - 2.50)m s^{-1}/3.00s

= 1.42m s^{-2} (3s.f.)

Chapter 2: Kinematics

Velocity-Time Graphs

- When an object **gains speed**, the acceleration has the **same sign** and direction as the velocity (graphs = <)
    - Positive velocity and positive acceleration
    - Negative velocity and negative acceleration
- When an object **slows down**, the acceleration has the **opposite sign** and direction as the velocity (graphs = >)
    - Positive velocity and negative acceleration
    - Negative velocity and positive acceleration
    - The graph gets **closer to 0**, meaning the object slows down



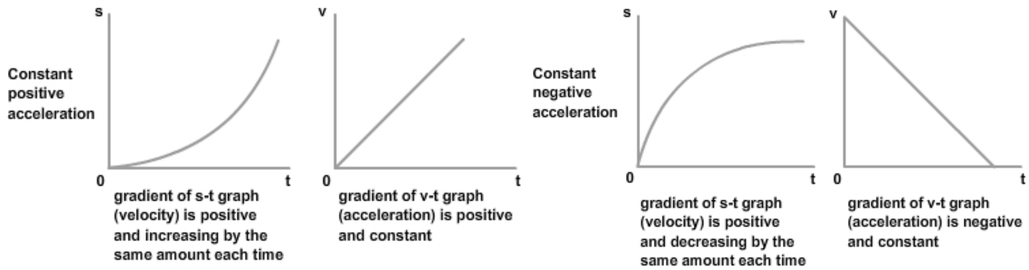
Signs of Velocity and Acceleration

- Case 1: Speeding up → v(+) a(+) $v_f > v_i$ = a(+)
- Case 2: Slowing down → v(+) a(-) $v_f < v_i$ = a(-)
- Case 3: Speeding up (opp. Dir.) ← v(-) a(-) $-v_f > -v_i$ = a(-)
- Case 4: Slowing down (opp. Dir.) ← v(-) a(+) $-v_f < -v_i$ = a(+)

Chapter 2: Kinematics

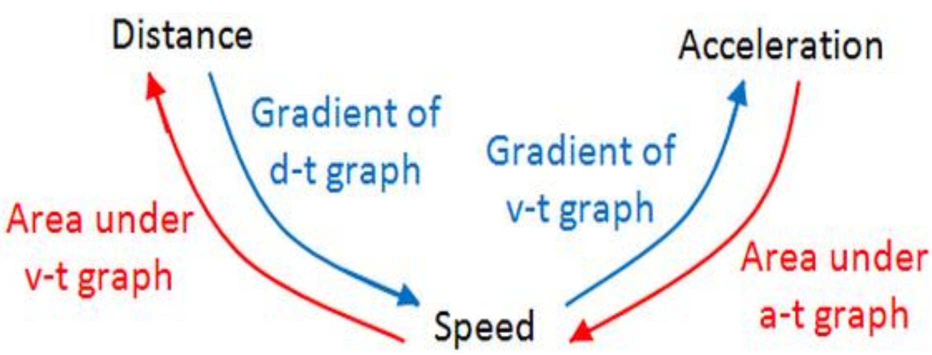
Displacement-Time Graphs

- Constant Displacement: v = 0m s^{-1}
- Increasing Velocity: Gradient increases (ref. graph below)
- Decreasing Velocity: Gradient decreases (ref. graph below)



- Displacement/Distance
  = Area under velocity/speed-time graph

  = Area of triangle/square
- Instantaneous Velocity/Speed
  = Gradient of displacement/distance-time graph
- Instantaneous Acceleration
  = Gradient of velocity-time graph



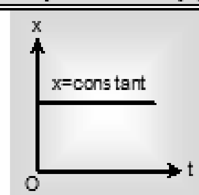
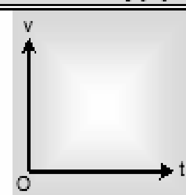
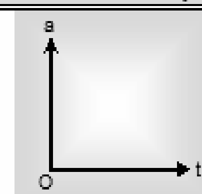
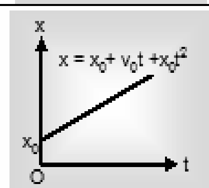
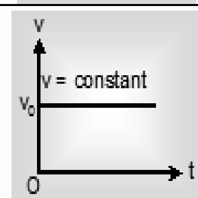
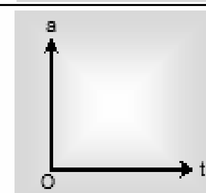
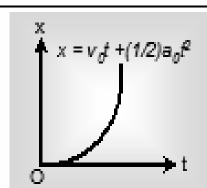
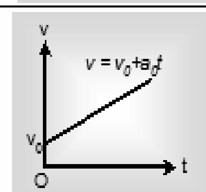
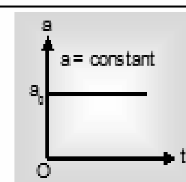
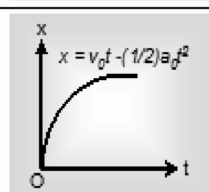
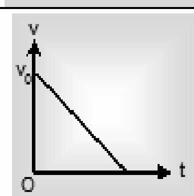
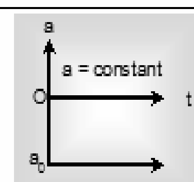
Chapter 2: Kinematics

'Describe Motion' Questions

- Divide the graph into sections based on the shape of the graph
- X moves in the positive / negative **direction** from reference point / from point… to… at a constant / increasing / decreasing **speed** of __ms^{-1} from **t** = **__s to t** = **__s**

Relationships between Graphs

- A curved velocity-time or speed-time graph means acceleration is increasing or decreasing (non-uniform) at a constant rate.

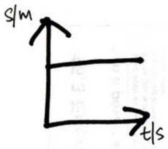
	Displacement(x)	Velocity(v)	Acceleration (a)
a. At v=0;			
b. Motion with constant velocity			
c. Motion with constant acceleration			
d. Motion with constant deceleration			

Chapter 2: Kinematics

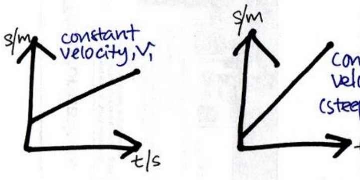
Distance-Time Graph
(s) (t)

gradient = velocity

velocity = $\frac{\text{distance}}{\text{time}}$



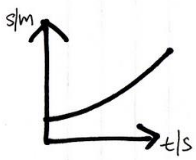
gradient = 0
∴ velocity = 0
stationary (distance remains unchanged over time)



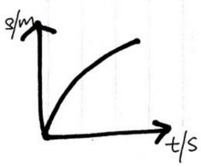
constant velocity, V_1

constant velocity, V_2 (steeper slope)

$V_2 > V_1$



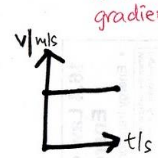
increasing velocity (increasing gradient)



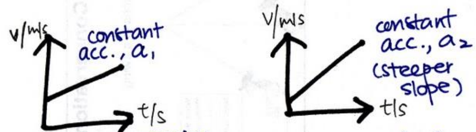
decreasing velocity (decreasing gradient)

Velocity-Time Graph
(v) (t)

area under graph = distance travelled
gradient = acceleration



velocity is constant
acceleration = 0

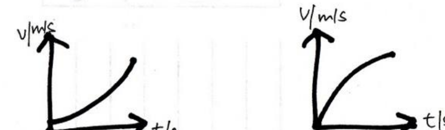


constant acc., a_1

velocity increasing linearly

constant acc., a_2 (steeper slope)

$a_2 > a_1$

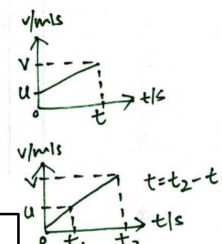


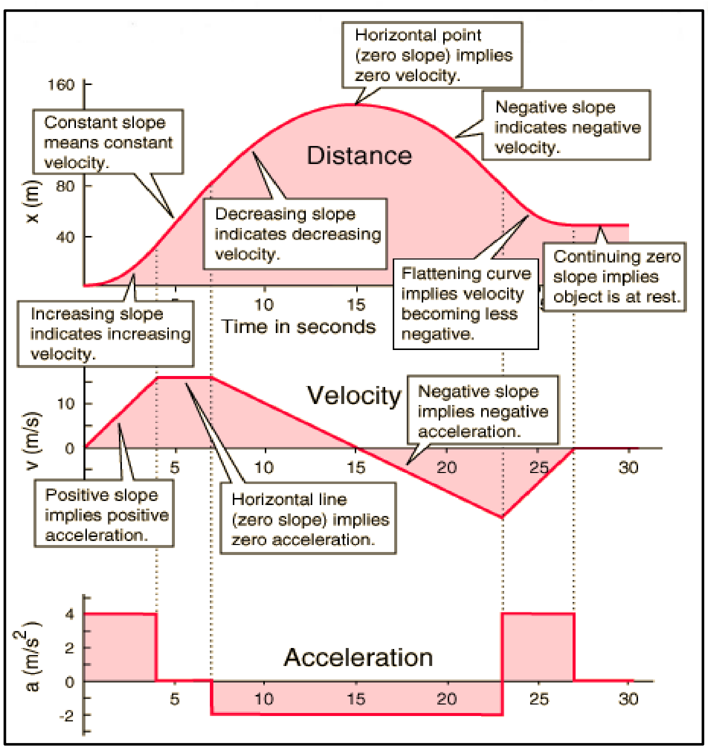
increasing acceleration

decreasing acceleration

$a = \frac{v-u}{t}$

v = final velocity
u = initial velocity
t = time taken





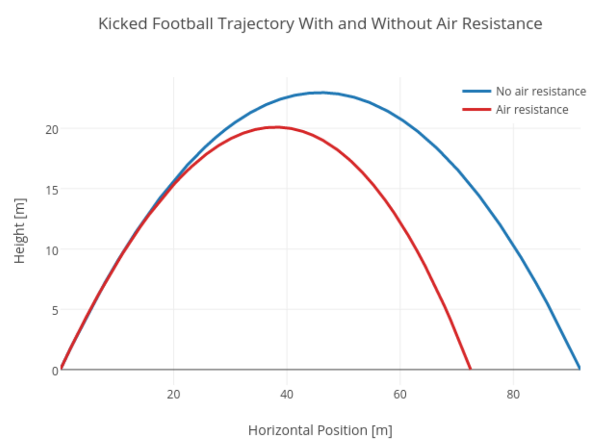
Chapter 2: Kinematics

Acceleration of Free Fall on Earth:

- About $10ms^{-2}$
    - Objects falling with negligible air resistance
    - If air resistance is present, objects fall with a constant speed

Air resistance:

- Opposes the motion of moving object
- Increases with the speed of the object
- Increases with surface area
- Increases with density of air
    - With air resistance, it will reach **TERMINAL VELOCITY**



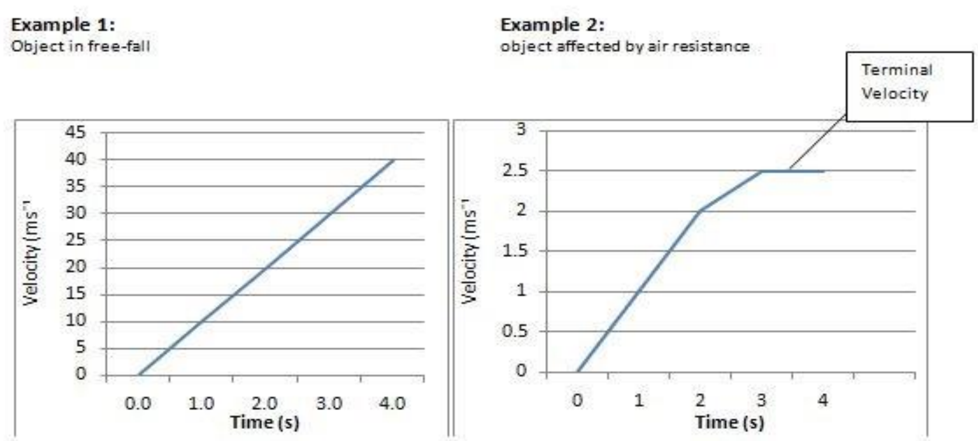


Figure 2.1.1 – air resistance in a velocity time graph