
Acceleration of free fall:

- An object that is moving only under the influence of gravity is said to be under free fall.
- Free falling objects accelerate at a constant rate.
- The acceleration due to gravity is approximately 10m/s
- Under free fall, objects reach the earth at the same time , irrespective of their masses; if dropped from the same height above the earth's surface because the acceleration of free fall is constant.
- A non zero resultant force acts on a free falling object that has just been released.

FALLING OBJECTS ARE AFFECTED BY TWO TYPES OF FORCES:

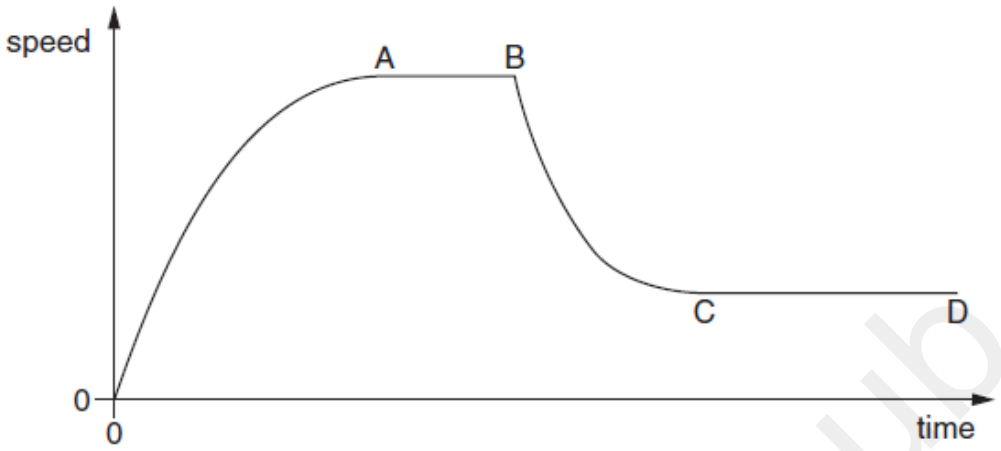
1. **The weight of the object:** This is a force acting downwards, caused by the object's mass being pulled by the Earth's gravitational field.
2. **Air resistance:** This is a frictional force acting in the opposite direction to the movement of the object.

THE ACT OF FALLING OF OBJECTS CAN BE CATEGORISED INTO 3 STAGES BEFORE IT HITS THE GROUND:

1. At the start, the object accelerates downwards because of its weight. There is no air resistance. There is a resultant force acting downwards.
2. As it gains speed, the object's weight stays the same, but the air resistance on it increases. There is a resultant force acting downwards.
3. Travelling at steady speed: Eventually, the object's weight is balanced by the air resistance. There is no resultant force and the object reaches a steady speed, called the terminal velocity.

Free fall graphs:

A parachutist jumps out of an aeroplane but does not open his parachute until some time has elapsed.



a. **The value of the acceleration immediately after he has jumped from the aeroplane is:** $10m/s^2$.
b. **The acceleration decreases until point A on the graph is reached.** This is because the graph becomes less steep (or the gradient decreases)
c. **The parachutist's speed in region AB is:** constant
d. **The forces on the parachute in the AB region:** There is no resultant force(Or upward force = downward force or weight= air resistance)
e. **The point at which the parachutist opened his parachute:** B
f. **The speed decrease from B-D because:** the air resistance is bigger than the weight because as the parachute is opened it provides a larger surface area

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APPLICATION BASED QUESTIONS

4 Two stones of different weight fall at the same time from a table. Air resistance may be ignored.

What will happen and why?

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	what will happen	why
A	both stones hit the floor at the same time	acceleration of free fall is constant
B	both stones hit the floor at the same time	they fall at constant speed
C	the heavier stone hits the floor first	acceleration increases with weight
D	the heavier stone hits the floor first	speed increases with weight

3 A stone falls freely from the top of a cliff into the sea. Air resistance may be ignored.

Which graph shows how the acceleration of the stone varies with time as it falls?

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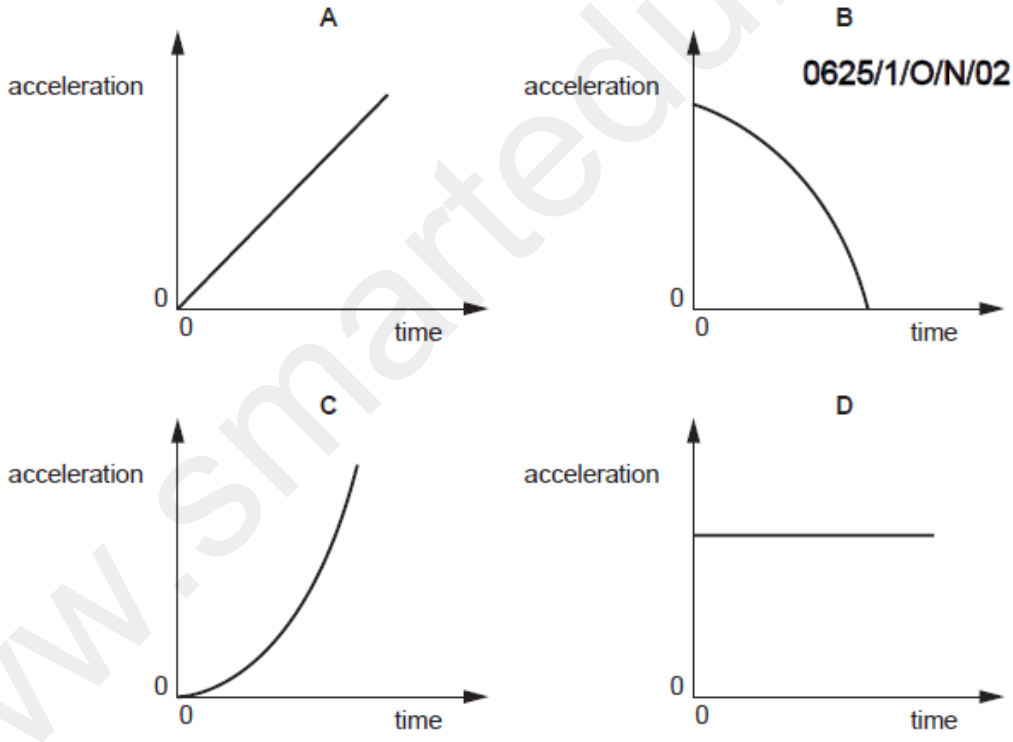


APPLICATION BASED QUESTIONS:

1 An experiment is carried out to find the acceleration of free fall.

A strip of paper is attached to a heavy object. The object is dropped and falls to the ground, pulling the paper strip through a timer. The timer marks dots on the paper strip at intervals of 0.020 s.

Fig. 1.1 shows a section of the paper strip with the first three dots marked. The first dot on the paper strip, labelled A, is marked at the instant the object is dropped.

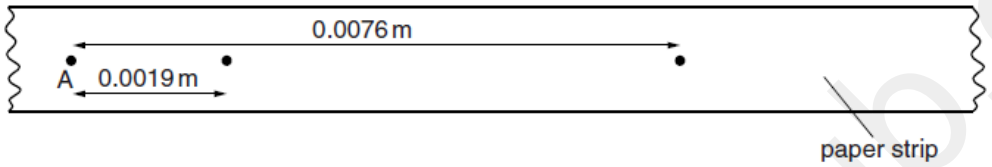


Fig. 1.1 (not to scale)

(a) State how the dots on the paper strip show that the object is accelerating.

.....

.....[1]

(b) Calculate the average speed of the object

(i) in the first 0.020 s after the object is dropped,

average speed = ...

(ii) in the second 0.020 s after the object is dropped.

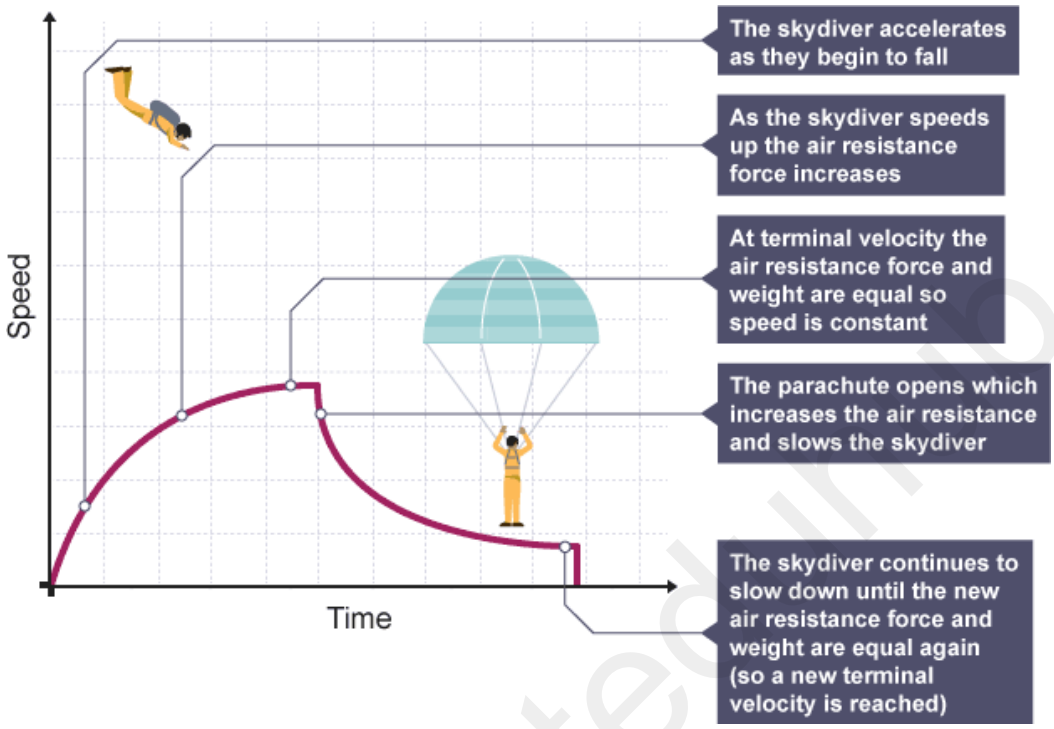
average speed = ...
[3]

(c) Use the results from **(b)** to calculate the acceleration of the falling object.

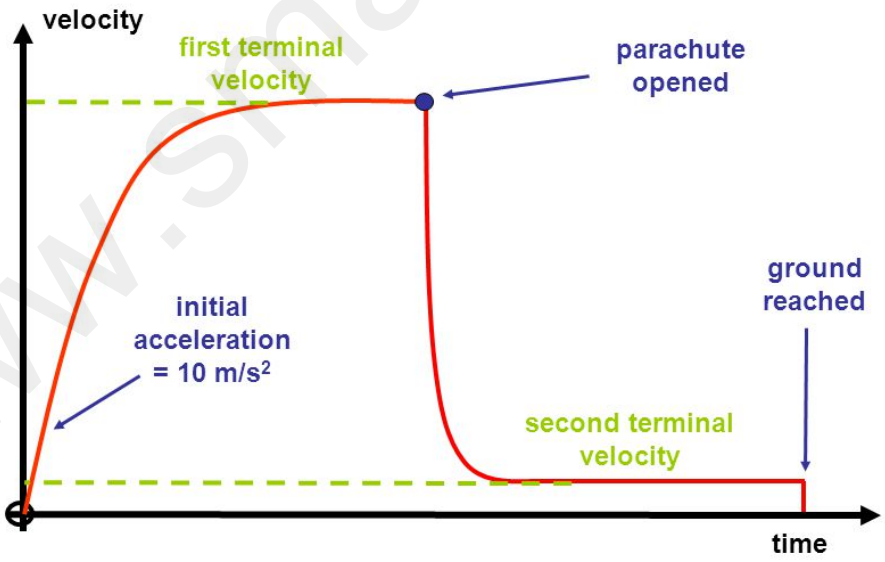
acceleration = ...[3]

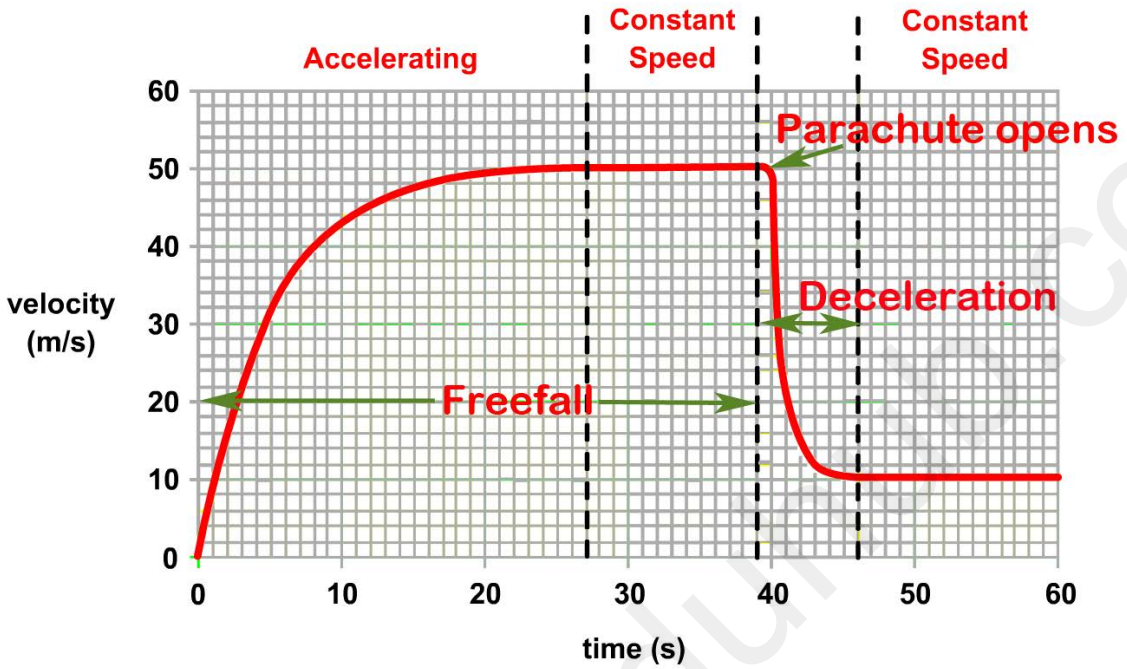
[Total: 7]

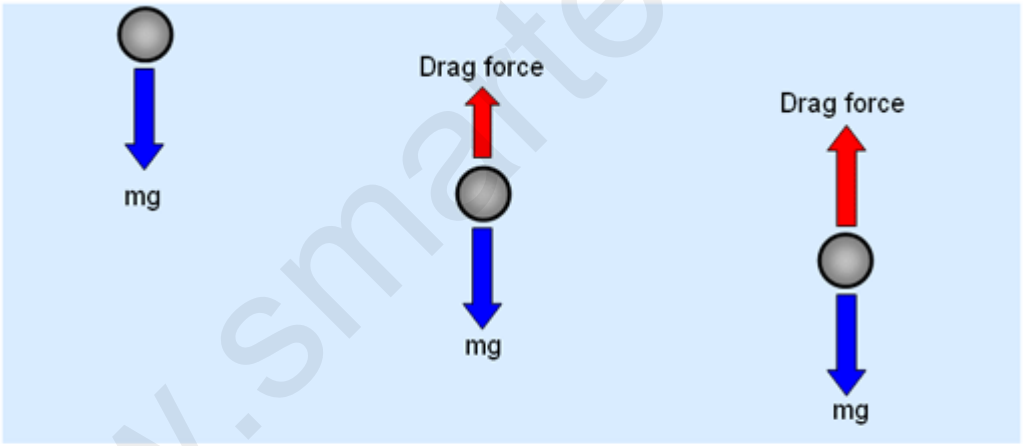
FREE FALL GRAPHS:



Velocity-time graph of a parachutist







Body released from rest

Forces on body during acceleration

Forces on body at terminal velocity

EXTENDED THEORY

1 A free-fall parachutist jumps from a helium balloon, but does not open his parachute for some time.

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Fig. 1.1 shows the speed-time graph for his fall. Point B indicates when he opens his parachute.

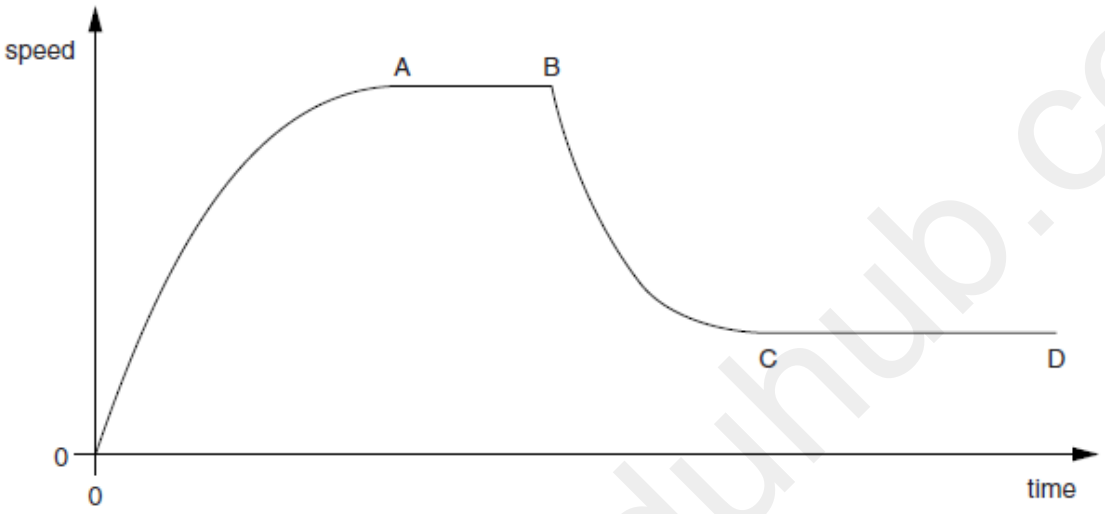

Fig. 1.1

(a) (i) State the value of the gradient of the graph immediately after time $t = 0$.

gradient = ... [1]

(ii) Explain why the gradient has this value.

.....

.....[1]

(b) State how Fig. 1.1 shows that the acceleration decreased between time $t = 0$ and the time to A.

.....

.....[1]

(c) Explain, in terms of forces, what is happening in section AB of the graph in Fig. 1.1.

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.....[2]