Topic 2: Mechanics

2.1 – GRAPHS of MOTION

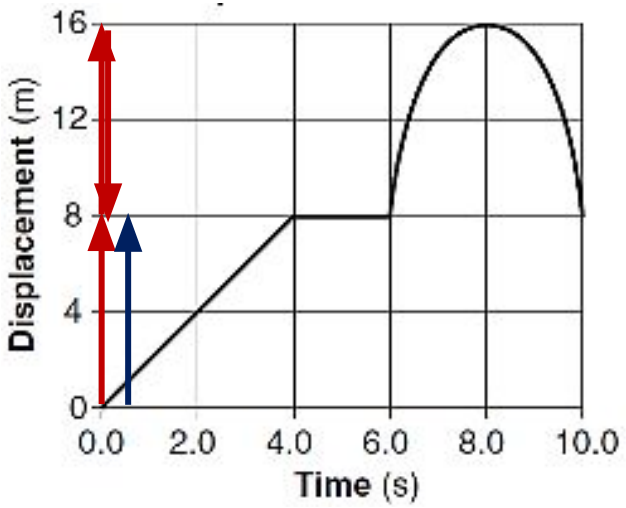
GRAPHS

What can we find from graphs of motion ?

- displacement *vs.* distance

What is:

1. the total distance travelled by the object during the 10.0 second time interval?
2. the displacement covered by the object during the 10.0 second time interval?

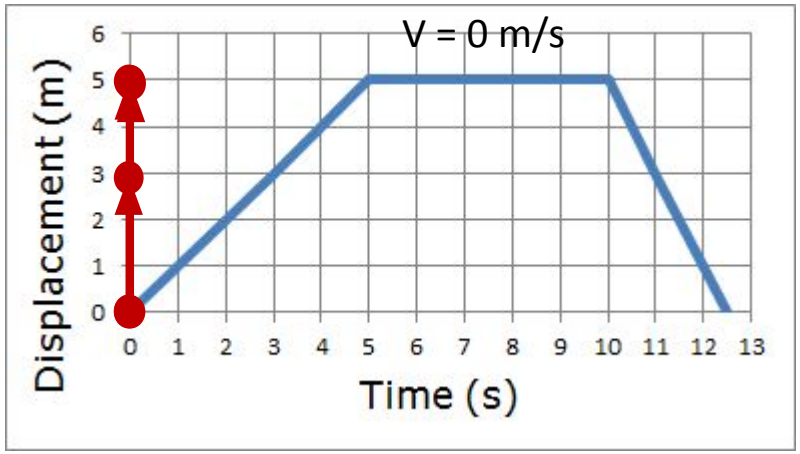


Total distance = 8m + 8m + 8m = 24 m

Displacement = 8m, away from initial position

Displacement – time graphs

- The gradient of a displacement time graph is the velocity



What is displacement at t = 0s?
What is displacement at t = 3s?
What is displacement at t = 5s?
What is displacement at t = 9s?
What is displacement at t = 13s?

Velocity and speed first 5 sec.?

Velocity and speed next 5 sec.?

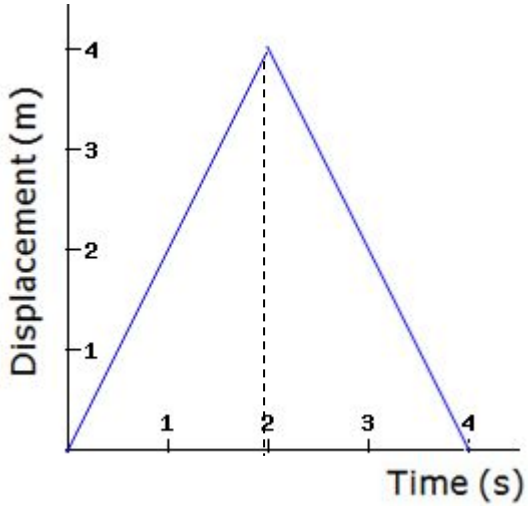
Velocity and speed last 2.5 sec.?

- first 5s at constant speed
- speed=$\frac{5}{5}$ = 1m/s
- velocity=1m/s away from initial position

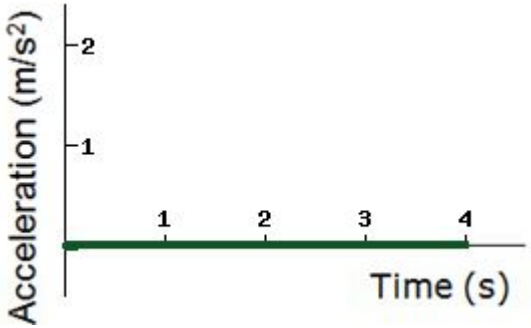
- last 2.5s at constant speed
- speed=$\frac{5}{2.5}$ = 2m/s
- velocity=1m/s toward initial position

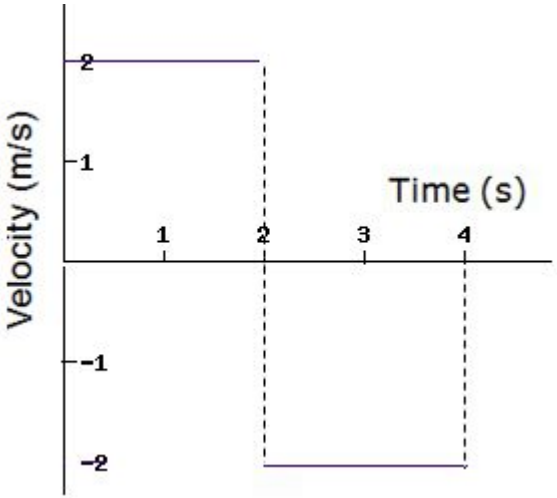
Displacement – time graphs

- The gradient of a displacement time graph is the velocity



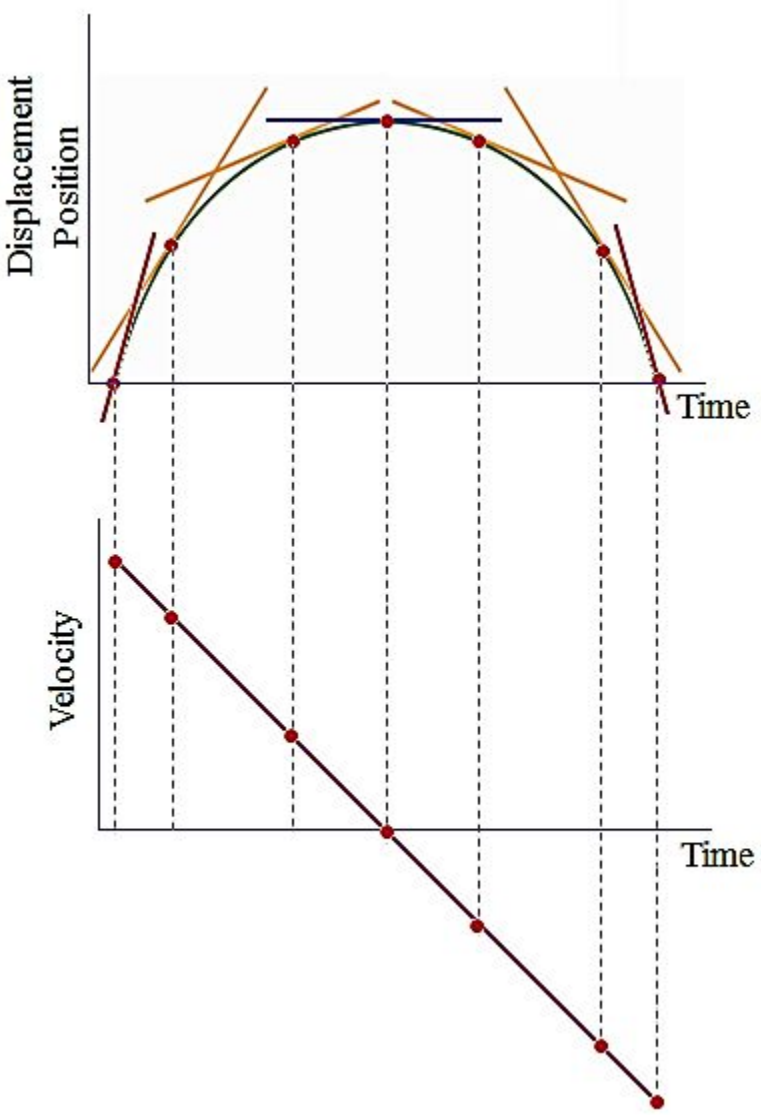
speed = 2 m/s

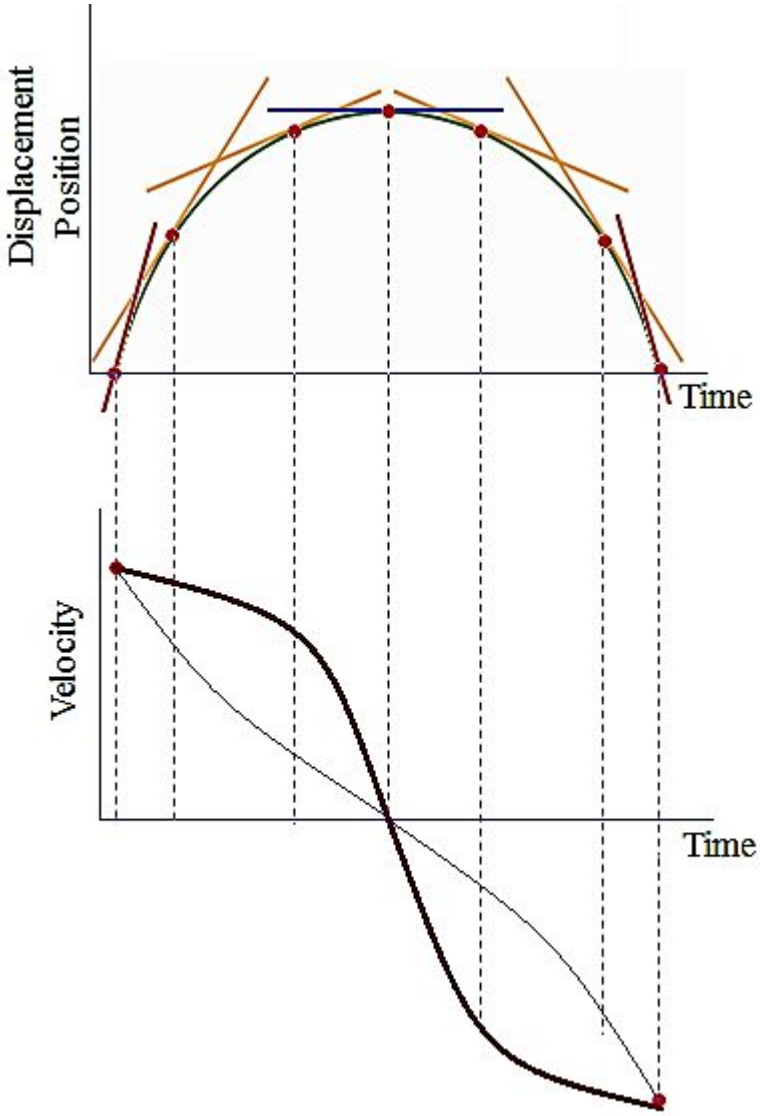




- Velocity is a slope of displacement–time graph

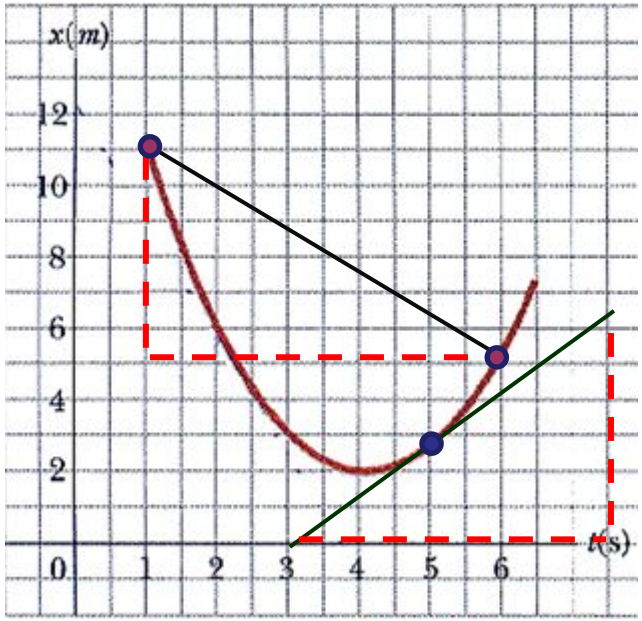
Sketch velocity vs. time graph from position vs. time graph





These two graphs for velocity are also acceptable.
The main thing is that velocity decreases all the time.

- Velocity is a slope of displacement–time graph

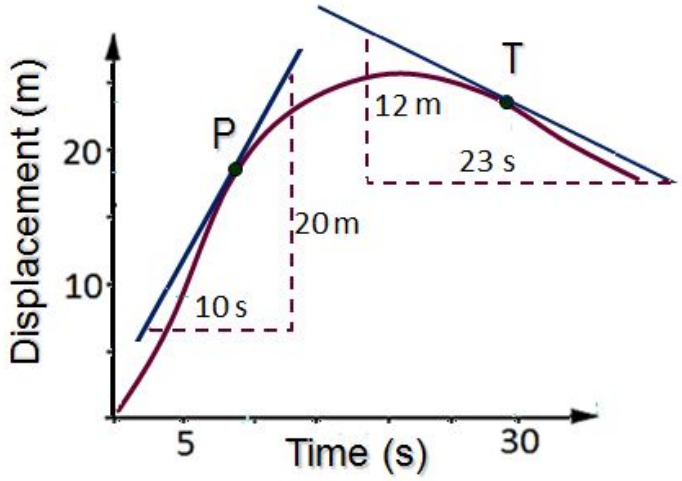


1. What is the average velocity from t = 1s to t = 6s

$$v_{avg} = \frac{5 - 11}{6 - 1} = -1.2\ m/s$$

2. What is the instantaneous velocity at t = 5s?

$$v = \frac{6.5 - 0}{7.5 - 3.1} = 1.5\ m/s$$

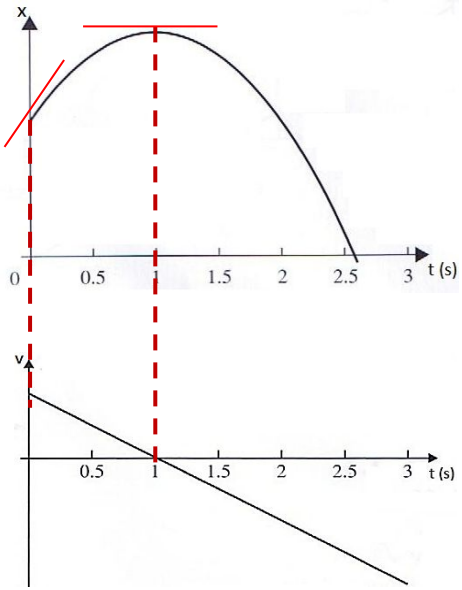


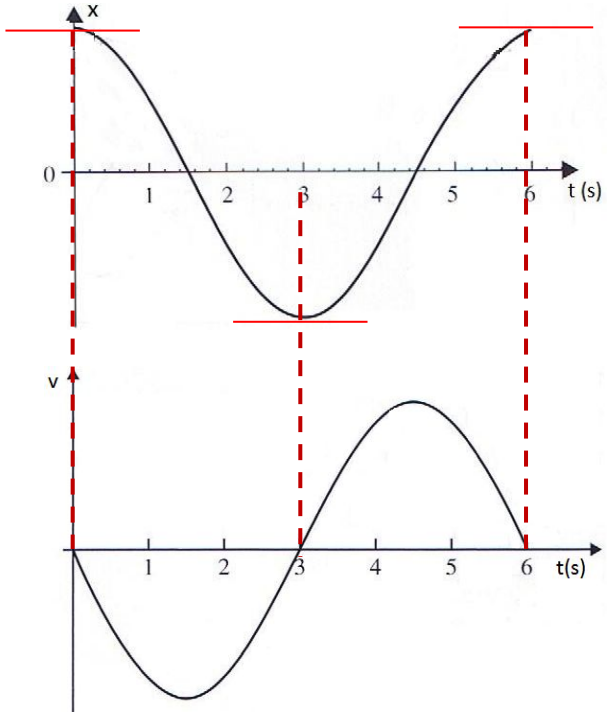
$v_P = 2\ m/s$ $v_T = -0.52\ m/s$

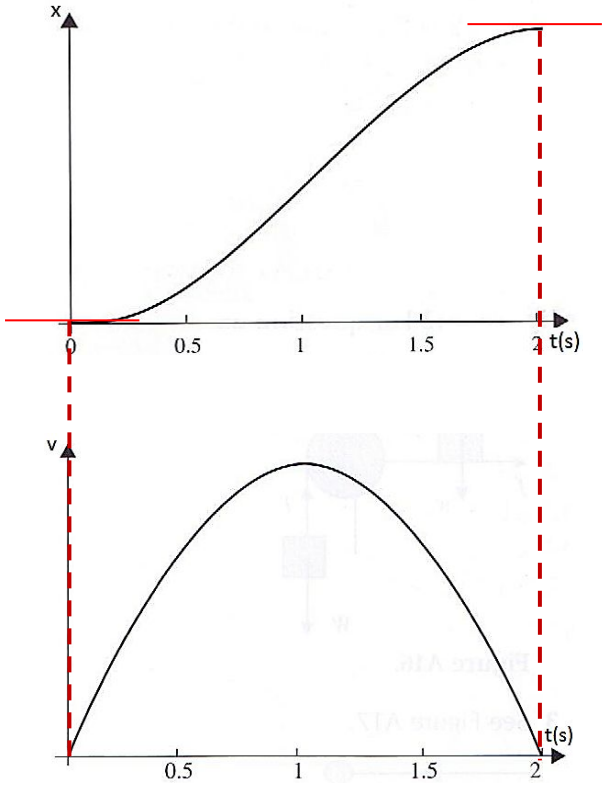
The ***instantaneous velocity*** of an object at a particular time is equal to the slope of its position vs. time graph at that time. On the other hand, the ***average velocity between*** two times is equal to the slope of the line joining the two points on the position vs. time graph.

- Velocity is a slope of displacement–time graph

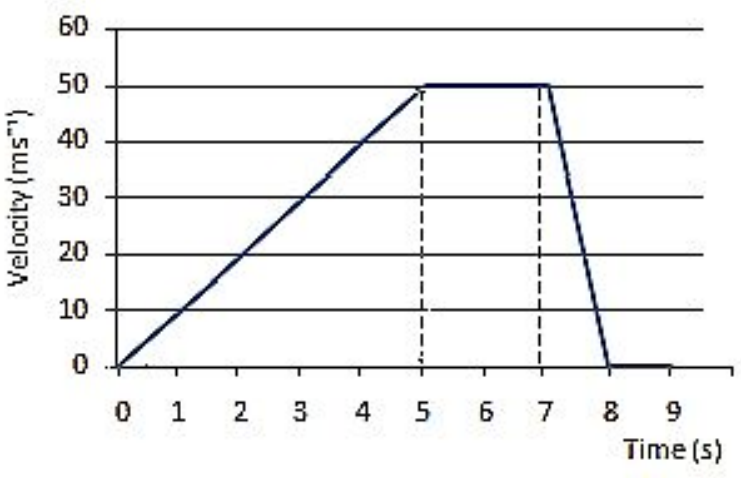
Sketch velocity vs. time graph from position vs. time graph







- The gradient of a velocity–time graph is the acceleration

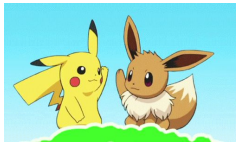


First 5 seconds:

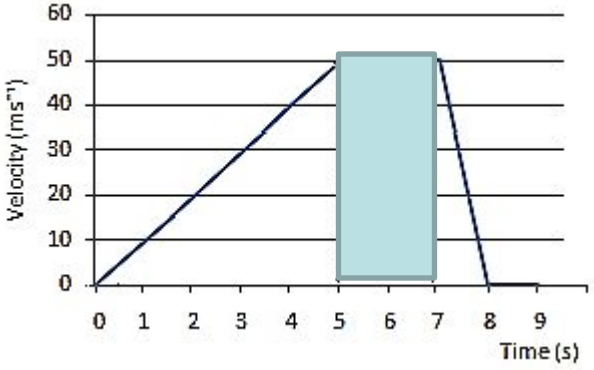
Slope of the graph $= \frac{\Delta v}{\Delta t} = \frac{v(5s)-v(0s)}{time\ interval} =$ 10 m /s^2

Acceleration $= \frac{\Delta v}{\Delta t} = \frac{v(5s)-v(0s)}{time\ interval} =$ 10 m /s^2

Conclusion:



- The area under a velocity-time graph is the displacement.

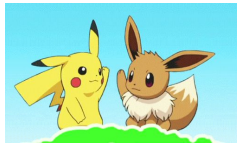


Time interval from 5s to 7s

Area = (velocity btw 5s and 7s)(time interval) = 100 m

Displacement=vt= (velocity btw 5s and 7s)(time interval) = 100 m

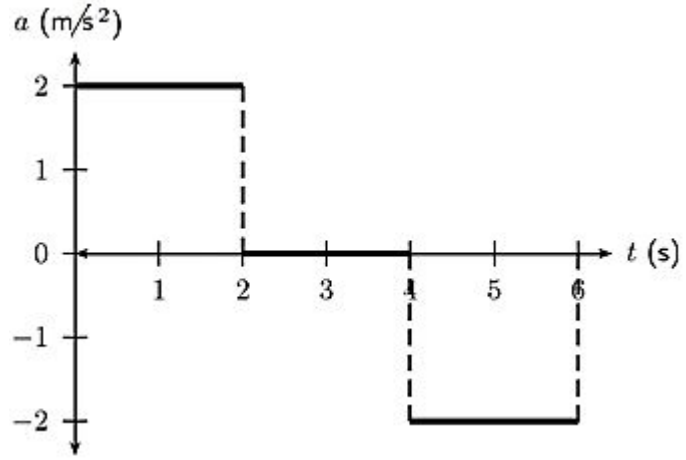
Conclusion:



During the first 5 s the object has travelled: ½ x 50 x 5 = 125m

- The area under a acceleration-time graph is change in velocity.

The acceleration vs. time graph for a car starting from **rest**. Calculate the velocity of the car and hence draw the velocity vs. time graph.

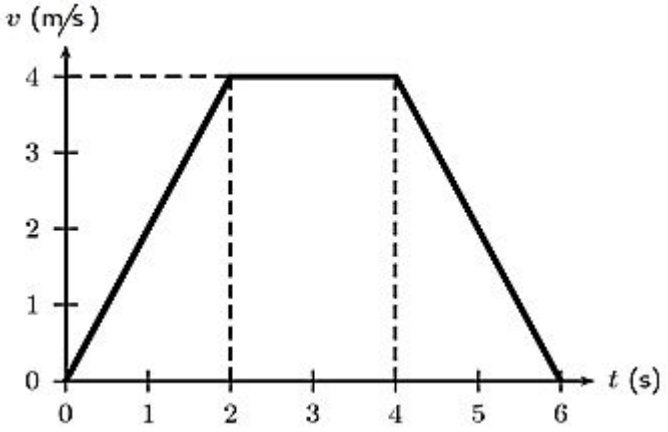


From 0 – 2 seconds:

$$\Delta v = at = \left(2\frac{m}{s^2}\right)(2s) = \frac{4m}{s} = Area$$

From 2 – 4 seconds:

$$\Delta v = at = \left(0\frac{m}{s^2}\right)(2s) = 0m/s = Area$$

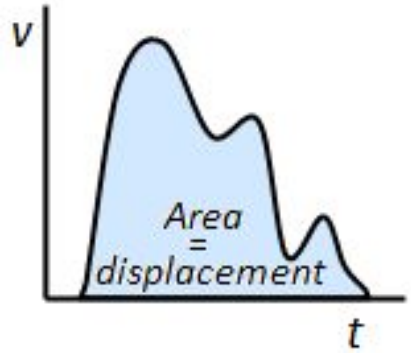


From 4 – 6 seconds:

$$\Delta v = at = \left(-2\frac{m}{s^2}\right)(2s) = -4m/s = Area$$

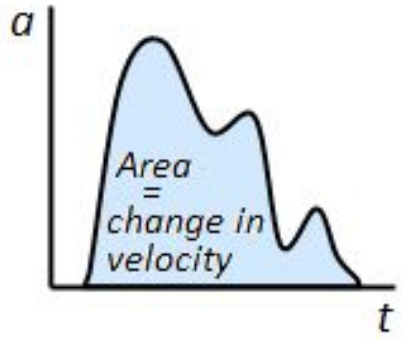
The acceleration had a negative value, which means that the velocity is decreasing. It starts at a velocity of 4 m/s and decreases to 0 m/s.

Interpreting motion graphs

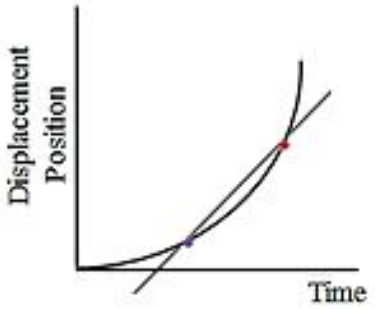


❤ The **area** under a velocity-time graph is the displacement.

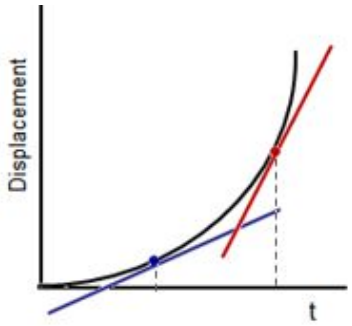
❤ The **area** under an acceleration-time graph is the change in velocity.



❤ Velocity is a **slope** of displacement – time graph.

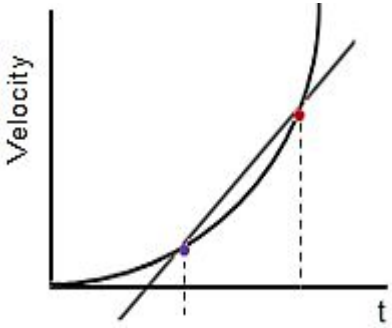


Average velocity

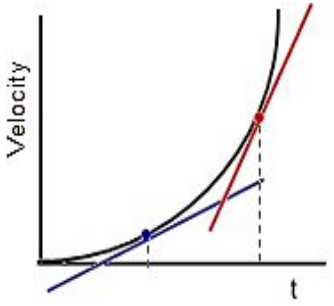


Instantaneous velocity

❤ Acceleration is a **slope** of velocity – time graph.



Average acceleration

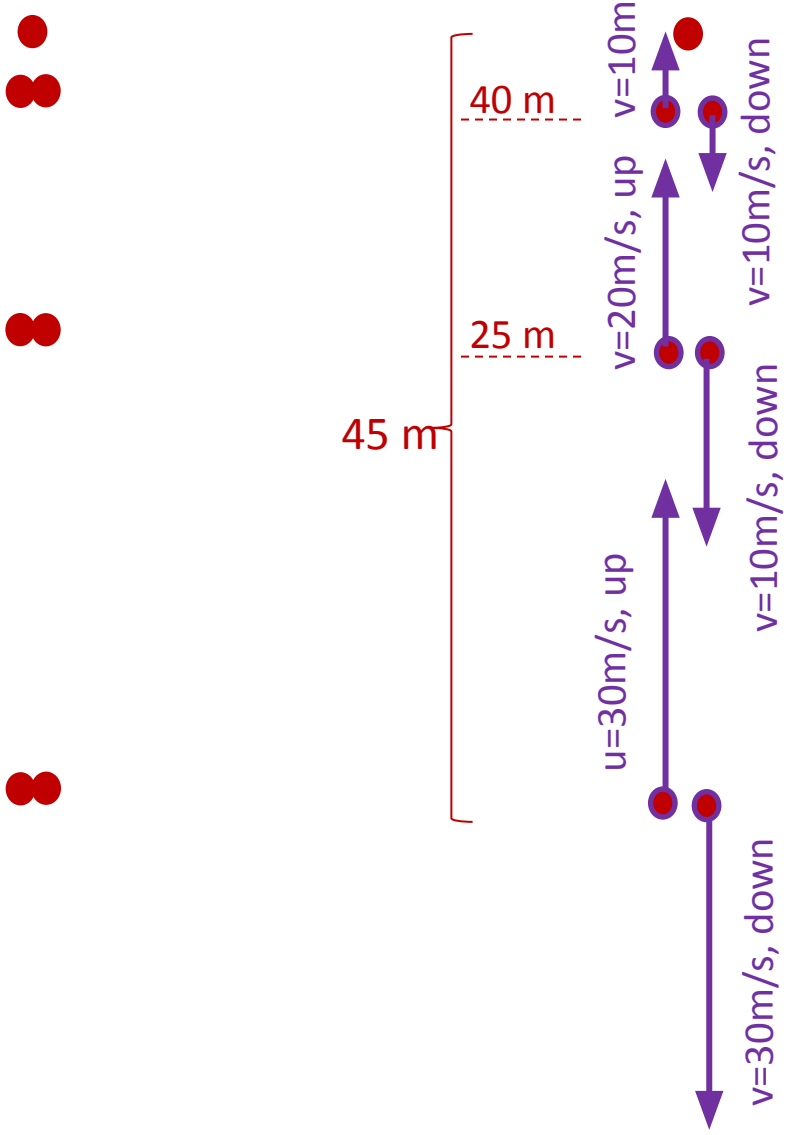


Instantaneous acceleration

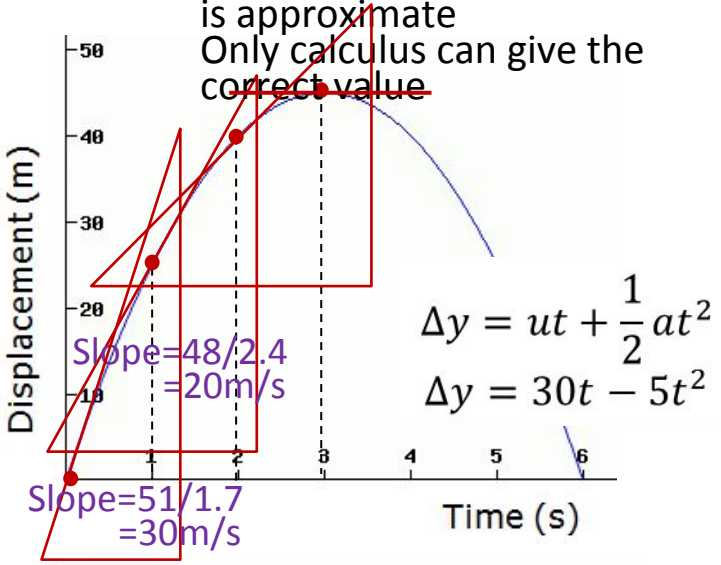
A small quiz 1

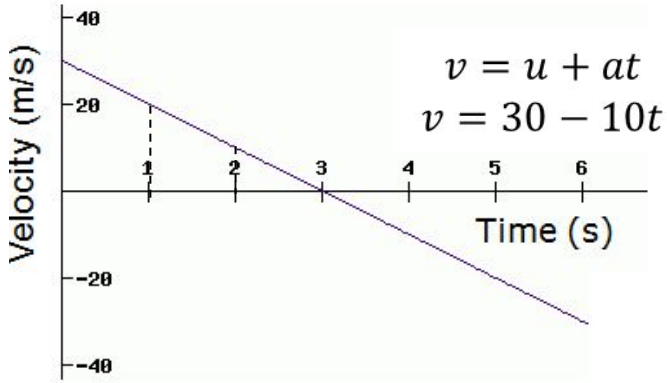
A small quiz 2

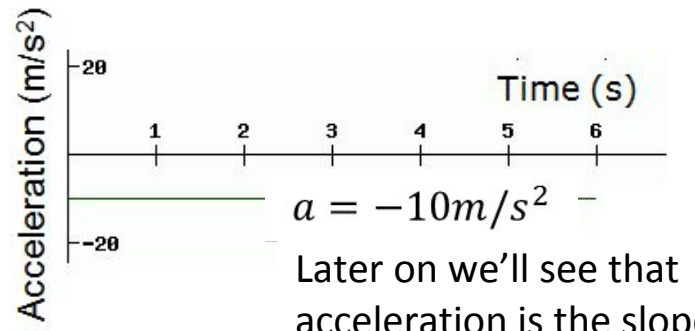
- Free fall graphs



velocity calculated this way is approximate
Only calculus can give the correct value

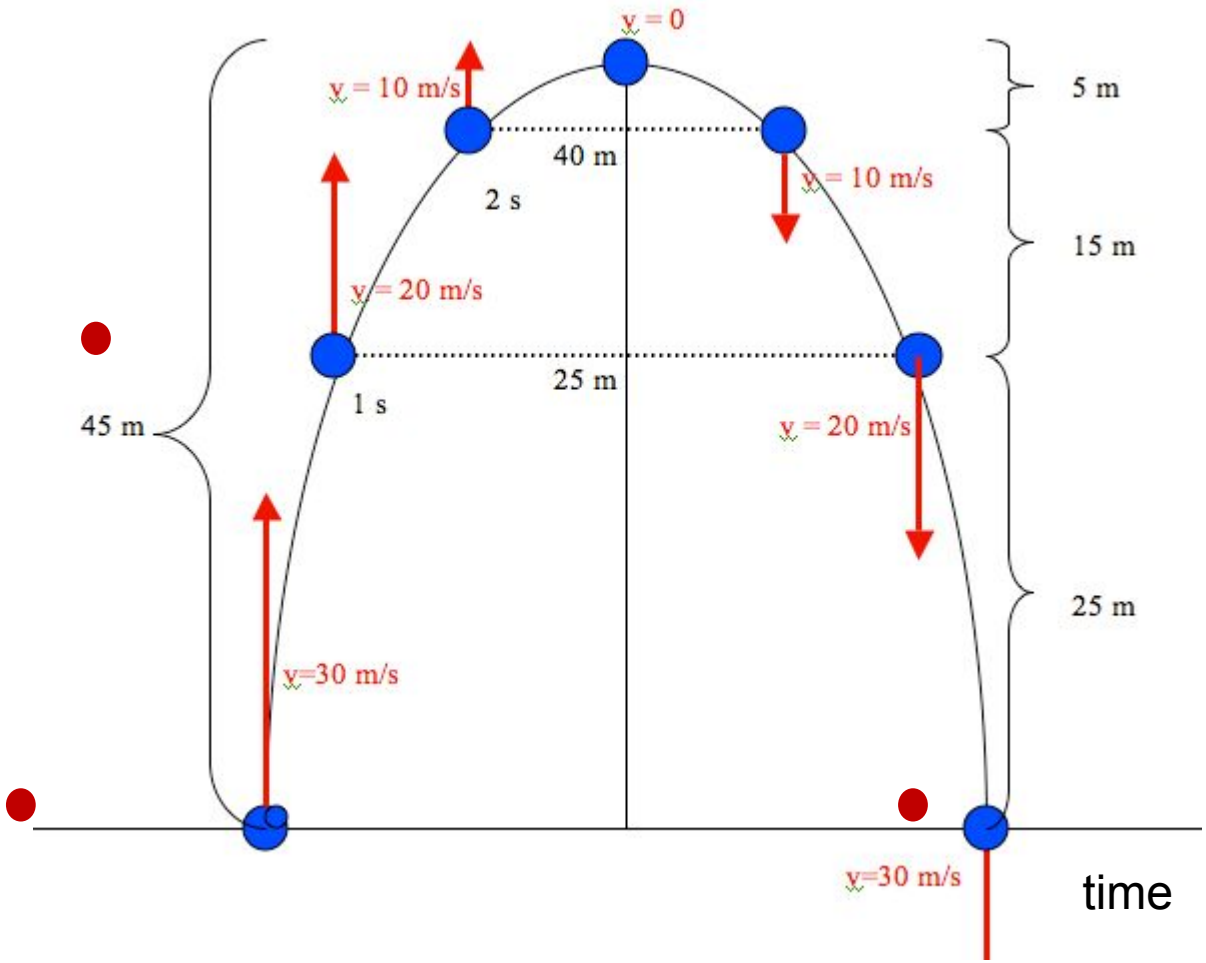






Later on we'll see that acceleration is the slope of velocity–time graph

- Free fall


v = 0
v = 10 m/s
40 m
2 s
v = 10 m/s
5 m
15 m
v = 20 m/s
25 m
1 s
45 m
v = 20 m/s
25 m
v=30 m/s
v=30 m/s
time