

Mechanics & Relativity

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28-30 September 2021 (Week 1)

Kinematics

This week's topics:

1.1 Displacement, Velocity & Acceleration

1.2 Equations of motion (SUVAT)

1.3 Reading graphs

Quiz 1.2 suvat

A sprinter is trying to cover 300 m in exactly 30 s. If they accelerates from rest at 5 m/s^2 for the first 10 seconds, what must their acceleration be for the last 20 seconds? m/s^2

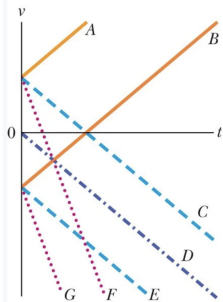
Quiz 1.2 suvat

If you want to quadruple the time it takes for a ball thrown vertically to return to the ground, how much higher must it be thrown?

- ☐ sixteen times as high
- ☐ twice as high
- ☐ nine times as high
- ☐ four times as high

Poll Everywhere Checkpoint

You are standing on a bridge with two eggs. You drop one, and you throw the other directly downwards.



Use your phone to go to: pollev.com/ilovephysics

- Which line best describes the motion of the dropped egg?
- Which line best describes the motion of the thrown egg?

Integrating acceleration over time

We know that $a = \frac{dv}{dt}$

$$\begin{aligned}\int_{t_0}^t a dt &= \int_{t_0}^t \frac{dv}{dt} dt \\ &= \int_{t_0}^t dv \\ &= v_t - v_{t0}\end{aligned}$$

$$\int_{t_0}^t a dt = v_t - v_{t0}$$

1.1

The integral of the acceleration over time gives the change in velocity

Integrating velocity over time

Similarly $v = \frac{ds}{dt}$

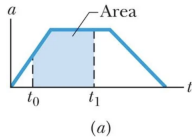
$$\begin{aligned}\int_{t_0}^t v dt &= \int_{t_0}^t \frac{ds}{dt} dt \\ &= \int_{t_0}^t ds \\ &= s_t - s_{t0}\end{aligned}$$

$$\int_{t_0}^t v dt = s_t - s_{t0}$$

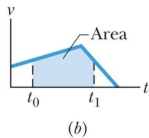
1.2

The integral of the velocity over time gives the change in position

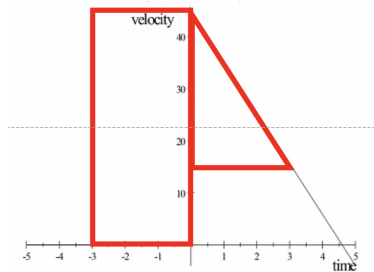
The area under a curve



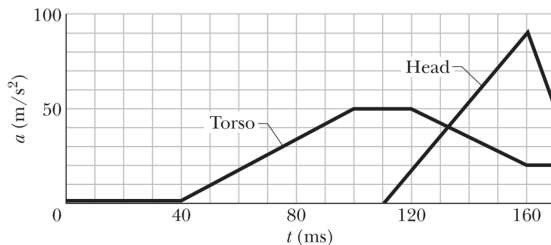
This area gives the change in velocity.



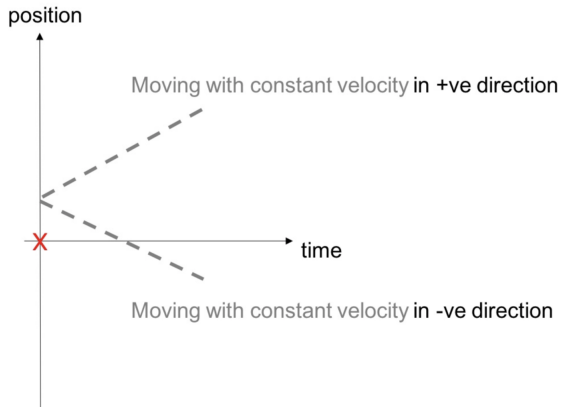
This area gives the change in position.



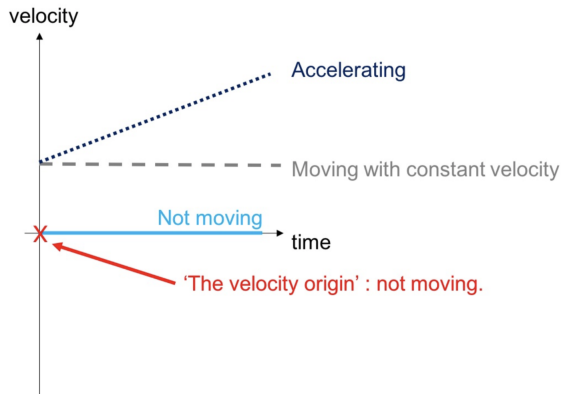
A example: whiplash curve



Tackling confusion with directions

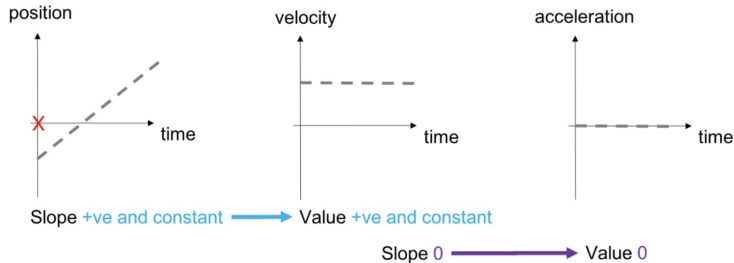


Zero velocity is constant velocity



Matching slopes to values

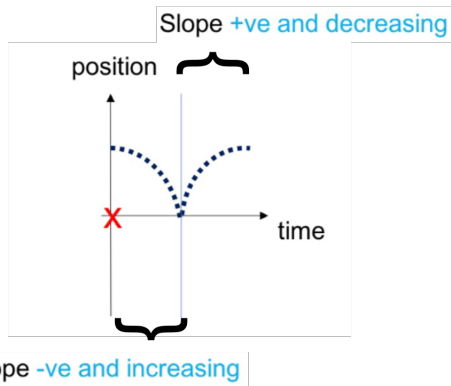
Example: A fire engine passes me (x) at 50 mph



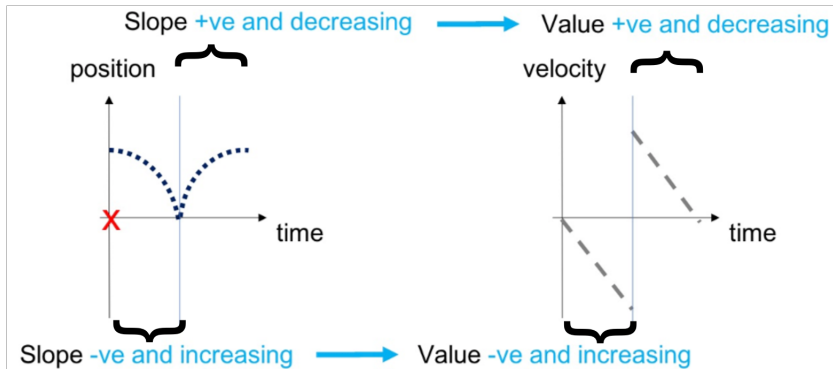
A bouncing ball

How would we draw the motion of a ball being dropped from height, reaching ground, and bouncing back up again?

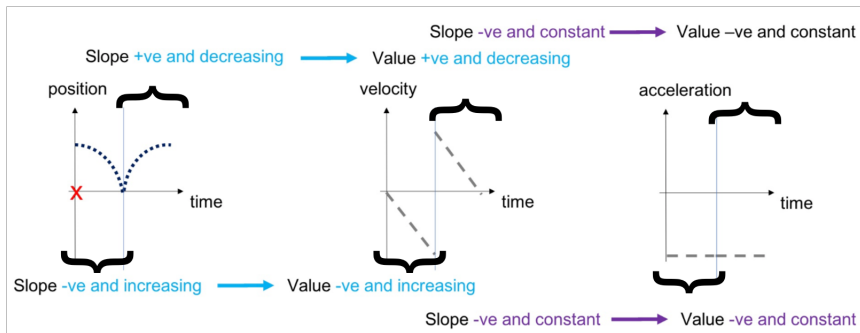
Divide & Conquer



Divide & Conquer



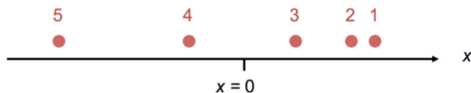
Divide & Conquer



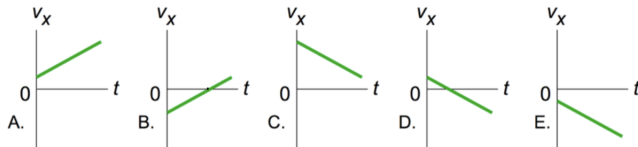
Poll Everywhere Checkpoint (pollev.com/ilovephysics)



This is a motion diagram of an object moving along the x -direction with constant acceleration. The dots 1, 2, 3, ... show the position of the object at equal time intervals Δt starting at $t=0$ s.



Which of the following v_x against t graphs best matches the motion shown in the motion diagram?

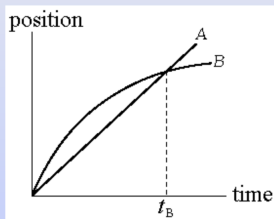


Reading graphs: additional problem

Concept Question: Instantaneous Velocity

The graph shows the position as a function of time for two trains running on parallel tracks. For times greater than $t = 0$, which of the following is true:

1. At time t_B , both trains have the same velocity.
2. Both trains speed up all the time.
3. Both trains have the same velocity at some time before t_B .
4. Somewhere on the graph, both trains have the same acceleration.



Preparing for next week's Kinematics Workshop

- The problems for the workshop are on Canvas.
- Have a go at the problems prior to your workshop, so you know in advance what you would like the DT's help with.
- Each workshop has a question marked out as the one you will be graded on.
- Upload your solution to this before the end of next week.

Tips

- You will need to use the quadratic formula at least once, so remind yourself what that is and when it is useful.
- What information is given in the question? Write it down.
- What information is known but not given? Write it down.
- Underline or draw a box around your answer and take a photo of it (including working) and upload it to canvas.