

## Multi-Stage Problems

### Starter

- (Review of last lesson)** A youth is playing with a ball in a garden surrounded by a wall 2.5 m high and kicks the ball vertically up from a height of 0.4 m with a speed of 14 m/s. For how long is the ball above the height of the wall? Give your answer to 2 s.f.
- (Review of last lesson)** A competitor is attempting a dive that is 6 m above the water. She leaves the springboard with an upward velocity of 7 m/s. Taking  $g = 10$ , find the speed at which the diver enters the water and the time for which she is in the air.

### Notes

When solving multi-stage problems, you may find it useful to sketch a velocity-time graph or distance-time graph to help you.

**E.g. 1** A train has a maximum speed of 144 km/h which it can achieve at an acceleration of  $0.25 \text{ m/s}^2$ . With its brakes applied fully, the train has a deceleration of  $0.5 \text{ m/s}^2$ . Two stations are 8 km apart. The trains stop at both stations.

- What is the shortest time for the train to travel between these two stations?
- How is your answer to (a) changed if there is a restriction on speed, between the two stations, of 72 km/h?

**Working:** (a)  $144 \text{ km/h} \equiv 40 \text{ m/s}$

**Accelerating:**

$$a = 0.25, u = 0, v = 40, t = ?$$

$$\text{No } s \Rightarrow v = u + at$$

$$40 = 0 + 0.25t$$

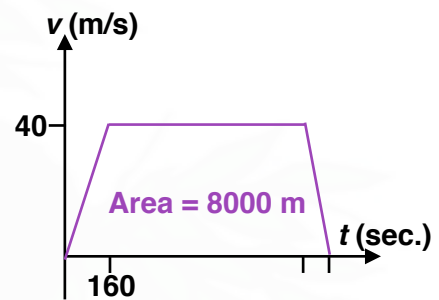
$$t = 160$$

$$a = 0.25, u = 0, v = 40, s = ?$$

$$\text{No } t \Rightarrow v^2 = u^2 + 2as$$

$$40^2 = 0^2 + 2 \times 0.25 \times s$$

$$s = 3200 \text{ distance travelled while accelerating}$$



**Decelerating:**

$$a = -0.5, u = 40, v = 0, t = ?$$

$$\text{No } s \Rightarrow v = u + at$$

$$0 = 40 + (-0.5) \times t$$

$$t = 80$$

$$a = -0.5, u = 40, v = 0, s = ?$$

$$\text{No } t \Rightarrow v^2 = u^2 + 2as$$

$$0^2 = 40^2 + 2 \times (-0.5) \times s$$

$$s = 1600 \text{ distance travelled while decelerating}$$

So distance travelled at constant speed =  $8000 - 3200 - 1600 = 3200$

Time taken to travel 3200 m at 40 m/s is 80 s.

Total time between stations  $160 + 80 + 80 = 300 \text{ s}$

i.e. 5 minutes 20 seconds

**Video:** [Multi-stage problem](#)

[Solutions to Starter and E.g.s](#)

### Exercise

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