* **1.** Jake starts from rest at the top of a 3.2 m long playground slide and slides to the bottom with a constant acceleration. If he takes 2.4 s to reach the bottom, calculate:
a his acceleration

$s = \frac{at^2}{2} \quad 3.2 = \frac{a \times 2.4^2}{2} \quad a = \frac{6.4}{2.4^2} = 1.1\ m/s^2$

b his final speed

$s = \frac{u+v}{2} t \quad 3.2 = \frac{v}{2} \times 2.4 \quad v = \frac{6.4}{2.4} = 2.7\ m/s$

2. Vybavi rides her skateboard up a ramp. She begins with a speed of 8.0 m/s but slows with a constant deceleration of 2.0 m/s2. She travels some distance up the ramp before coming to rest, then rolls down again. Ignoring air resistance and friction, calculate:
a the distance that Vybavi travels up the ramp before stopping

$u^2 = 2as \quad s = \frac{8^2}{2 \times 2} = 16\ m$

b the time that it takes Vybavi to reach this highest point.

$u = at \quad t = \frac{8}{2} = 4\ s$

3. Vinh is investigating the bouncing ability of a golf ball and a tomato. He drops both objects from a height of 2.00 m and measures the rebound heights. He found that the golf ball rebounded to 1.50 m and the tomato just splattered without rebounding at all.
a What was the speed of the golf ball just before it landed?

$\cancel{v = g} \quad v^2 = 2gh \quad v = \sqrt{2gh} = 6.26\ m/s$

b What was the speed of the tomato just before it hit the ground?

$6.26\ m/s$

c Calculate the speed of the golf ball as it rebounded.

$u^2 = 2gh \quad u = \sqrt{2 \times 9.8 \times 1.5}$

$= 5.4\ m/s$

4. A body moving in a straight line has uniform acceleration and an initial velocity of 20 m/s. If the body stops after 40 metres, find the acceleration of the body.

$u^2 = 2as$

$a = \frac{u^2}{2s}$ $\quad a = \frac{20^2}{2 \times 40} = 5\ m/s^2$

* **5.** If Michael Jordan has a vertical leap of 1.29 m, then what is his takeoff speed and his hang time (total time to move upwards to the peak and then return to the ground)?

$u^2 = 2gh$ $\quad h = \frac{gt^2}{2}$

$u = \sqrt{2gh} = 5.03\ m/s$ $\quad t = \sqrt{\frac{2h}{g}}$ $\quad t = \sqrt{\frac{2 \times 1.29}{9.8}}$

$= 0.51\ s$

Total $1.02\ s$

6. A baseball is popped straight up into the air and has a hang-time of 6.25 s. Determine the height to which the ball rises.

$t_1 = 3.125\ s$

$h = \frac{gt^2}{2}$ $\quad h = \frac{9.8 \times 3.125^2}{2} = 47.85\ m$

* **7.** A ball thrown vertically upward returns to its starting point in 4 s. Find its initial speed.

$h = \frac{gt^2}{2}$ $\quad h = \frac{9.8 \times 2^2}{2} = 19.6\ m$

* **8.** If the stone is thrown vertically upwards from a cliff 17.5 m high at 21 m/s:
i How long will it take to reach the ground at the base of the cliff?

$y = 17.5 + 21t - \frac{9.8t^2}{2}$ $\quad 4.9t^2 - 21t - 17.5 = 0$

$t = \frac{21 \pm \sqrt{21^2 + 4 \times 4.9 \times 17.5}}{9.8}$

$= \frac{21 + 28}{9.8} = 5\ s$

ii What is the velocity of the stone when it hits the ground?

$v = u + at$

$= 21 - 9.8 \times 5 = -28\ m/s$

iii What is the maximum height reached by the stone?

$u^2 = 2gh$ $\quad h = \frac{21^2}{19.6} = \frac{441}{19.6} = 22.5$

$h = \frac{u^2}{2g}$

total $17.5 + 22.5 = 40\ m$

9. A particle starts from a fixed point O with an initial velocity of -10 m/s and a uniform acceleration of 4 m/s2. Find:

a the displacement of the particle from O after 6 seconds

$$x = -10t + \frac{4t^2}{2} \qquad x(6) = -60 + 72 = 12 \text{ m}$$

b the velocity of the particle after 6 seconds

$$v = u + at \qquad v = -10 + 4 \times 6 = 14 \text{ m/s}$$

c the time when the velocity is zero

$$0 = -10 + 4t$$
$$t = 2.5 \text{ s}$$

d the distance travelled in the first 6 seconds.

$$x(2.5) = -25 + \frac{4 \times 2.5^2}{2} = -25 + 12.5 = -12.5 \qquad d = 12.5 + 24.5 = 37 \text{ m}$$

10. A ballast bag is dropped from a balloon that is 300 m above the ground and rising at 13 m/s. For the bag, find

(a) the maximum height reached,

$$u^2 = 2gh$$
$$h = \frac{13^2}{2 \times 9.8} = 8.6 \text{ m} \qquad \text{total } 308.6 \text{ m}$$

(b) the time before it hits the ground.

$$y = 300 + 13t - \frac{9.8t^2}{2} \qquad 4.9t^2 - 13t - 300 = 0$$
$$t = \frac{13 + \sqrt{169 + 1200 \times 4.9}}{9.8} = \frac{13 + 77.8}{9.8}$$
$$= 9.27 \text{ s}$$

11. A stone is thrown vertically upward with velocity 40 m/s at the edge of a cliff having a height of 110 m. Neglecting air resistance, compute the time required to strike the ground at the base of the cliff. With what velocity does it strike?

$$110 + 40t - \frac{9.8t^2}{2} = 0 \qquad 4.9t^2 - 40t - 110 = 0$$
$$t = \frac{40 + \sqrt{1600 + 4 \times 4.9 \times 110}}{9.8}$$
$$= 10.3 \text{ s}$$

$$v = u + at$$
$$v = 40 - 9.8 \times 10.3$$
$$= -61.3 \text{ m/s}$$

✱ **12.** A man runs at a speed of 4.0 m/s to get into the standing bus. When he is 6.0 m behind the door, the bus moves forward and continues with a constant acceleration of 1.2 m/s2

(a) How long does it take for the man to gain the door?

$x_1 = 4t$

$x_2 = 6 + \frac{1.2t^2}{2}$

$4t = 6 + 0.6t^2$

$0.6t^2 - 4t + 6 = 0$

$t = \frac{4 \pm \sqrt{16 - 2.4 \times 6}}{1.2}$

$= 4.4\,s$ or $2.3\,s$

(b) If at the beginning he is 10.0 m from the door, will he (running at the same speed) ever catch up?

No $\cancel{\sqrt{}}16 - 2.4 \times 10 < 0$

13. A car travelling with a constant speed of 25 m/s passes a stationary motorcycle policeman. The policeman sets off in pursuit after 3 seconds, accelerating uniformly At 2 m/s2. How long it will take the policeman to catch up with the car?

$x_1 = 25(t+3)$

$x_2 = \frac{2t^2}{2}$

$25(t+3) = t^2$

$t^2 - 25t - 75 = 0$

$t = \frac{25 \pm \sqrt{625 + 300}}{2} = \frac{25 \pm 30.4}{2}$

$= 27.7\,s$

14. A ball is dropped from the top of a building. The ball takes 0.2 s to fall past the 3-m length of a window some distance from the top of the building. How far is the top of the window from the point at which the ball was dropped?

$s = ut + \frac{gt^2}{2}$

$3 = u \times 0.2 + 4.9 \times 0.2^2$

$3 = 0.2u + 0.196$

$u = \frac{3 - 0.196}{0.2} = 14.02\,m/s$

$u^2 = 2gh$

$h = \frac{u^2}{2g}$ $h = 10.03\,m$

AREA 1 – Motion

In a road test, a car was uniformly accelerated from rest over a distance of 400 m in 19.0 s. The driver then applied the brakes, stopping the car in 5.1 s with constant deceleration.

Question 1

Calculate the acceleration of the car for the first 400 m.

$$S = ut + \frac{at^2}{2}$$

$$400 = 0 + \frac{a \times 19^2}{2}$$

$$a = \frac{800}{19^2} = 2.2$$

$\boxed{2.2 \text{ m s}^{-2}}$

2 marks

Question 2

Calculate the average speed of the car for the entire journey, covering both the acceleration and braking sections.

$$V_{av} = \frac{S}{t} \qquad t = 19 + 5.1 = 24.1\text{ s}$$

$$S = 400 + S_2 \qquad \frac{V+U}{2}t = S_1 \qquad \frac{V_1}{2} \times 19 = 400$$

$$V_1 = \frac{800}{19} = 42.1 \text{ ms}^{-1} \qquad S_2 = \frac{U_2 + V_2}{2} \times 5.1$$

$$V_1 = U_2 \qquad S_2 = \frac{42.1}{2} \times 5.1 = 107.36\text{ m}$$

$\boxed{21.1 \text{ m s}^{-1}}$

$$S = 107.36 + 400$$

$$= 507.36$$

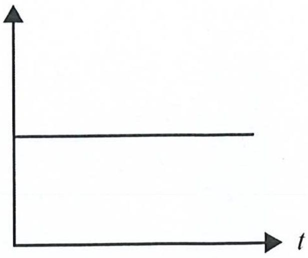
$$V_{av} = \frac{507.36}{24.1} = 21.1$$

2 marks

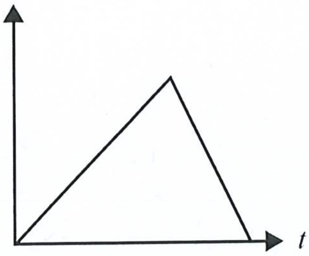
Questions 1 and 2 40%

The graphs (**A–F**) in the key below should be used when answering Questions 3 and 4. The horizontal axis represents time and the vertical axis could be velocity or distance.

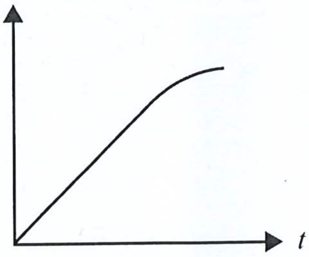
A.



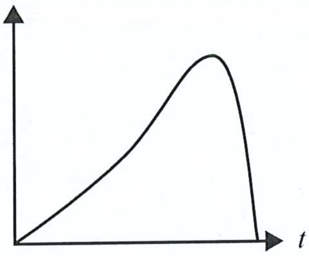
B.



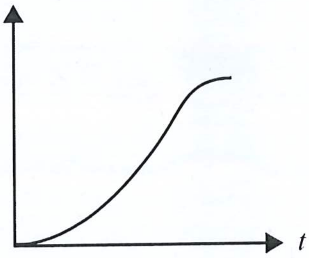
C.



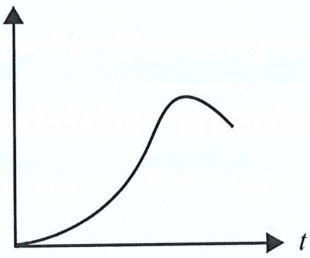
D.



E.



F.



KEY

Question 3 70%

Which of the graphs (**A–F**) best represents the velocity–time graph of the car for the entire journey?

B

Uniform acceleration then uniform deceleration

2 marks

Question 4 45%

Which of the graphs (**A–F**) best represents the distance–time graph of the car for the entire journey?

E

For acceleration part $d \sim t^2$, for deceleration part $d \sim -t^2$

2 marks

AREA 1 – continued

TURN OVER

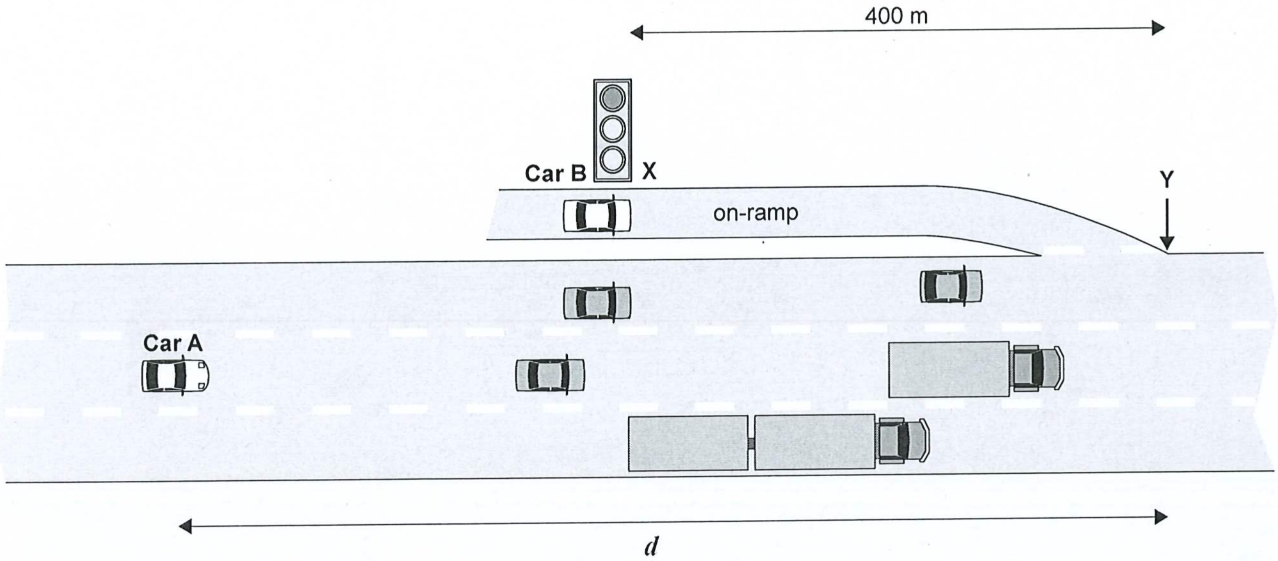


Figure 2

Figure 2 shows the merging lane of the on-ramp of a busy freeway. A set of traffic lights is installed at **X**, 400 m from **Y** where the cars merge into the traffic flow. The vehicles on the busy freeway are travelling at a constant speed of 80 km h^{-1}. When car **A**, a distance d along the road from point **Y**, is at the position shown, the traffic light at **X** changes to green. Car **B**, at the traffic light, is then expected to uniformly accelerate to 80 km h^{-1} at **Y** and merge into traffic beside car **A**.

Question 4

Calculate the distance d. (You **must** show your working.)

$80 \text{ km h}^{-1} = 22.2 \text{ m s}^{-1}$

Car B $\quad s = \frac{at^2}{2} \quad s = \frac{u+v}{2}t \quad 400 = \frac{0 + 22.2}{2} t$

$t = \frac{800}{22.2}$ s

Car A $\quad d = vt$

$= 22.2\, t$

$= 22.2 \times \frac{800}{22.2} = 800$ m

800 m

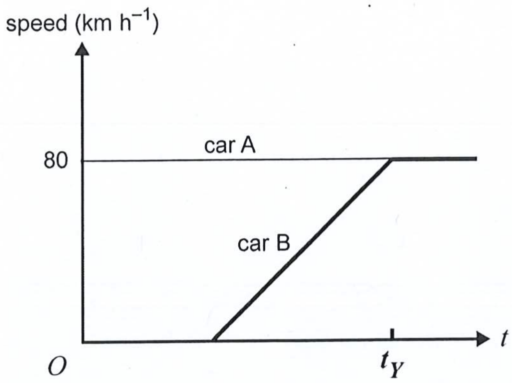
53%

3 marks

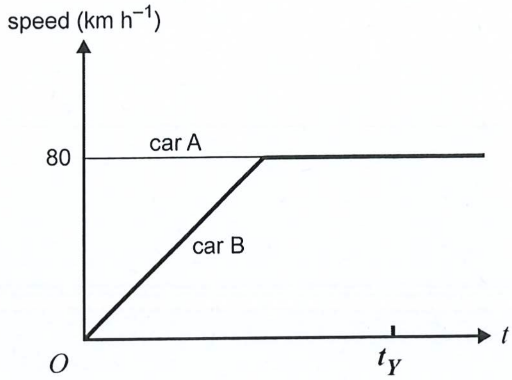
Question 5

Which of the speed–time graphs (**A.–D.**) best describes the motion of car **B** waiting at the traffic light and the motion of car **A**, from when the light changes to green ($t = 0$) until car **B** merges at time t_Y.

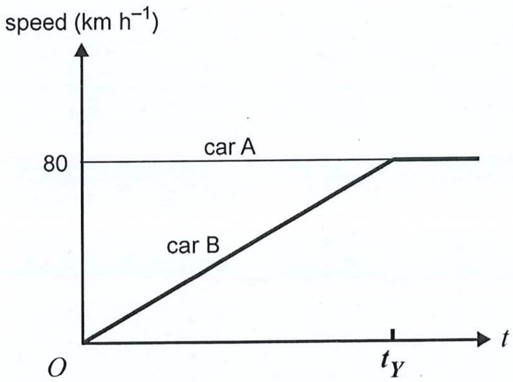
A.



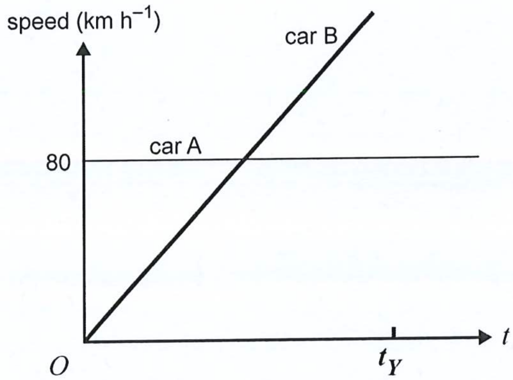
B.



C.



D.



C

2 marks

80 %

Question 9 (7 marks)

Giorgos is practising his tennis serve using a tennis ball of mass 56 g.

a. Giorgos practises throwing the ball vertically upwards from point A to point B, as shown in Figure 10. His daughter Eka, a physics student, models the throw, assuming that the ball is at the level of Giorgos's shoulder, point A, both when it leaves his hand and also when he catches it again. Point A is 1.8 m from the ground. The ball reaches a maximum height, point B, 1.8 m above Giorgos's shoulder.

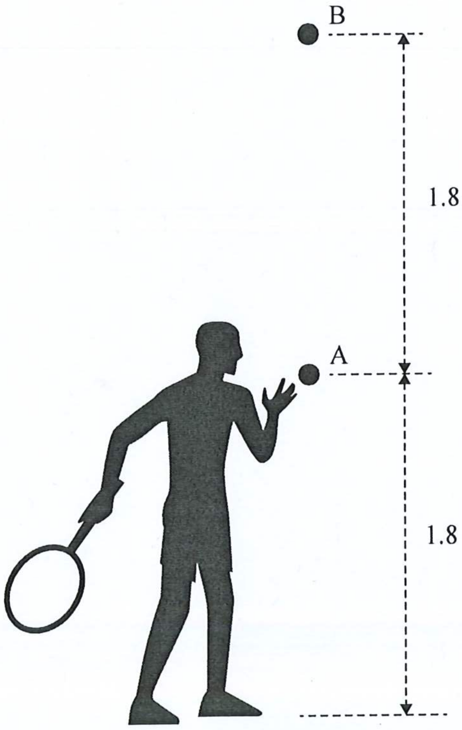


Figure 10

Show that the ball is in the air for 1.2 s from the time it leaves Giorgos's hand, which is level with his shoulder, until he catches it again at the same height. 2 marks

On way down $S = \frac{at^2}{2}$ $t = \sqrt{\frac{2S}{g}} = \sqrt{\frac{2 \times 1.8}{9.8}} = 0.6$

$t_{total} = 0.6 \times 2 = 1.2$ s