



Edexcel AS Mathematics

8MA0/22 - Mechanics

Thursday 23 May 2024

Questions and Fully Worked Model Solutions

This booklet places the **question and the solution together**. The mathematics is set out using proper fractions, powers, roots and exact notation, with extra written explanation so that a student can see *why* each step is being taken.

Solutions have been checked against the Pearson Edexcel Summer 2024 mark scheme. The aim is a clear **full-mark model response**, not merely a list of final answers.

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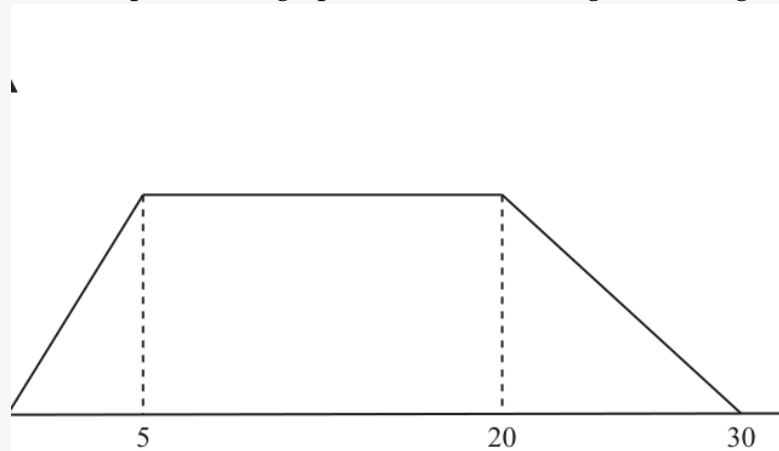
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Question 1

Question 1

Figure 1 is the speed–time graph for a car travelling on a straight horizontal road in a queue of



traffic.

Figure 1

At $t = 0$, the car is at rest at A. It accelerates uniformly for 5 s to 5 m s^{-1} , travels at this constant speed for the next 15 s, then decelerates uniformly to rest at B. The total journey time is 30 s.

(a) Find the distance AB.

(b) Sketch a distance–time graph for the journey from A to B.

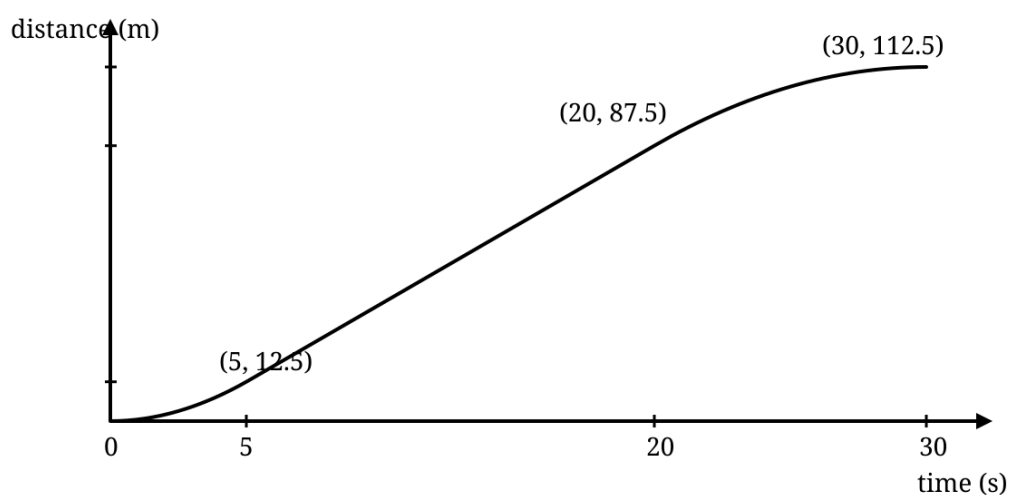
Model solution

(a) The distance travelled is the total area under the speed–time graph:

$$AB = \frac{1}{2}(5)(5) + (15)(5) + \frac{1}{2}(10)(5) = 12.5 + 75 + 25 = 112.5.$$

$$AB = 112.5 \text{ m.}$$

((a) 3) (b) The gradient is speed: it increases from 0 to 5 s, is constant and positive from 5 to 20 s, then decreases to zero. Key points are (5, 12.5), (20, 87.5), and (30, 112.5).



A continuous graph as shown: concave up, then straight, then concave down to $(30, 112.5)$.

((b) 3)

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Question 2

Question 2

In this question, all stages of working must be shown; calculator-based solutions are not acceptable. A particle moves along a straight line. At time t seconds, $t > 0$, its velocity is

$$v = 2t - 7\sqrt{t} + 6 \text{ m s}^{-1}.$$

(a) Find its acceleration when $t = 4$.

When $t = 1$, the particle is at X, and when $t = 2$, it is at Y. Given that the particle does not come to instantaneous rest for $1 < t < 2$,

(b) show that $XY = \frac{1}{3}(41 - 28\sqrt{2})$ metres.

Model solution

(a) Differentiate the velocity:

$$a = \frac{dv}{dt} = 2 - \frac{7}{2\sqrt{t}}.$$

$$a|_{t=4} = 2 - \frac{7}{2\sqrt{4}} = 2 - \frac{7}{4} = \frac{1}{4}.$$

$$0.25 \text{ m s}^{-2}.$$

((a) 3) (b) As the particle does not reverse direction, XY is the displacement. Integrating gives

$$\int (2t - 7\sqrt{t} + 6) dt = t^2 - \frac{14}{3}t^{3/2} + 6t + C.$$

$$\begin{aligned} XY &= \left[t^2 - \frac{14}{3}t^{3/2} + 6t \right]_1^2 \\ &= \left(4 - \frac{28\sqrt{2}}{3} + 12 \right) - \left(1 - \frac{14}{3} + 6 \right) \\ &= 16 - \frac{28\sqrt{2}}{3} - \frac{7}{3} = \frac{1}{3}(41 - 28\sqrt{2}) \text{ m}. \end{aligned}$$

$$XY = \frac{1}{3}(41 - 28\sqrt{2}) \text{ m, as required.}$$

((b) 4)

Question 3

Question 3

$\mathbf{i}$ and $\mathbf{j}$ are perpendicular unit vectors in a horizontal plane. A particle P, of mass 2 kg, moves on a smooth horizontal surface under the forces

$$(2\mathbf{i} + 4\mathbf{j}) \text{ N} \quad \text{and} \quad (c\mathbf{i} - 2\mathbf{j}) \text{ N},$$

where c is a constant. The magnitude of its acceleration is $\sqrt{5} \text{ m s}^{-2}$. Find the two possible values of c .

Model solution

The resultant force is

$$\mathbf{F} = (2 + c)\mathbf{i} + (4 - 2)\mathbf{j} = (c + 2)\mathbf{i} + 2\mathbf{j}.$$

By $\mathbf{F} = m\mathbf{a}$, its magnitude is $2\sqrt{5} \text{ N}$. Therefore

$$\sqrt{(c + 2)^2 + 2^2} = 2\sqrt{5}.$$

$$(c + 2)^2 + 4 = 20 \quad \Rightarrow \quad (c + 2)^2 = 16 \quad \Rightarrow \quad c = -2 \pm 4.$$

$$c = 2 \text{ or } c = -6.$$

(5)

Question 4

Question 4

Figure 2 shows a car towing a trailer on a straight horizontal road.

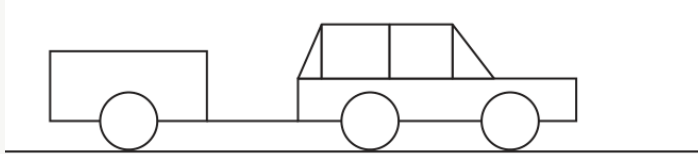


Figure 2

car towing a trailer along a straight horizontal road.

car is 800 kg and the mass of the trailer is 600 kg.

ched to the car by a towbar which is parallel to the road and parallel

The car has mass 800 kg and the trailer has mass 600 kg. They are joined by a light towbar, parallel to the road and direction of motion. The car experiences a constant 400 N resistance; the trailer's resistance is R N. The engine supplies a constant horizontal force of 1740 N. The acceleration is 0.6 m s^{-2} , and the towbar tension is T N.

Using the model:

(a) show that $R = 500$;

(b) find T .

When their speed is 12.5 m s^{-1} , the towbar breaks. The trailer moves a further distance d metres before resting, with its resistance modelled as a constant 500 N.

(c) Show that its deceleration is $\frac{5}{6} \text{ m s}^{-2}$.

(d) Find d .

(e) Give two different reasons why, in reality, d is likely to differ from the answer in part (d).

Model solution

(a) Take forward as positive and consider the car and trailer as one system. Newton's second law gives

$$1740 - 400 - R = (800 + 600)(0.6).$$

$$1340 - R = 840 \quad \Rightarrow \quad R = 500.$$

$$R = 500 \text{ N, as required.}$$

((a) 3) (b) For the trailer alone, tension acts forward and resistance backwards:

$$T - 500 = 600(0.6) = 360.$$

$$T = 860 \text{ N.}$$

((b) 3) (c) After the break, resistance is the only horizontal force. Taking forward as positive,

$$-500 = 600a \quad \Rightarrow \quad a = -\frac{5}{6} \text{ m s}^{-2}.$$

Deceleration = $\frac{5}{6} \text{ m s}^{-2}$, as required.

((c) 1) (d) With $u = 12.5 \text{ m s}^{-1}$, $v = 0$, $a = -\frac{5}{6} \text{ m s}^{-2}$, and $s = d$,

$$v^2 = u^2 + 2as \Rightarrow 0 = (12.5)^2 + 2 \left(-\frac{5}{6} \right) d.$$

$$d = \frac{(12.5)^2}{2(5/6)} = 93.75.$$

$d = 93.75 \text{ m}$ (approximately 94 m).

((d) 3) (e) The air resistance can change once the trailer is no longer in the car's slipstream, so it need not remain 500 N. Also, uneven road surfaces, such as bumps or potholes, can affect its motion.

For example: the resistance need not remain constant at 500 N; and the road may be uneven.

((e) 2)

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