



Edexcel AS Mathematics

8MA0/22 - Mechanics

Friday 23 May 2025

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 2025 mark scheme. The aim is a clear **full-mark model response**, not merely a list of final answers.

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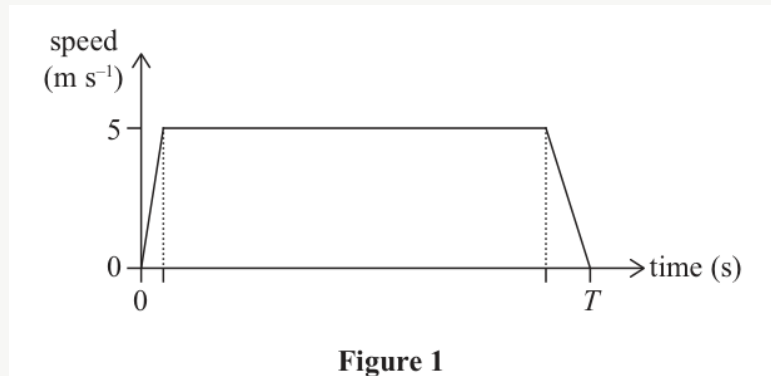
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Question 1

Question 1

Figure 1 is a sketch of the speed–time graph for a model of a runner travelling in a straight line along a horizontal road from A to B. The distance AB is 400 m.



In the model, the runner starts from rest at $t = 0$, accelerates uniformly for 5 seconds to a maximum speed of 5 m s^{-1} , travels at this constant speed, then decelerates uniformly for 15 seconds to rest at B. The total journey time is T seconds.

- (a) Find T . (3)
 (b) State one reason why the actual time taken to travel from A to B might not be T seconds. (1)

Model solution

(a) The distance travelled is the area under the speed–time graph. The initial and final triangular areas have bases 5 and 15, respectively. The constant-speed part has duration $T - 20$.

$$\frac{1}{2}(5)(5) + 5(T - 20) + \frac{1}{2}(15)(5) = 400.$$

$$12.5 + 5T - 100 + 37.5 = 400 \Rightarrow 5T = 450.$$

$$T = 90 \text{ s.}$$

(3)

(b) For example, a real runner is unlikely to maintain a constant speed during the middle part of the journey.

The actual time need not be 90 s because the constant-speed assumption may not hold.

(1)

Question 2

Question 2

A particle P, of mass 0.25 kg, moves on a smooth horizontal surface under horizontal forces

$$\mathbf{F}_1 = (3\mathbf{i} - 5\mathbf{j}) \text{ N}, \quad \mathbf{F}_2 = (-6\mathbf{i} + 9\mathbf{j}) \text{ N}.$$

(a) Find, in terms of $\mathbf{i}$ and $\mathbf{j}$, the resultant force on P. (1)

(b) Find the magnitude of the acceleration of P. (3)

A third horizontal force $\mathbf{F}_3$ is applied. Under the action of all three forces, P moves with constant velocity.

(c) Find $\mathbf{F}_3$, in terms of $\mathbf{i}$ and $\mathbf{j}$. (1)

Model solution

(a) Add corresponding vector components.

$$\mathbf{R} = \mathbf{F}_1 + \mathbf{F}_2 = (3 - 6)\mathbf{i} + (-5 + 9)\mathbf{j}.$$

$$\mathbf{R} = (-3\mathbf{i} + 4\mathbf{j}) \text{ N}.$$

(1)

(b) Newton's second law gives $\mathbf{R} = m\mathbf{a}$, so

$$\mathbf{a} = \frac{-3\mathbf{i} + 4\mathbf{j}}{0.25} = -12\mathbf{i} + 16\mathbf{j} \text{ m s}^{-2}.$$

$$|\mathbf{a}| = \sqrt{(-12)^2 + 16^2} = 20.$$

The magnitude of the acceleration is 20 m s^{-2} .

(3)

(c) Constant velocity means zero acceleration, hence the resultant force must be zero. Therefore $\mathbf{F}_3 = -\mathbf{R}$.

$$\mathbf{F}_3 = (3\mathbf{i} - 4\mathbf{j}) \text{ N}.$$

(1)

Question 3

Question 3

Package P, of mass 2 kg, is initially at rest on a horizontal table and is attached by a taut light, inextensible rope to package Q, of mass 3 kg, hanging freely over a small smooth pulley at the table edge. Initially P is 1.2 m from the pulley and Q is 0.4 m above the floor.

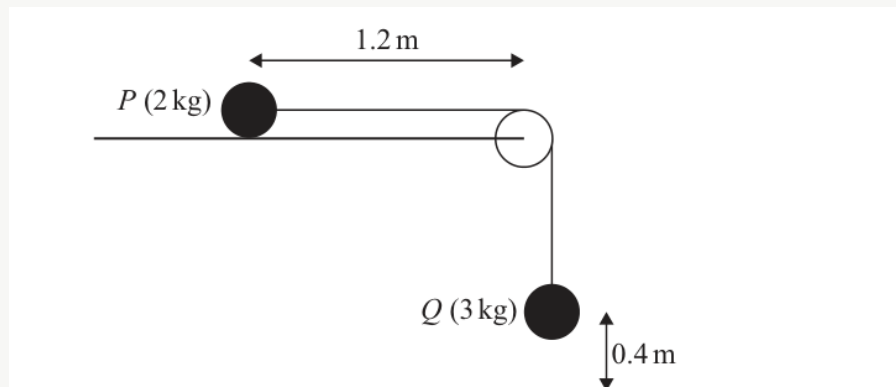


Figure 2

Initially, the table is smooth, the packages are particles, air resistance is negligible, and the pulley and rope are modelled as described above. P is released and Q moves downwards.

- (a) Write down an equation of motion for Q as it moves downwards. (2)
- (b) Find the acceleration of Q. (3)
- (c) Find the speed of Q when it hits the floor. (2)

Given that K seconds after Q hits the floor, P hits the pulley:

- (d) Use the model to find K. (2)

In a refinement, a resistance acts against the motion of P.

- (e) State, with a reason, whether the new acceleration of Q is greater than, equal to, or less than that in part (b). (1)
- (f) Suggest one further refinement of the model, apart from including air resistance, that would make it more realistic. (1)

Model solution

(a) Take downwards as positive for Q. Its weight acts downwards and its tension acts upwards, so Newton's second law gives

$$3g - T = 3a.$$

Taking downwards as positive for Q, $3g - T = 3a.$

(2)

(b) For P, taking its direction of motion towards the pulley as positive, the only horizontal force is the tension:

$$T = 2a.$$

Substitute this into the equation for Q:

$$3g - 2a = 3a \Rightarrow 3g = 5a \Rightarrow a = \frac{3g}{5} = 5.88 \text{ m s}^{-2}.$$

Q accelerates downwards at 5.88 m s^{-2} .

(3)

(c) Before Q reaches the floor, it moves 0.4 m from rest with the acceleration found in part (b). Using $v^2 = u^2 + 2as$,

$$v^2 = 0 + 2 \left(\frac{3g}{5} \right) (0.4) = 4.704.$$

$$v = 2.17 \text{ m s}^{-1}.$$

The speed is 2.17 m s^{-1} .

(2)

(d) When Q hits the floor, P has moved 0.4 m, leaving $1.2 - 0.4 = 0.8 \text{ m}$ before it reaches the pulley. The rope goes slack, so on the smooth table P continues at the speed 2.17 m s^{-1} . Thus

$$0.8 = (2.17)K, \quad K = 0.369 \dots \text{ s}.$$

$K = 0.369 \text{ s}$ (or 0.37 s).

(2)

(e) The acceleration is less: the resistance on P opposes the motion, reducing the resultant driving force on the system.

Less than 5.88 m s^{-2} .

(1)

(f) One refinement is to model the pulley as having mass (and hence rotational inertia), rather than treating it as small and smooth.

Model the pulley as having mass.

(1)

Question 4

Question 4

In this question, all stages of working must be shown. A fixed point O lies on a straight line. A particle P moves along the line and, at time t seconds ($t \geq 0$), its distance s metres from O is

$$s = 2t^3 - 12t^2 + 18t.$$

- (a) Find the values of t for which P is instantaneously at rest. (4)
- (b) Find the total distance travelled in $0 \leq t \leq 4$. (3)
- (c) Find the maximum speed in $1 \leq t \leq 3$. (3)

Model solution

(a) Velocity is the rate of change of displacement:

$$v = \frac{ds}{dt} = 6t^2 - 24t + 18.$$

At an instant of rest, $v = 0$. Hence

$$6t^2 - 24t + 18 = 0 \Rightarrow t^2 - 4t + 3 = 0 \Rightarrow (t-1)(t-3) = 0.$$

P is instantaneously at rest at $t = 1$ s and $t = 3$ s.

(4)

(b) The direction can change only when $v = 0$, so evaluate s at $t = 0, 1, 3, 4$:

$$s(0) = 0, \quad s(1) = 8, \quad s(3) = 0, \quad s(4) = 8.$$

Therefore the total distance is

$$|8 - 0| + |0 - 8| + |8 - 0| = 24.$$

The total distance travelled is 24 m.

(3)

(c) For $1 \leq t \leq 3$, $v \leq 0$, so the speed is $-v$. Complete the square in the velocity:

$$v = 6t^2 - 24t + 18 = 6(t-2)^2 - 6.$$

This is smallest at $t = 2$, where $v = -6 \text{ m s}^{-1}$. Hence the greatest speed is $|-6|$.

The maximum speed is 6 m s^{-1} .

(3)