GCE Examinations

Mechanics
Module M1

Advanced Subsidiary / Advanced Level

Paper C

Time: 1 hour 30 minutes

Instructions and Information

Candidates may use any calculator except those with a facility for symbolic algebra and/or calculus.

Full marks may be obtained for answers to ALL questions.

Mathematical and statistical formulae and tables are available.

This paper has 7 questions.

When a numerical value of g is required, use $g = 9.8 \text{ m s}^{-2}$.

Advice to Candidates

You must show sufficient working to make your methods clear to an examiner. Answers without working will gain no credit.

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1.

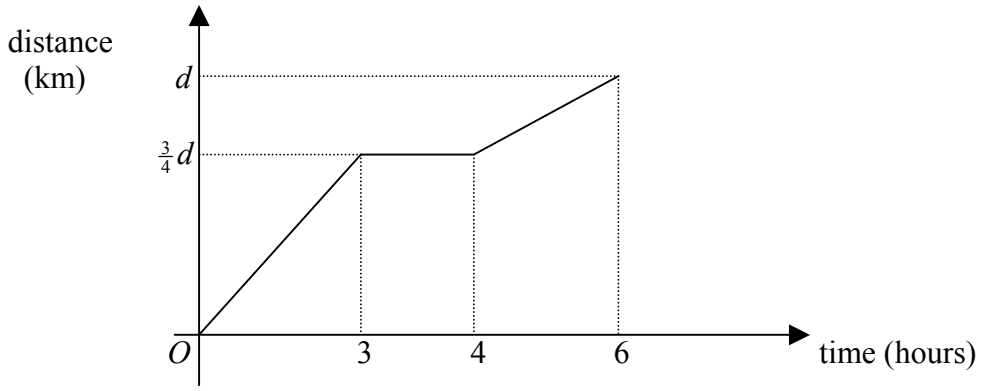


Fig. 1

Figure 1 shows a distance-time graph for a car journey from Birmingham to Newquay which included a stop for lunch at a service station near Exeter. During the first part of the journey three-quarters of the total distance, d, was covered in 3 hours. After a 1 hour stop, the remaining distance was completed in 2 hours.

(a) Calculate, in the form $k : 1$, the ratio of the average speed during the first 3 hours of the journey to the average speed during the last 2 hours of the journey. **(4 marks)**

Given that the average speed of the car over the whole journey (excluding the stop) was $80\ \text{km h}^{-1}$,

(b) find the average speed of the car on the first part of the journey. **(4 marks)**

2.

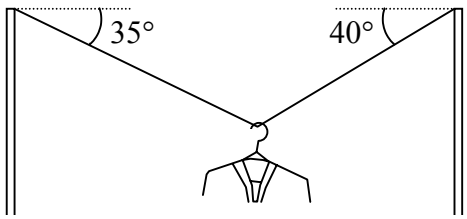


Fig. 2

Figure 2 shows a washing line suspended at either end by vertical rigid poles. A jacket of mass 0.7 kg is suspended in equilibrium part of the way along the line. The sections of the washing line on either side of the jacket make angles of 35° and 40° with the horizontal.

(a) Find the tension in the washing line on each side of the jacket. **(7 marks)**

(b) Explain why, in practice, the angles are likely to be very similar in value. **(1 mark)**

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3. In a simple model for the motion of a car, its velocity, $\mathbf{v}$, at time t seconds, is given by

$$\mathbf{v} = (3t^2 - 2t + 8)\mathbf{i} + (5t + 6)\mathbf{j} \text{ m s}^{-1}.$$

(a) Calculate the speed of the car when $t = 0$. **(3 marks)**

(b) Find the values of t for which the velocity of the car is parallel to the vector $(\mathbf{i} + \mathbf{j})$.

(5 marks)

(c) Why would this model not be appropriate for large values of t? **(1 mark)**

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4. The force $\mathbf{F_1} = (5\mathbf{i} + 2\mathbf{j})$ N acts at the point A on a lamina where the position vector of A, relative to a fixed origin O, is $(3\mathbf{i} - 2\mathbf{j})$ m.

(a) Calculate the magnitude and the sense of the moment of the force about O. **(4 marks)**

Another force $\mathbf{F_2} = (p\mathbf{i} + q\mathbf{j})$, acts at the point B with position vector $(^{-}\mathbf{i} + 4\mathbf{j})$ m so that the resultant moment of the two forces, $\mathbf{F_1}$ and $\mathbf{F_2}$, about O is zero.

Given also that the moment of $\mathbf{F_2}$ about A is 34 N s in a clockwise sense,

(b) find the values of p and q. **(6 marks)**

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5. A car and a motorbike are at rest adjacent to one another at a set of traffic lights on a long, straight stretch of road. They set off simultaneously at time $t = 0$. The motorcyclist accelerates uniformly at 6 m s^{-2} until he reaches a speed of 30 m s^{-1} which he then maintains. The car driver accelerates uniformly for 9 seconds until she reaches 36 m s^{-1} and then remains at this speed.

(a) Find the acceleration of the car. **(2 marks)**

(b) Draw on the same diagram speed-time graphs to illustrate the movements of both vehicles.

(4 marks)

(c) Find the value of t when the car again draws level with the motorcyclist. **(7 marks)**

Turn over

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6. Corinne and her brother Dermot are lifted by their parents onto the two ends of a rope which is slung over a large, horizontal branch. When their parents let go of them Dermot, whose mass is 54 kg, begins to descend with an acceleration of 1 $m\,s^{-2}$.

By modelling the children as a pair of particles connected by a light inextensible string, and the branch as a smooth pulley,

(a) show that Corinne's mass is 44 kg, **(7 marks)**

(b) calculate the tension in the rope, **(3 marks)**

(c) find the force on the branch. **(2 marks)**

In a more sophisticated model, the branch is assumed to be rough.

(d) Explain what effect this would have on the initial acceleration of the children. **(1 mark)**

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7. Two particles A and B, of mass $3M$ kg and $2M$ kg respectively, are moving towards each other on a rough horizontal track. Just before they collide, A has speed 3 $m\,s^{-1}$ and B has speed 5 $m\,s^{-1}$. Immediately after the impact, the direction of motion of both particles has been reversed and they are both travelling at the same speed, v.

(a) Show that $v = 1$ $m\,s^{-1}$. **(4 marks)**

The magnitude of the impulse exerted on A during the collision is 24 Ns.

(b) Find the value of M. **(3 marks)**

Given that the coefficient of friction between A and the track is 0.1,

(c) find the time taken from the moment of impact until A comes to rest. **(7 marks)**

END

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