

# GCE Examinations

## Mechanics

### Module M1

Advanced Subsidiary / Advanced Level

Paper C

Time: 1 hour 30 minutes

#### *Instructions and Information*

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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*

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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.

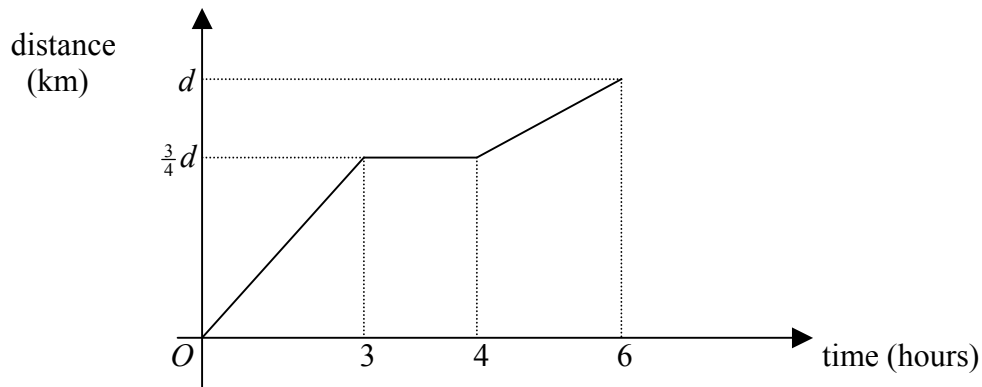


Fig. 1

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.

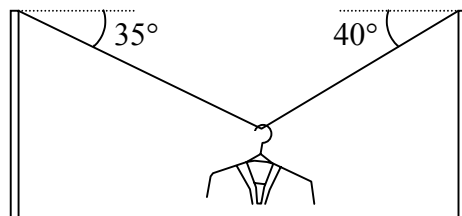


Fig. 2

Figure 2 shows a washing line suspended at either end by vertical rigid poles. A jacket of mass  $0.7 \text{ kg}$  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  $35^\circ$  and  $40^\circ$  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)**

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

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

- (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  $6 \text{ ms}^{-2}$  until he reaches a speed of  $30 \text{ ms}^{-1}$  which he then maintains. The car driver accelerates uniformly for 9 seconds until she reaches  $36 \text{ ms}^{-1}$  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)**
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*Turn over*

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  $1 \text{ m s}^{-2}$ .

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)**

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  $3 \text{ m s}^{-1}$  and  $B$  has speed  $5 \text{ m s}^{-1}$ . 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  $v = 1 \text{ m s}^{-1}$ . **(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**