# GCE Examinations

# Mechanics
# Module M1

Advanced Subsidiary / Advanced Level

Paper B

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.** A constant force, **F**, acts on a particle, $P$, of mass 5 kg causing its velocity to change from $(^{-}2\mathbf{i} + \mathbf{j})$ m s$^{-1}$ to $(4\mathbf{i} - 7\mathbf{j})$ m s$^{-1}$ in 2 seconds.

*(a)* Find, in the form $a\mathbf{i} + b\mathbf{j}$, the acceleration of $P$. **(2 marks)**

*(b)* Show that the magnitude of **F** is 25 N and find, to the nearest degree, the acute angle between the line of action of **F** and the vector **j**.

**(5 marks)**

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**2.** A particle $A$ of mass $3m$ is moving along a straight line with constant speed $u$ m s$^{-1}$. It collides with a particle $B$ of mass $2m$ moving at the same speed but in the opposite direction. As a result of the collision, $A$ is brought to rest.

*(a)* Show that, after the collision, $B$ has changed its direction of motion and that its speed has been halved.

**(4 marks)**

Given that the magnitude of the impulse exerted by $A$ on $B$ is $9m$ Ns,

*(b)* find the value of $u$. **(3 marks)**

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**3.**

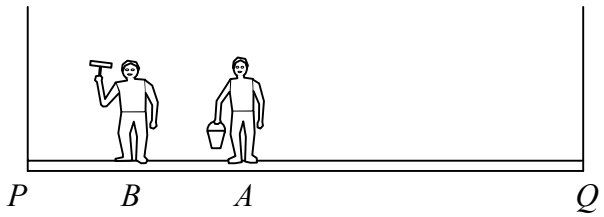



Fig. 1

Figure 1 shows two window cleaners, Alan and Baber, of mass 60 kg and 100 kg respectively standing on a platform $PQ$ of length 3 metres and mass 20 kg. The platform is suspended by two vertical cables attached to the ends $P$ and $Q$. Alan is standing at the point $A$, 1.25 metres from $P$, Baber is standing at the point $B$ and the tension in the cable at $P$ is twice the tension in the cable at $Q$.

Modelling the platform as a uniform rod and Alan and Baber as particles,

*(a)* find the tension in the cable at $P$, **(2 marks)**

*(b)* find the distance $BP$. **(5 marks)**

*(c)* State how you have used the modelling assumptions that

(i) the platform is uniform,

(ii) the platform is a rod. **(2 marks)**

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**4.** A sports car is being driven along a straight test track. It passes the point $O$ at time $t = 0$ at which time it begins to decelerate uniformly. The car passes the points $L$ and $M$ at times $t = 1$ and $t = 4$ respectively.

Given that $OL$ is 54 m and $LM$ is 90 m,

*(a)* find the rate of deceleration of the car. **(5 marks)**

The car subsequently comes to rest at $N$.

*(b)* Find the distance $MN$. **(4 marks)**

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**5.**

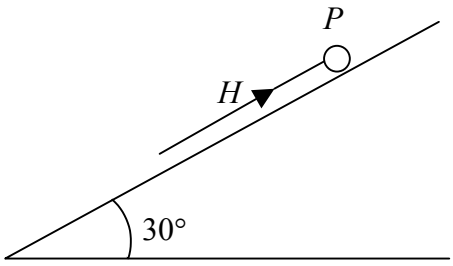



Fig. 2

A particle $P$, of mass 2 kg, lies on a rough plane inclined at an angle of 30° to the horizontal. A force $H$, whose line of action is parallel to the line of greatest slope of the plane, is applied to the particle as shown in Figure 2. The coefficient of friction between the particle and the plane is $\frac{1}{\sqrt{3}}$.

Given that the particle is on the point of moving up the plane,

*(a)* draw a diagram showing all the forces acting on the particle, **(2 marks)**

*(b)* show that the ratio of the magnitude of the frictional force to the magnitude of $H$ is equal to 1 : 2

**(7 marks)**

The force $H$ is now removed but $P$ remains at rest.

*(c)* Use the principle of friction to explain how this is possible. **(2 marks)**

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***Turn over***

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**6.** A car of mass 1.25 tonnes tows a caravan of mass 0.75 tonnes along a straight, level road. The total resistance to motion experienced by the car and the caravan is 1200 N. The car and caravan accelerate uniformly from rest to 25 m $s^{-1}$ in 20 seconds.

*(a)* Calculate the driving force produced by the car's engine. **(4 marks)**

Given that the resistance to motion experienced by the car and by the caravan are in the same ratio as their masses,

*(b)* find these resistances and the tension in the towbar. **(4 marks)**

When the car and caravan are travelling at a steady speed of 25 m $s^{-1}$, the towbar snaps. Assuming that the caravan experiences the same resistive force as before,

*(c)* calculate the distance travelled by the caravan before it comes to rest, **(5 marks)**

*(d)* give a reason why your answer to *(c)* may be unrealistic. **(2 marks)**

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**7.** Two ramblers, Alison and Bill, are out walking. At midday, Alison is at the fixed origin $O$, and Bill is at the point with position vector $(^{-}5\mathbf{i} + 12\mathbf{j})$ km relative to $O$, where **i** and **j** are perpendicular, horizontal unit vectors.

They are both walking with constant velocity – Alison at $(2\mathbf{i} + 5\mathbf{j})$ km $h^{-1}$, and Bill at a speed of $2\sqrt{10}$ km $h^{-1}$ in a direction parallel to the vector $(3\mathbf{i} + \mathbf{j})$.

*(a)* Find the distance between the two ramblers at midday. **(2 marks)**

*(b)* Show that the velocity of Bill is $(6\mathbf{i} + 2\mathbf{j})$ km $h^{-1}$. **(3 marks)**

*(c)* Show that, at time $t$ hours after midday, the position vector of Bill relative to Alison is

$$[(4t - 5)\mathbf{i} + (12 - 3t)\mathbf{j}] \text{ km}. \quad \textbf{(5 marks)}$$

*(d)* Show that the distance, $d$ km, between the two ramblers is given by

$$d^2 = 25t^2 - 112t + 169. \quad \textbf{(2 marks)}$$

*(e)* Using your answer to part *(d)*, find the length of time to the nearest minute for which the distance between the Alison and Bill is less than 11 km. **(5 marks)**

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**END**

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