# GCE Examinations

# Mechanics
# Module M1

Advanced Subsidiary / Advanced Level

Paper L

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.** Two particles $P$ and $Q$, of mass $m$ and $km$ respectively, are travelling in opposite directions on a straight horizontal path with speeds $3u$ and $2u$ respectively. $P$ and $Q$ collide and, as a result, the direction of motion of both particles is reversed and their speeds are halved.

*(a)* Find the value of $k$. **(4 marks)**

*(b)* Write down an expression in terms of $m$ and $u$ for the magnitude of the impulse which $P$ exerts on $Q$ during the collision. **(3 marks)**

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**2.**

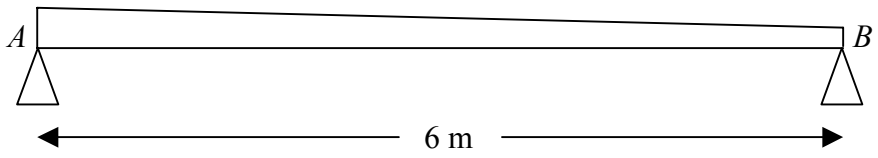



Fig. 1

Figure 1 shows a plank $AB$ of mass 40 kg and length 6 m, which rests on supports at each of its ends. The plank is wedge-shaped, being thicker at end $A$ than at end $B$.

A woman of mass 60 kg stands on the plank at a distance of 2 m from $B$.

*(a)* Suggest suitable modelling assumptions which can be made about

(i) the plank,

(ii) the woman. **(3 marks)**

Given that the reactions at each support are of equal magnitude,

*(b)* find the magnitude of the reaction on the support at $A$, **(2 marks)**

*(c)* calculate the distance of the centre of mass of the plank from $A$. **(4 marks)**

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**3.**

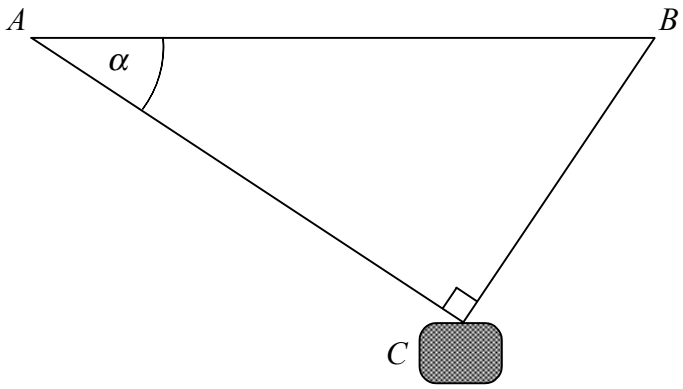



Fig. 2

Figure 2 shows a cable car $C$ of mass 1 tonne which has broken down. The cable car is suspended in equilibrium by two perpendicular cables $AC$ and $BC$ which are attached to fixed points $A$ and $B$, at the same horizontal level on either side of a valley. The cable $AC$ is inclined at an angle $\alpha$ to the horizontal where $\tan\alpha = \frac{3}{4}$.

*(a)* Show that the tension in the cable $AC$ is 5880 N and find the tension in the cable BC.

**(7 marks)**

A gust of wind then blows along the valley.

*(b)* Explain the effect that this will have on the tension in the two cables. **(2 marks)**

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**4.** Andrew hits a tennis ball vertically upwards towards his sister Barbara who is leaning out of a window 7.5 m above the ground to try to catch it. When the ball leaves Andrew's racket, it is 1.9 m above the ground and travelling at 21 $\mathrm{m\,s^{-1}}$. Barbara fails to catch the ball on its way up but succeeds as the ball comes back down.

Modelling the ball as a particle and assuming that air resistance can be neglected,

*(a)* find the maximum height above the ground which the ball reaches. **(4 marks)**

*(b)* find how long Barbara has to wait from the moment that the ball first passes her until she catches it.

**(6 marks)**

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***Turn over***

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**5.**

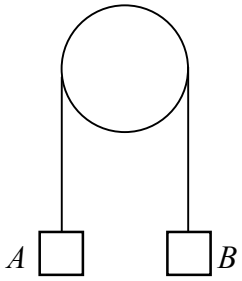



Fig. 3

Figure 3 shows two particles $A$ and $B$ of masses $m$ and $km$ respectively, connected by a light inextensible string which passes over a smooth fixed pulley.

When the system is released from rest with both particles 0.5 m above the ground, particle $A$ moves vertically upwards with acceleration $\frac{1}{4}g\ \mathrm{m\,s^{-2}}$.

*(a)* Write down, with a brief justification, the magnitude and direction of the acceleration of $B$.

**(2 marks)**

*(b)* Find the value of $k$. **(6 marks)**

Given that $A$ does not hit the pulley,

*(c)* calculate, correct to 3 significant figures, the speed with which $B$ hits the ground.

**(3 marks)**

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**6.** Two trains $A$ and $B$ leave the same station, $O$, at 10 a.m. and travel along straight horizontal tracks. $A$ travels with constant speed 80 $\mathrm{km\,h^{-1}}$ due east and $B$ travels with constant speed 52 $\mathrm{km\,h^{-1}}$ in the direction $(5\mathbf{i} + 12\mathbf{j})$ where $\mathbf{i}$ and $\mathbf{j}$ are unit vectors due east and due north respectively.

*(a)* Show that the velocity of $B$ is $(20\mathbf{i} + 48\mathbf{j})\ \mathrm{km\,h^{-1}}$. **(3 marks)**

*(b)* Find the displacement vector of $B$ from $A$ at 10:15 a.m. **(3 marks)**

Given that the trains are 23 km apart $t$ minutes after 10 a.m.

*(c)* find the value of $t$ correct to the nearest whole number. **(6 marks)**

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**7.**

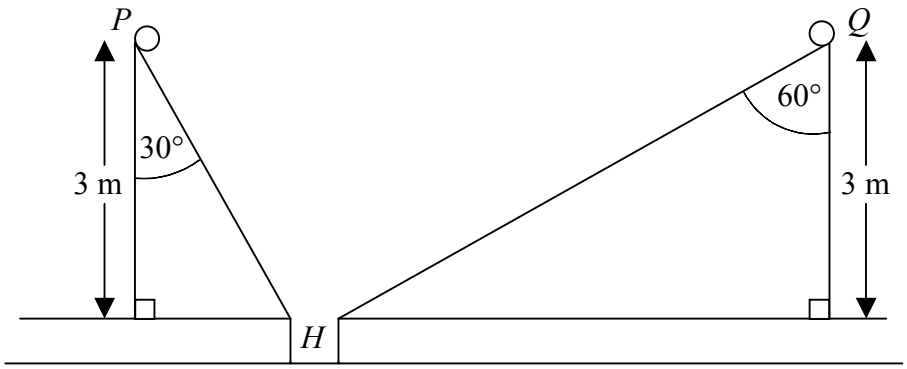



Fig. 4

Figure 4 shows two golf balls $P$ and $Q$ being held at the top of planes inclined at 30° and 60° to the vertical respectively. Both planes slope down to a common hole at $H$, which is 3 m vertically below $P$ and $Q$.

$P$ is released from rest and travels down the line of greatest slope of the plane it is on which is assumed to be smooth.

*(a)* Find the acceleration of $P$ down the slope. **(3 marks)**

*(b)* Show that the time taken for $P$ to reach the hole is 0.904 seconds, correct to 3 significant figures. **(5 marks)**

$Q$ travels down the line of greatest slope of the plane it is on which is rough. The coefficient of friction between $Q$ and the plane is $\mu$.

Given that the acceleration of $Q$ down the slope is 3 m s$^{-2}$,

*(c)* find, correct to 3 significant figures, the value of $\mu$. **(5 marks)**

In order for the two balls to arrive at the hole at the same time, $Q$ must be released $t$ seconds before $P$.

*(d)* Find the value of $t$ correct to 2 decimal places. **(4 marks)**

**END**

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