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.

Written by Shaun Armstrong & Chris Huffer

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)**

2.

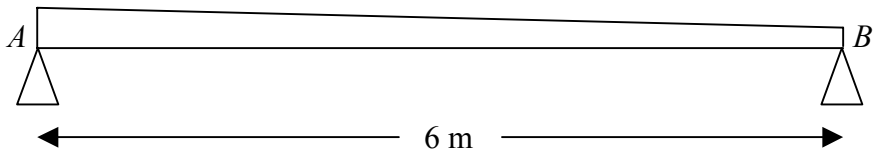

Fig. 1

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)**

3.

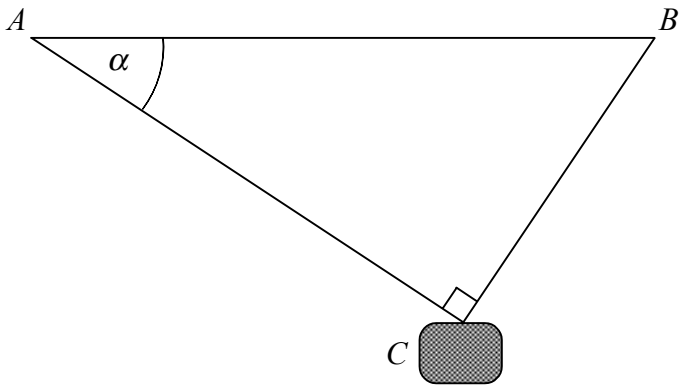

Fig. 2

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 α 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)

Turn over

5.

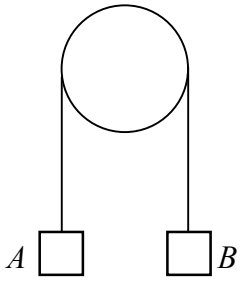

Fig. 3

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)**

7.

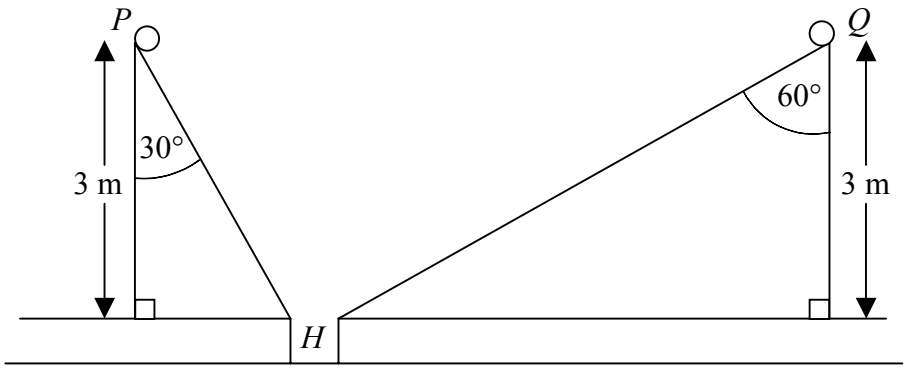

Fig. 4

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 μ.

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

(c) find, correct to 3 significant figures, the value of μ. **(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