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MATHEMATICS M1

Mechanics 1

A.M. THURSDAY, 7 June 2007

($1\frac{1}{2}$ hours)

ADDITIONAL MATERIALS

In addition to this examination paper, you will need:

- a 12 page answer book;
- a Formula Booklet;
- a calculator.

INSTRUCTIONS TO CANDIDATES

Answer **all** questions.

Take g as 9·8 ms $^{-2}$.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

You are reminded of the necessity for good English and orderly presentation in your answers.

1. A train is travelling along a straight horizontal track and its speed as it passes a signal box A is $5\,\text{ms}^{-1}$. Immediately after passing A the train accelerates at a rate of $0{\cdot}6\,\text{ms}^{-2}$ for 25 s; it then travels at a constant speed of $V\,\text{ms}^{-1}$ before it finally decelerates uniformly for 30 s, coming to rest at station B. The total time taken by the train to travel from A to B is 12 minutes.

(a) Calculate the value of V. [3]

(b) Sketch a velocity-time graph for the journey from A to B. [3]

(c) Determine the magnitude of the deceleration of the train in the last 30 s of the journey. [2]

(d) Find the distance between A and B. [3]

2. A ball is hit vertically up into the air from a point A, which is $1{\cdot}75\,\text{m}$ above the ground. The ball hits the ground for the first time after $2{\cdot}5\,\text{s}$. Ignoring air resistance,

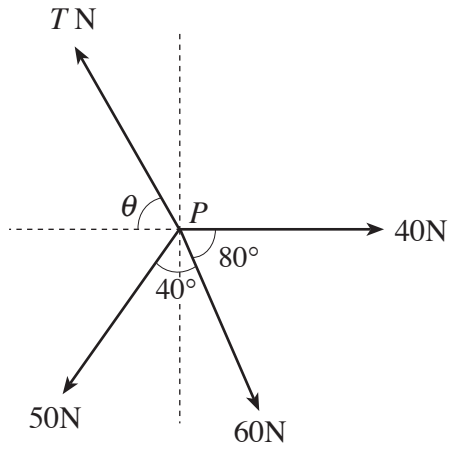
(a) show that the initial speed of the ball is $11{\cdot}55\,\text{ms}^{-1}$, [2]

(b) find the greatest height above the ground reached by the ball, [3]

(c) calculate the speed of the ball as it hits the ground, [3]

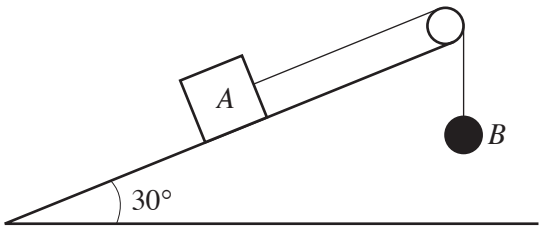
(d) calculate the speed of the ball immediately after the first bounce if the coefficient of restitution between the ball and the ground is 0·8. [2]

3. The diagram shows four horizontal forces acting at a point P.



Given that the forces are in equilibrium, calculate the value of T and the size of the angle θ. Give each of your answers correct to one decimal place. [9]

4. The diagram shows a block A of mass 8 kg on a smooth plane inclined at an angle of 30° to the horizontal. The block is connected to a body B, of mass 6 kg, by means of a light inextensible string passing over a light smooth pulley fixed at the top of the plane.



Initially, the system is held at rest with the string taut. The system is then released.

(a) Calculate the magnitude of the acceleration of A and the tension in the string. [7]

(b) What assumption did the word 'inextensible', underlined above, enable you to make in your solution? [1]

5. Two objects A and B are sliding towards each other on a smooth horizontal surface and collide directly. Object A has mass 49 kg and Object B has mass 56 kg. Just before collision, A has speed $1{\cdot}6\,\text{ms}^{-1}$ and B has speed $0{\cdot}9\,\text{ms}^{-1}$. Immediately after the collision, A has a speed of $0{\cdot}24\,\text{ms}^{-1}$ in the direction of its original motion.

(a) Show that the speed of B immediately after the collision is $0{\cdot}29\,\text{ms}^{-1}$. [3]

(b) Calculate the coefficient of restitution between A and B. [3]

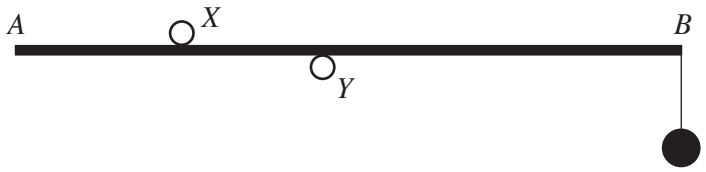
(c) Determine the magnitude of the impulse exerted by A on B during the collision. State your units clearly. [3]

(d) Write down one modelling assumption you have made in your solution. [1]

6. A **horizontal** force, of magnitude T N, acts on a body of mass 0·8 kg on a rough plane inclined at an angle α to the horizontal, where $\sin\alpha = \frac{3}{5}$. The coefficient of friction between the body and the plane is 0·4. Given that the body is on the point of moving up the plane, calculate the value of T. [8]

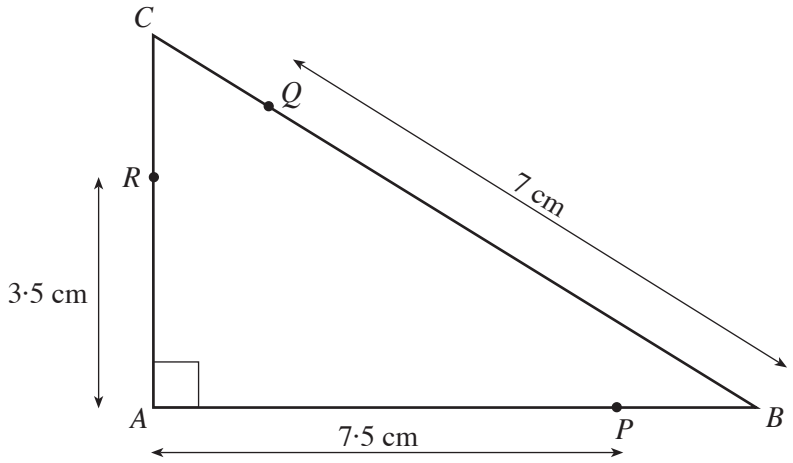
TURN OVER

7. The diagram shows a uniform rod AB, of length 1·6 m and mass 8 kg, held horizontally in equilibrium by means of two small smooth cylindrical pegs X and Y, such that $AX = XY = 0{\cdot}3$ m. A body of mass 5 kg is attached to the rod at point B.



Find the magnitude of each of the forces exerted on the rod by the pegs X and Y. [7]

8. The diagram shows three particles P, Q, R attached to **light** rods AB, BC, CA respectively. The rods are rigidly jointed together so that ABC is a right-angled triangle with $AB = 8$ cm, $AC = 6$ cm and $\hat{CAB} = 90°$. The masses (in kg) of P, Q, R, are $2m$, $3m$, $5m$ respectively and $AP = 7{\cdot}5$ cm, $BQ = 7$ cm, $AR = 3{\cdot}5$ cm.



(a) Find the distance of the centre of mass of the system from

(i) AC,
(ii) AB. [9]

(b) The system is freely suspended from B and hangs in equilibrium. Calculate the angle that AB makes with the vertical. [3]