MECHANICS EXAMINATION

CANDIDATE NAME

Date **Candidate No.**

MATHEMATICS **9709/02**
Paper 4 Mechanics

1 Hour 15 Minutes

You must answer on this question paper.

You will need: List of formulae (MF19)

READ THESE INSTRUCTIONS FIRST

- Answer **all** questions.
- Write your name, date & class on all the work you hand in.
- Write in dark blue or black pen.
- You may use an HB pencil for any diagrams or graphs.
- Do not use staples, paper clips, glue, or correction fluid.
- Write your answer to each question in the space provided.
- If additional space is needed, you should use the lined page at the end of this booklet; the question number or numbers must be clearly shown.
- Where a numerical value for the acceleration due to gravity is needed, **use 10 m s^{-2}**.
- You must show all necessary working clearly; no marks will be given for unsupported answers from a calculator.
- Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place for angles in degrees, unless a different level of accuracy is specified in the question.

INFORMATION

- The total mark for this paper is **50**.
- The number of marks for each question or part question is shown in brackets [ ].

1 A weightlifter performs an exercise in which he raises a mass of 200 kg from rest vertically through a distance of 0.7 m and holds it at that height.

(i) Find the work done by the weightlifter. [2]

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(ii) Given that the time taken to raise the mass is 1.2 s, find the average power developed by the weightlifter. [2]

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2 A particle of mass 0.5 kg starts from rest and slides down a line of greatest slope of a smooth plane. The plane is inclined at an angle of 30° to the horizontal.

(i) Find the time taken for the particle to reach a speed of $2.5\,\text{m s}^{-1}$. [3]

When the particle has travelled 3 m down the slope from its starting point, it reaches rough horizontal ground at the bottom of the slope. The frictional force acting on the particle is 1 N.

(ii) Find the distance that the particle travels along the ground before it comes to rest. [3]

3 A lorry of mass 24 000 kg is travelling up a hill which is inclined at 3° to the horizontal. The power developed by the lorry's engine is constant, and there is a constant resistance to motion of 3200 N.

(i) When the speed of the lorry is $25\,\text{m}\,\text{s}^{-1}$, its acceleration is $0.2\,\text{m}\,\text{s}^{-2}$. Find the power developed by the lorry's engine. [4]

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(ii) Find the steady speed at which the lorry moves up the hill if the power is 500 kW and the resistance remains 3200 N. [2]

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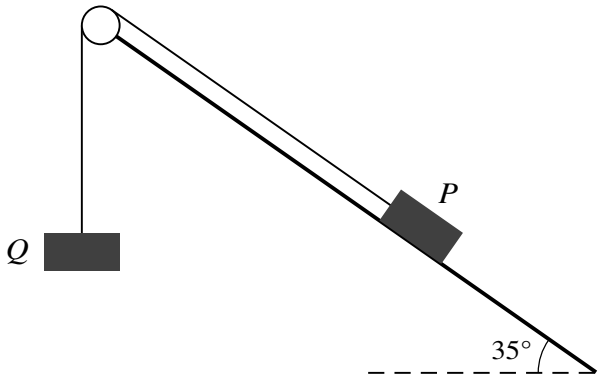

Blocks P and Q, of mass m kg and 5 kg respectively, are attached to the ends of a light inextensible string. The string passes over a small smooth pulley which is fixed at the top of a rough plane inclined at 35° to the horizontal. Block P is at rest on the plane and block Q hangs vertically below the pulley (see diagram). The coefficient of friction between block P and the plane is 0.2. Find the set of values of m for which the two blocks remain at rest. [6]

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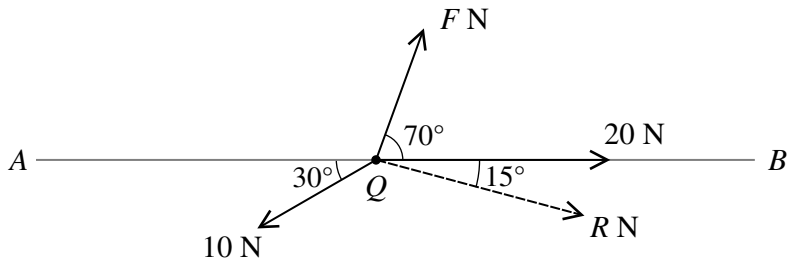

A small bead Q can move freely along a smooth horizontal straight wire AB of length 3 m. Three horizontal forces of magnitudes F N, 10 N and 20 N act on the bead in the directions shown in the diagram. The magnitude of the resultant of the three forces is R N in the direction shown in the diagram.

(i) Find the values of F and R. [5]

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(ii) Initially the bead is at rest at A. It reaches B with a speed of $11.7\,\mathrm{m\,s^{-1}}$. Find the mass of the bead. [3]

6 A particle P moves in a straight line, starting from a point O. The velocity of P, measured in $\mathrm{m\,s^{-1}}$, at time t s after leaving O is given by

$$v = 0.6t - 0.03t^2.$$

(i) Verify that, when $t = 5$, the particle is 6.25 m from O. Find the acceleration of the particle at this time. [4]

(ii) Find the values of t at which the particle is travelling at half of its maximum velocity. [6]

7 A cyclist starts from rest at point A and moves in a straight line with acceleration $0.5\,\text{m}\,\text{s}^{-2}$ for a distance of 36 m. The cyclist then travels at constant speed for 25 s before slowing down, with constant deceleration, to come to rest at point B. The distance AB is 210 m.

(i) Find the total time that the cyclist takes to travel from A to B. [5]

24 s after the cyclist leaves point A, a car starts from rest from point A, with constant acceleration $4\,\text{m s}^{-2}$, towards B. It is given that the car overtakes the cyclist while the cyclist is moving with constant speed.

(ii) Find the time that it takes from when the cyclist starts until the car overtakes her. [5]

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