MATHEMATICS **9709/04**

Paper 4 Mechanics 1 **(M1)** **May/June 2009**

1 hour 15 minutes

Additional Materials: Answer Booklet/Paper
Graph Paper
List of Formulae (MF9)

READ THESE INSTRUCTIONS FIRST

If you have been given an Answer Booklet, follow the instructions on the front cover of the Booklet.

Write your Centre number, candidate number and name on all the work you hand in.

Write in dark blue or black pen.

You may use a soft pencil for any diagrams or graphs.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** the questions.

Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.

Where a numerical value for the acceleration due to gravity is needed, use $10 \, \text{m s}^{-2}$.

The use of an electronic calculator is expected, where appropriate.

You are reminded of the need for clear presentation in your answers.

At the end of the examination, fasten all your work securely together.

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

The total number of marks for this paper is 50.

Questions carrying smaller numbers of marks are printed earlier in the paper, and questions carrying larger numbers of marks later in the paper.

This document consists of **4** printed pages.

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International Examinations

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1
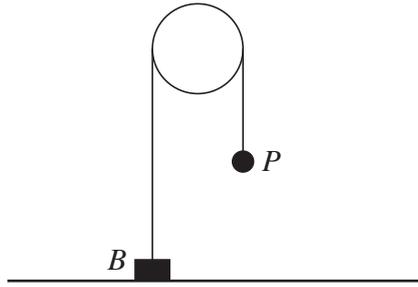
A block B of mass 5 kg is attached to one end of a light inextensible string. A particle P of mass 4 kg is attached to other end of the string. The string passes over a smooth pulley. The system is in equilibrium with the string taut and its straight parts vertical. B is at rest on the ground (see diagram). State the tension in the string and find the force exerted on B by the ground. [3]

2
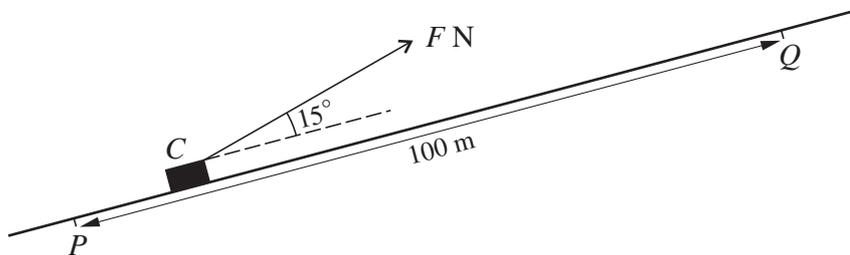
A crate C is pulled at constant speed up a straight inclined path by a constant force of magnitude F N, acting upwards at an angle of $15°$ to the path. C passes through points P and Q which are 100 m apart (see diagram). As C travels from P to Q the work done against the resistance to C's motion is 900 J, and the gain in C's potential energy is 2100 J. Write down the work done by the pulling force as C travels from P to Q, and hence find the value of F. [3]

3
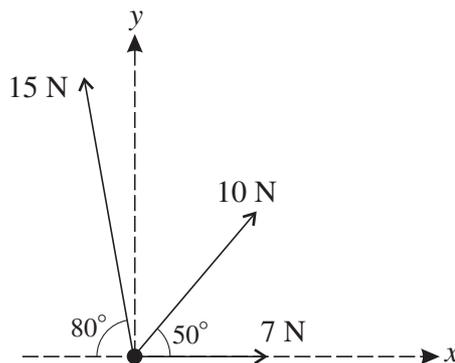
Forces of magnitudes 7 N, 10 N and 15 N act on a particle in the directions shown in the diagram.

   (i) Find the component of the resultant of the three forces

   (a) in the x-direction,

   (b) in the y-direction.

[3]

   (ii) Hence find the direction of the resultant. [2]

4
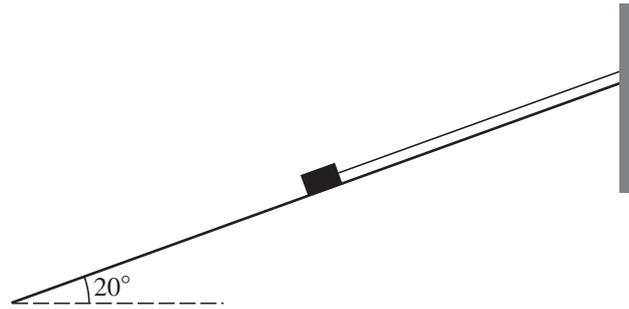
A block of mass 8 kg is at rest on a plane inclined at 20° to the horizontal. The block is connected to a vertical wall at the top of the plane by a string. The string is taut and parallel to a line of greatest slope of the plane (see diagram).

(i) Given that the tension in the string is 13 N, find the frictional and normal components of the force exerted on the block by the plane. [4]

The string is cut; the block remains at rest, but is on the point of slipping down the plane.

(ii) Find the coefficient of friction between the block and the plane. [2]

5
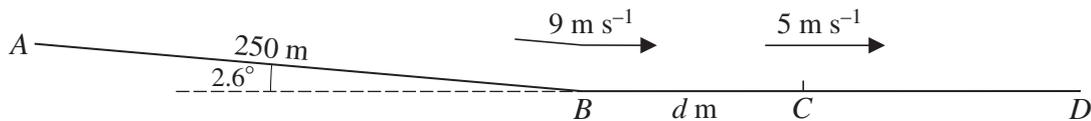
A cyclist and his machine have a total mass of 80 kg. The cyclist starts from rest at the top A of a straight path AB, and freewheels (moves without pedalling or braking) down the path to B. The path AB is inclined at 2.6° to the horizontal and is of length 250 m (see diagram).

(i) Given that the cyclist passes through B with speed $9\,\text{m s}^{-1}$, find the gain in kinetic energy and the loss in potential energy of the cyclist and his machine. Hence find the work done against the resistance to motion of the cyclist and his machine. [3]

The cyclist continues to freewheel along a horizontal straight path BD until he reaches the point C, where the distance BC is d m. His speed at C is $5\,\text{m s}^{-1}$. The resistance to motion is constant, and is the same on BD as on AB.

(ii) Find the value of d. [3]

The cyclist starts to pedal at C, generating 425 W of power.

(iii) Find the acceleration of the cyclist immediately after passing through C. [3]

6
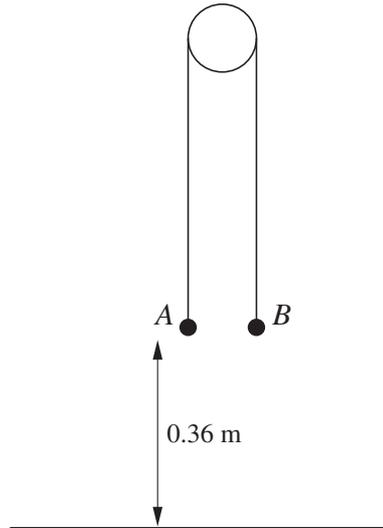
Particles A and B are attached to the ends of a light inextensible string which passes over a smooth pulley. The system is held at rest with the string taut and its straight parts vertical. Both particles are at a height of 0.36 m above the floor (see diagram). The system is released and A begins to fall, reaching the floor after 0.6 s.

(i) Find the acceleration of A as it falls. [2]

The mass of A is 0.45 kg. Find

(ii) the tension in the string while A is falling, [2]

(iii) the mass of B, [3]

(iv) the maximum height above the floor reached by B. [3]

7 A particle P travels in a straight line from A to D, passing through the points B and C. For the section AB the velocity of the particle is $(0.5t - 0.01t^2)\,\text{m s}^{-1}$, where t s is the time after leaving A.

(i) Given that the acceleration of P at B is $0.1\,\text{m s}^{-2}$, find the time taken for P to travel from A to B. [3]

The acceleration of P from B to C is constant and equal to $0.1\,\text{m s}^{-2}$.

(ii) Given that P reaches C with speed $14\,\text{m s}^{-1}$, find the time taken for P to travel from B to C. [3]

P travels with constant deceleration $0.3\,\text{m s}^{-2}$ from C to D. Given that the distance CD is 300 m, find

(iii) the speed with which P reaches D, [2]

(iv) the distance AD. [6]