ZIMBABWE SCHOOL EXAMINATIONS COUNCIL

General Certificate of Education Advanced Level

MECHANICAL MATHEMATICS 6021/2

PAPER 1

SPECIMEN PAPER 3 hours

Additional materials:
Answer paper
Graph paper
List of Formulae
Electronic calculator

TIME 3 hours

INSTRUCTIONS TO CANDIDATES

Write your name, centre number and candidate number in the spaces provided on the answer paper/answer booklet.

Answer all questions in Section A and any five from Section B

If a numerical answer cannot be given exactly, and the accuracy required is not specified in the question, then in the case of an angle it should be given to the nearest degree, and in other cases it should be given correct to 2 significant figures.

If a numerical value for g is necessary, take $g = 9.81\ \text{ms}^{-2}$.

INFORMATION FOR CANDIDATES

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 120.

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

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

This question paper consists of 7 printed pages and 1 blank page.

[Turn over

Section A (40)

Answer all questions in this section

1 A particle of mass 0,5 kg rests on a rough horizontal surface. A force of 3 N acts on the particle at an angle of 60° to the horizontal.

(i) Show that R_1, the normal reaction is $\frac{10 - 3\sqrt{3}}{2}$. [3]

(ii) Given that the particle is in limiting equilibrium, find μ, the coefficient of friction between the surface and the particle to one decimal place. [3]

2 A particle of mass 4 kg resting on a rough horizontal table is acted on by two horizontal forces of magnitudes 20 N and 30 N. The angle between the two forces is 120°. The coefficient of friction between the particle and the table is $\frac{1}{4}$.

Find the acceleration of the particle. [6]

3 A body of mass 3 kg is on a plane inclined at 45° to the horizontal. A force F N acts up the plane such that the body is in limiting equilibrium.

Calculate F if the surface is,

(i) smooth, [3]

(ii) rough and the coefficient of friction between the particle and the plane is $\frac{1}{3}$. [4]

4 A force of 1 N acts on a particle of mass 2 kg which is initially at rest on a smooth horizontal surface.

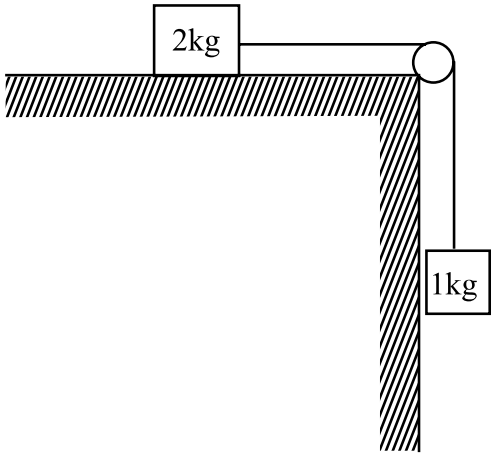
Find the,

(i) acceleration, [3]

(ii) velocity of the particle after 5 seconds, [3]

(iii) distance travelled in the first 5 seconds. [3]

5 The diagram shows a block of mass 2 kg resting on a horizontal table where the coefficient of friction is 0,3. The block is attached to a light, inextensible string which passes over a smooth pulley and a mass of 1 kg is hanging freely.



(a) Calculate the tension in the string and the acceleration of the system when it is released from rest. [4]

(b) Calculate the time taken for the 2 kg mass to reach the pulley that is 2,5 m away given that the 1 kg mass does not reach the ground. [3]

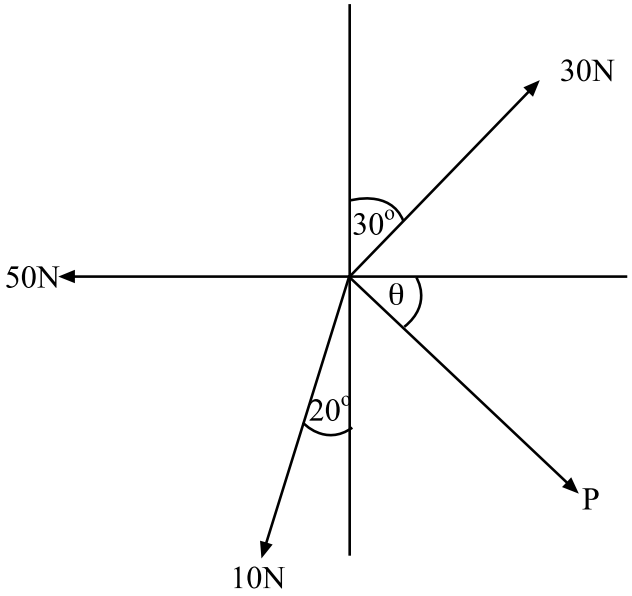
(c) Calculate the loss in potential energy in the system during this time. [2]

(d) Calculate the kinetic energy of the 2 kg particle immediately before it reaches the pulley. [3]

Section B (80)

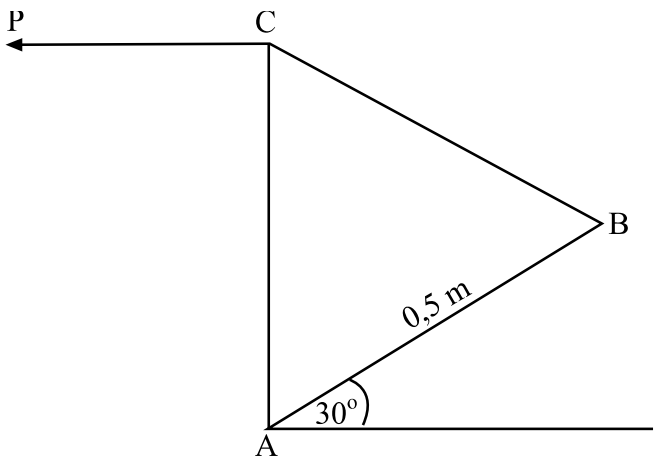
Answer any five questions from this section.
Each question carries 16 marks.

6 (a) Four coplanar forces 50 N, 10 N, P N and 30 N act on a body as shown in the diagram.



Given that the forces are in equilibrium, find the values of angle θ and force P. [6]

(b)



A uniform lamina of mass 6 kg is in the form of an equilateral triangle ABC of side 0.5 m. It is held vertically with side AB inclined at 30° to the horizontal by a horizontal force, P, applied at point C (see diagram).

By taking moments at A or otherwise, calculate the magnitude of force P. [10]

7 A particle of mass 10 kg is pulled up a rough plane by a force parallel to the plane. The angle of inclination of the plane to the horizontal is $\sin^{-1}\left(\frac{4}{5}\right)$.

The work done by the force in moving the particle a distance of 5 m at a constant speed is 600 joules.

(a) Find the

(i) normal reaction on the particle by the plane, [3]

(ii) work done against gravity, [3]

(iii) coefficient of friction between the particle and the plane. [3]

(b) **(i)** If it takes 2 seconds to cover the 5 m distance, find the power of the pulling force. [3]

(ii) Hence or otherwise, find the constant speed. [4]

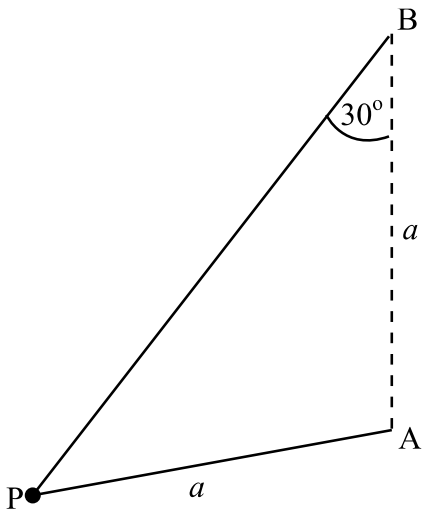
8 (a) A particle of mass 0.02 kg is fired vertically upwards with an initial velocity of $4\,\text{ms}^{-1}$. It passes through the resisting medium where the resistance to motion is proportional to its velocity, $V\,\text{ms}^{-1}$ at a time, t seconds.

(i) Show that $\frac{dV}{dt} = -\left(g + 50kV\right)$ where g is acceleration due to gravity and k, a positive constant. [3]

(ii) Express V in terms of t, g and k. [3]

(iii) Hence, show that as t increases, $V = \frac{-g}{50k}$. [3]

(b)



The diagram shows a particle, P, of mass 1 kg which is attached to fixed points A and B by means of two light inextensible strings. AP = AB = a metres. PB makes an angle of 30° with the vertical AB. The system rotates with a speed of V ms^{-1} about AB with both strings taut.

(i) Express length PB in terms of a. [2]

(ii) Find the tensions in the two strings in terms of a, g and V. [5]

9 A particle is travelling in a straight line with simple harmonic motion. The greatest speed of the particle is 4 ms^{-1} and the period of motion of the particle is 2 seconds.

(a) Find the

(i) amplitude, [3]

(ii) speed of the particle when it is $\frac{2}{p}$ m from the centre of the path, [4]

(iii) maximum acceleration. [5]

(b) At t = 0, the particle is passing through the centre of the path.

Find the least positive value of t when x = 0.3 m. [4]

10 A block of mass 3 kg is suspended by an elastic string of modulus of elasticity 40 N. In the equilibrium position, the length of the string is 9 m.

(a) Find the natural length of the string, giving your answer to 2 decimal places. [6]

(b) The 3 kg mass is pulled vertically down from the equilibrium position until the length of the string is 15 m and then released.

Find the velocity of the block when the string first becomes slack. [10]

11 A particle is projected from a point O which is 5 m above the horizontal ground. The initial velocity of the particle is 30 ms^{-1} at an angle of elevation $\arctan\left(\frac{3}{4}\right)$.

(i) Calculate the speed of the particle 4 seconds after projection. [5]

(ii) Find the direction of the particle as it passes a point that is 5 m above the ground. [5]

(ii) The particle hits the ground at point T.

Find the displacement OT. [6]

12 **(a)** A train of mass 300 tonnes is moving up an inclined plane of angle θ to the horizontal, where $\text{Sin } \theta = \frac{1}{250}$. The resistance to motion is 3 000 N and the train is accelerating at 0,2 m/s^2.

Find,

(i) the driving force of the engine, [6]

(ii) the power exerted by the engine when the speed is 10 m/s. [4]

(b) A trolley is pulled horizontally through 5 m by a force of 70 N at an angle of 60° to the horizontal. Calculate the work done, if the surface is smooth. [6]

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