Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel Level 3 GCE

Centre Number | Candidate Number

Mock Paper

Paper Reference **9MA0-31**

Mathematics

Advanced

Paper 3B – Mechanics

You must have:
Mathematical Formulae and Statistical Tables, calculator

Total Marks

Candidates may use any calculator allowed by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

Use **black** ink or ball-point pen.
If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
Fill in the boxes at the top of this page with your name, centre number and candidate number.
Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
Answer the questions.
You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
Inexact answers should be given to three significant figures unless otherwise stated.

Information

A booklet 'Mathematical Formulae and Statistical Tables' is provided.
There are 10 questions in this question paper. The total mark for this paper is 104.
The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question*.

Advice

Read each question carefully before you start to answer it.
Try to answer every question.
Check your answers if you have time at the end.

1.

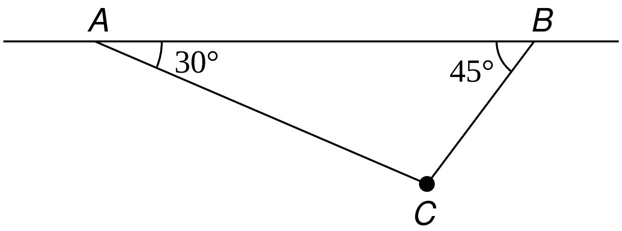

Figure 1

A particle of weight *W* is attached at *C* to two light inextensible strings *AC* and *BC*. The other ends of the strings are attached to fixed points *A* and *B* on a horizontal ceiling. The particle hangs in equilibrium with the strings in a vertical plane and with *AC* and *BC* inclined to the horizontal at 30° and 45° respectively, as shown in Figure 1.

Find, in terms of *W*,

(i) the tension in *AC*,

(ii) the tension in *BC*.

(Total 7 marks)

2.

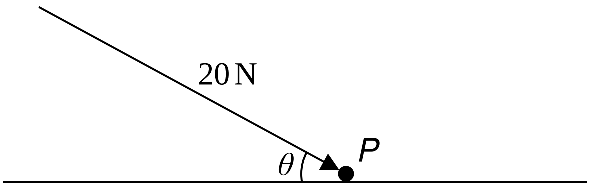

Figure 2

A particle *P* of weight 40 N lies at rest in equilibrium on a fixed rough horizontal surface. A force of magnitude 20 N is applied to *P*. The force acts at angle θ to the horizontal, as shown in Figure 2. The coefficient of friction between *P* and the surface is μ.

Given that the particle remains at rest, show that

$$\mu \geqslant \frac{\cos\theta}{2 + \sin\theta}$$

(Total 6 marks)

---

3. A package of mass 6 kg is held at rest at a fixed point *A* on a rough plane. The plane is inclined at 30° to the horizontal. The package is released from rest and slides down a line of greatest slope of the plane. The coefficient of friction between the package and the plane is $\frac{1}{4}$. The package is modelled as a particle.

(*a*) Find the magnitude of the acceleration of the package.

(6)

As it slides down the slope the package passes through the point *B*, where *AB* = 10 m.

(*b*) Find the speed of the package as it passes through *B*.

(2)

(Total 8 marks)

---

4. A cyclist is travelling along a straight horizontal road. The cyclist starts from rest at point *A* on the road and accelerates uniformly at 0.6 m s^{-2} for 20 seconds. He then moves at constant speed for $4T$ seconds, where $T < 20$. He then decelerates uniformly at 0.3 m s^{-2} and after T seconds passes through point *B* on the road. The distance from *A* to *B* is 705 m.

(*a*) Sketch a speed-time graph for the motion of the cyclist between points *A* and *B*.

(2)

(*b*) Find the value of T.

(7)

The cyclist continues his journey, still decelerating uniformly at 0.3 m s^{-2}, until he comes to rest at point *C* on the road.

(*c*) Find the total time taken by the cyclist to travel from *A* to *C*.

(3)

(Total 12 marks)

---

5. [*In this question* **i** *and* **j** *are perpendicular horizontal unit vectors.*]

A particle P of mass 2 kg moves under the action of two forces, $(2\mathbf{i} + 3\mathbf{j})$ N and $(4\mathbf{i} - 5\mathbf{j})$ N.

(*a*) Find the magnitude of the acceleration of P.

(4)

At time $t = 0$, P has velocity $(-u\mathbf{i} + u\mathbf{j})$ m s^{-1}, where u is a positive constant.

At time $t = T$ seconds, P has velocity $(10\mathbf{i} + 2\mathbf{j})$ m s^{-1}.

(*b*) Find

(i) the value of T,

(ii) the value of u.

(5)

(Total 9 marks)

6.

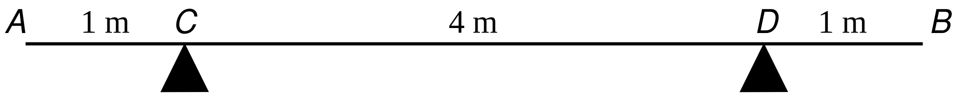

Figure 3

A non-uniform rod AB has length 6 m and mass 8 kg. The rod rests in equilibrium, in a horizontal position, on two smooth supports at C and at D, where $AC = 1$ m and $DB = 1$ m, as shown in Figure 3. The magnitude of the reaction between the rod and the support at D is twice the magnitude of the reaction between the rod and the support at C. The centre of mass of the rod is at G, where $AG = x$ m.

(*a*) Show that $x = \frac{11}{3}$.

(6)

The support at C is moved to the point F on the rod, where $AF = 2$ m. A particle of mass 3 kg is placed on the rod at A. The rod remains horizontal and in equilibrium. The magnitude of the reaction between the rod and the support at D is k times the magnitude of the reaction between the rod and the support at F.

(*b*) Find the value of k.

(6)

(Total 12 marks)

7.

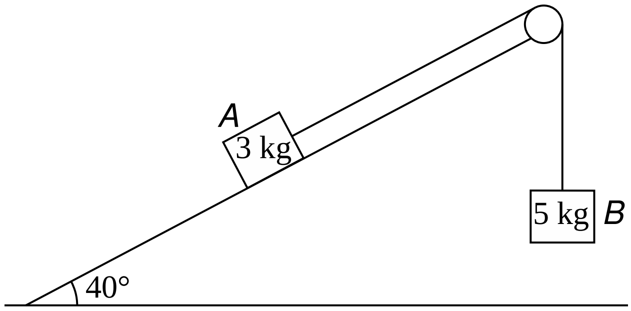

Figure 4

One end of a light inextensible string is attached to a block *A* of mass 3 kg. Block *A* is held at rest on a smooth fixed plane. The plane is inclined at 40° to the horizontal ground. The string lies along a line of greatest slope of the plane and passes over a small smooth pulley which is fixed at the top of the plane. The other end of the string is attached to a block *B* of mass 5 kg. Block *B* hangs freely at rest below the pulley, as shown in Figure 4. The system is released from rest with the string taut.

By modelling the two blocks as particles,

(*a*) find the tension in the string as *B* descends.

(6)

After falling for 1.5 s, block *B* hits the ground and is immediately brought to rest. In its subsequent motion, *A* does not reach the pulley.

(*b*) Find the speed of *B* at the instant it hits the ground.

(3)

(*c*) Find the total distance moved up the plane by *A* before it comes to instantaneous rest.

(5)

(Total 14 marks)

---

8. A particle *P* moves in a straight line. At time $t = 0$, *P* passes through a point *O* on the line. At time *t* seconds, the velocity of *P* is v m s^{-1} where

$$v = (2t - 1)(1 - t)$$

(*a*) Find the acceleration of *P* when $t = \frac{1}{2}$

(3)

(*b*) Find the distance travelled by *P* in the interval $0 \leqslant t \leqslant 1$

(6)

(Total 9 marks)

9.

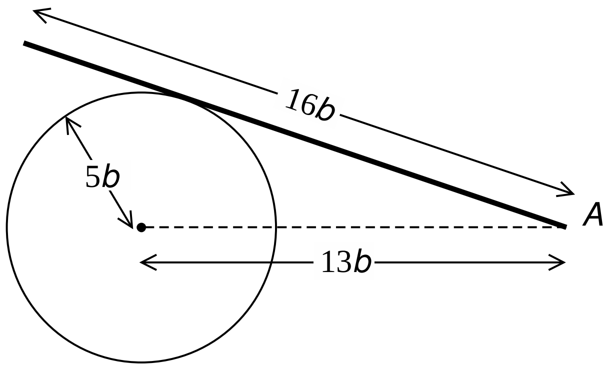

Figure 5

A uniform rod, of weight W and length $16b$, has one end freely hinged to a fixed point A. The rod rests against a smooth circular cylinder, of radius $5b$, fixed with its axis horizontal and at the same horizontal level as A. The distance of A from the axis of the cylinder is $13b$, as shown in Figure 5. The rod rests in a vertical plane which is perpendicular to the axis of the cylinder.

(a) Find, in terms of W, the magnitude of the reaction on the rod at its point of contact with the cylinder.

(4)

(b) Show that the resultant force acting on the rod at A is inclined to the vertical at an angle α where $\tan \alpha = \frac{40}{73}$

(6)

(Total 10 marks)

---

10. A particle is projected from a point O with speed U at an angle of elevation α to the horizontal and moves freely under gravity. When the particle has moved a horizontal distance x, its height above O is y.

(*a*) Show that

$$y = x\tan\alpha - \frac{gx^2(1+\tan^2\alpha)}{2U^2}$$

(7)

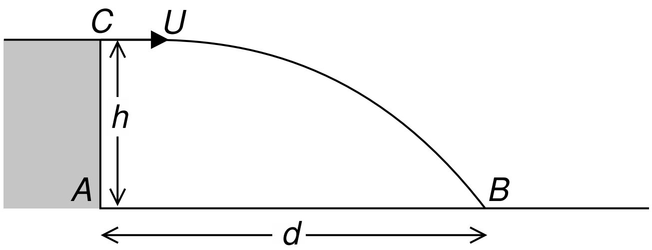

Figure 6

A small stone is projected horizontally with speed U from a point C at the top of a vertical cliff AC so as to hit a fixed target B on the horizontal ground. The point C is a height h above the ground, as shown in Figure 6. The time of flight of the stone from C to B is T, and the stone is modelled as a particle moving freely under gravity.

(*b*) Find, in terms of U, g and T, the speed of the stone as it hits the target at B.

(4)

It is found that, using the same initial speed U, the target can also be hit by projecting the stone from C at an angle α above the horizontal. The stone is again modelled as a particle moving freely under gravity and the distance $AB = d$.

(*c*) Using the result in part (*a*), or otherwise, show that

$$d = \frac{1}{2}gT^2\tan\alpha$$

(6)

(Total 17 marks)

TOTAL FOR PAPER: 75 MARKS