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 11 questions in this question paper. The total mark for this paper is 114.
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.

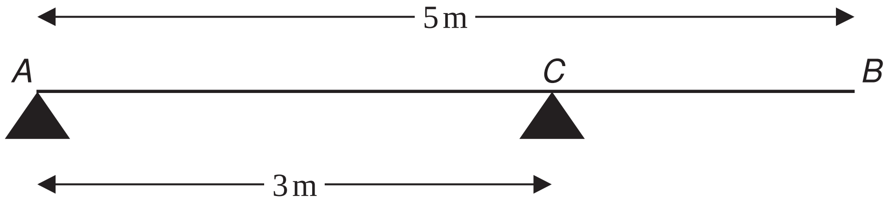

Figure 1

A non-uniform plank *AB* has weight 60 N and length 5 m. The plank rests horizontally in equilibrium on two smooth supports at *A* and *C*, where *AC* = 3 m, as shown in Figure 1. A parcel of weight 12 N is placed on the plank at *B* and the plank remains horizontal and in equilibrium. The magnitude of the reaction of the support at *A* on the plank is half the magnitude of the reaction of the support at *C* on the plank.

By modelling the plank as a non-uniform rod and the parcel as a particle,

(*a*) find the distance of the centre of mass of the plank from *A*.

(6)

(*b*) State briefly how you have used the modelling assumption

(i) that the parcel is a particle,

(ii) that the plank is a rod.

(2)

(Total 8 marks)

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2. At time $t = 0$, a stone is thrown vertically upwards with speed 19.6 m s^{-1} from a point *A* which is *h* metres above horizontal ground. At time $t = 3$ s, another stone is released from rest from a point *B* which is also *h* metres above the same horizontal ground. Both stones hit the ground at time $t = T$ seconds. The motion of each stone is modelled as that of a particle moving freely under gravity.

Find

(i) the value of *T*,

(ii) the value of *h*.

(7)

(Total 7 marks)

3.

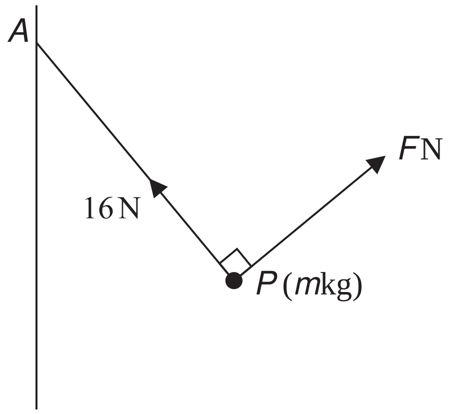

Figure 2

A particle P of mass m kg is attached to one end of a light inextensible string of length 2.5 m. The other end of the string is attached to a fixed point A on a vertical wall. The tension in the string is 16 N. The particle held in equilibrium by a force of magnitude F newtons, acting in the vertical plane which is perpendicular to the wall and contains the string. This force acts in a direction perpendicular to the string, as shown in Figure 2.

Given that the horizontal distance of P from the wall is 1.5 m, find

(i) the value of F,

(ii) the value of m.

(7)

(Total 7 marks)

4.

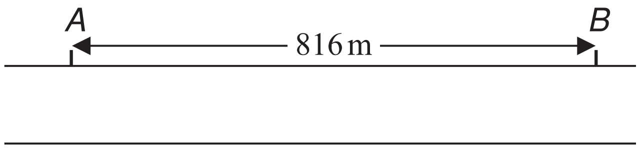

Figure 3

Two posts, *A* and *B*, are fixed at the side of a straight horizontal road and are 816 m apart, as shown in Figure 3. A car and a van are at rest side by side on the road and level with *A*. The car and the van start to move at the same time in the direction *AB*. The car accelerates from rest with constant acceleration until it reaches a speed of 24 m s^{-1}. The car then moves at a constant speed of 24 m s^{-1}. The van accelerates from rest with constant acceleration for 12 s until it reaches a speed of V m s^{-1}. The van then moves at a constant speed of V m s^{-1}. When the car has been moving at 24 m s^{-1} for 30 s, the van draws level with the car at *B*, and each vehicle has then travelled a distance of 816 m.

(*a*) Sketch, on the same diagram, a speed-time graph for the motion of each vehicle from *A* to *B*.

(3)

(*b*) Find the time for which the car is accelerating.

(3)

(*c*) Find the value of V.

(3)

(Total 9 marks)

[*In this question the unit vectors* **i** *and* **j** *are horizontal vectors due east and due north respectively and position vectors are given relative to a fixed origin*.]

5. The point A on a horizontal playground has position vector $(3\mathbf{i} - 2\mathbf{j})$ m. At time $t = 0$, a girl kicks a ball from A. The ball moves horizontally along the playground with constant velocity $(4\mathbf{i} + 5\mathbf{j})$ m s^{-1}.

Modelling the ball as a particle, find

(*a*) the speed of the ball,

(2)

(*b*) the position vector of the ball at time t seconds.

(2)

The point B on the playground has position vector $(\mathbf{i} + 6\mathbf{j})$ m. At time $t = T$ seconds, the ball is due east of B.

(*c*) Find the value of T.

(2)

A boy is running due east with constant speed v m s^{-1}. At the instant when the girl kicks the ball from A, the boy is at B.

Given that the boy intercepts the ball,

(*d*) find the value of v.

(5)

(Total 11 marks)

6. A truck of mass 1600 kg is towing a car of mass 960 kg along a straight horizontal road. The truck and the car are joined by a light rigid tow bar. The tow bar is horizontal and is parallel to the direction of motion. The truck and the car experience constant resistances to motion of magnitude 640 N and *R* newtons respectively. The truck's engine produces a constant driving force of magnitude 2100 N. The magnitude of the acceleration of the truck and the car is 0.4 m s^{-2}.

(*a*) Show that $R = 436$

(3)

(*b*) Find the tension in the tow bar.

(3)

The two vehicles come to a hill inclined at an angle α to the horizontal where $\sin \alpha = \frac{1}{15}$.

The truck and the car move down a line of greatest slope of the hill with the tow bar parallel to the direction of motion. The truck's engine produces a constant driving force of magnitude 2100 N. The magnitudes of the resistances to motion on the truck and the car are 640 N and 436 N respectively.

(*c*) Find the magnitude of the acceleration of the truck and the car as they move down the hill.

(4)

(Total 10 marks)

7.

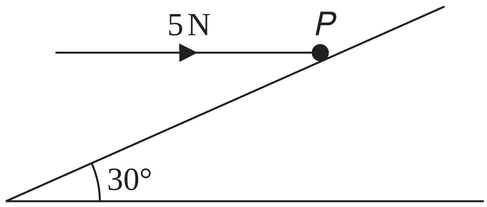

Figure 4

A rough plane is inclined at 30° to the horizontal. A particle P of mass 0.5 kg is held at rest on the plane by a horizontal force of magnitude 5 N, as shown in Figure 4. The force acts in a vertical plane containing a line of greatest slope of the inclined plane. The particle is on the point of moving up the plane.

(*a*) Find the magnitude of the normal reaction of the plane on P.

(4)

(*b*) Find the coefficient of friction between P and the plane.

(5)

The force of magnitude 5 N is now removed and P accelerates from rest down the plane.

(*c*) Find the speed of P after it has travelled 3 m down the plane.

(8)

(Total 17 marks)

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8. At time t seconds ($t \geqslant 0$) a particle P has position vector $\mathbf{r}$ metres, with respect to a fixed origin O, where

$$\mathbf{r} = (16t - 3t^3)\mathbf{i} + (t^3 - t^2 + 2)\mathbf{j}$$

Find

(*a*) the velocity of P at the instant when it is moving parallel to the vector $\mathbf{j}$,

(5)

(*b*) the magnitude of the acceleration of P when $t = 4$

(4)

(Total 9 marks)

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9. At time $t = 0$ a ball is projected from a fixed point A on horizontal ground to hit a target. The ball is projected from A with speed u m s–1 at an angle $\theta°$ to the horizontal. At time $t = 2$ s the ball hits the target. At the instant when it hits the target, the ball is travelling downwards at 30° below the horizontal with speed 12 m s^{-1}. The ball is modelled as a particle moving freely under gravity and the target is modelled as the point T.

(*a*) Find

(i) the value of θ,

(ii) the value of u.

(7)

The height of T above the ground is h metres.

(*b*) Find the value of h.

(3)

(*c*) Find the length of time for which the ball is more than h metres above the ground during the flight from A to T.

(3)

(Total 13 marks)

10.

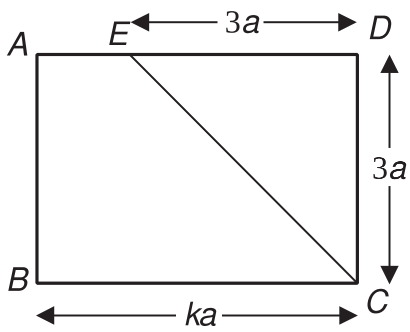

Figure 5

Figure 5 shows a uniform rectangular lamina *ABCD* with sides of length 3*a* and *ka*, where *k* > 3. The point *E* on side *AD* is such that *DE* = 3*a*. Rectangle *ABCD* is folded along the line *CE* to produce the folded lamina *L* shown in Figure 6.

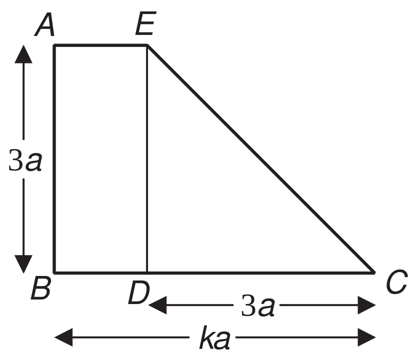

Figure 6

Find, in terms of *a* and *k*,

(*a*) the distance of the centre of mass of *L* from *AB*,

(5)

(*b*) the distance of the centre of mass of *L* from *AE*.

(4)

The folded lamina *L* is freely suspended from *A* and hangs in equilibrium with *AB* at 45° to the downward vertical.

(*c*) Find, to 3 significant figures, the value of *k*.

(4)

(Total 13 marks)

11.

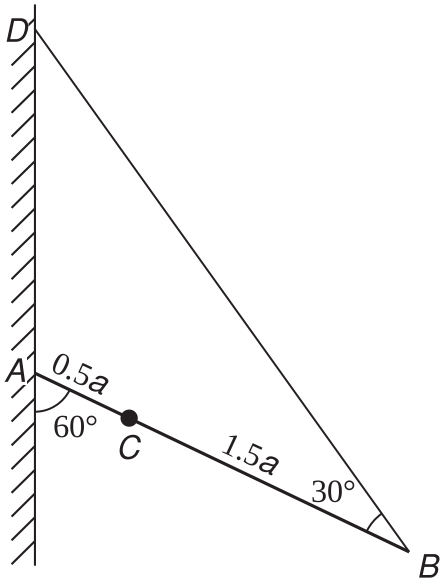

Figure 7

A uniform rod, *AB*, of mass $8m$ and length $2a$, has its end *A* resting against a rough vertical wall. One end of a light inextensible string is attached to the rod at *B* and the other end of the string is attached to the wall at the point *D*, which is vertically above *A*. The angle between the rod and the string is 30°. A particle of mass km is fixed to the rod at *C*, where $AC = 0.5a$. The rod is in equilibrium in a vertical plane perpendicular to the wall, and is at an angle of 60° to the wall, as shown in Figure 7. The tension in the string is *T*.

(*a*) Show that $T = \frac{\sqrt{3}}{4}(16 + k)\,mg$

(4)

The coefficient of friction between the wall and the rod is $\frac{2}{3}\sqrt{3}$.

Given that the rod is in limiting equilibrium,

(*b*) find the value of *k*.

(6)

(Total 10 marks)

TOTAL FOR MECHANICS IS 114 MARKS