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 8 questions in this question paper. The total mark for this paper is 88.
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. [*In this question* **i** *and* **j** *are horizontal unit vectors due east and due north respectively and position vectors are given relative to a fixed origin O*.]

At time $t = 0$, a bird A leaves its nest, that is located at the point with position vector $(20\mathbf{i} - 17\mathbf{j})$ m, and flies with constant velocity $(-6\mathbf{i} + 7\mathbf{j})$ m s^{-1}. At the same time a second bird B leaves its nest which is located at the point with position vector $(-8\mathbf{i} + 9\mathbf{j})$ m and flies with constant velocity $(p\mathbf{i} + 2p\mathbf{j})$ m s^{-1}, where p is a constant. At time $t = 4$ s, bird B is south west of bird A.

(*a*) Find the direction of motion of A, giving your answer as a bearing to the nearest degree.

(3)

(*b*) Find the speed of B.

(10)

(Total 13 marks)

2.

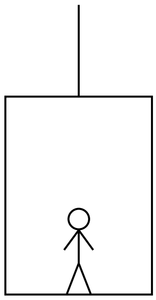

Figure 1

A lift of mass M kg is being raised by a vertical cable attached to the top of the lift. A person of mass m kg stands on the floor inside the lift, as shown in Figure 1. The lift ascends vertically with constant acceleration 1.4 m s^{-2}. The tension in the cable is 2800 N and the person experiences a constant normal reaction of magnitude 560 N from the floor of the lift. The cable is modelled as being light and inextensible, the person is modelled as a particle and air resistance is negligible.

(*a*) Write down an equation of motion for the person only.

(2)

(*b*) Write down an equation of motion for the lift only.

(2)

(*c*) Hence, or otherwise, find

(i) the value of m,

(ii) the value of M.

(3)

(Total 7 marks)

3.

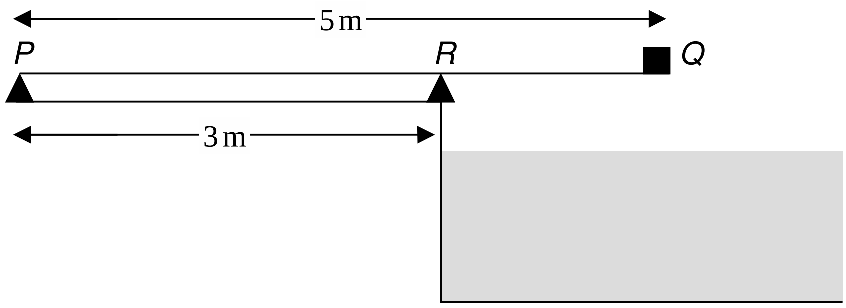

Figure 2

A boy sees a box on the end Q of a plank PQ which overhangs a swimming pool. The plank has mass 30 kg, is 5 m long and rests in a horizontal position on two bricks. The bricks are modelled as smooth supports, one acting on the rod at P and one acting on the rod at R, where $PR = 3$ m. The support at R is on the edge of the swimming pool, as shown in Figure 2. The boy has mass 40 kg and the box has mass 2.5 kg. The plank is modelled as a uniform rod and the boy and the box are modelled as particles.

The boy steps on to the plank at P and begins to walk slowly along the plank towards the box.

(*a*) Find the distance he can walk along the plank from P before the plank starts to tilt.

(4)

(*b*) State how you have used, in your working, the fact that the box is modelled as a particle.

(1)

A rock of mass M kg is placed on the plank at P. The boy is then able to walk slowly along the plank to the box at the end Q without the plank tilting. The rock is modelled as a particle.

(*c*) Find the smallest possible value of M.

(4)

(Total 9 marks)

4.

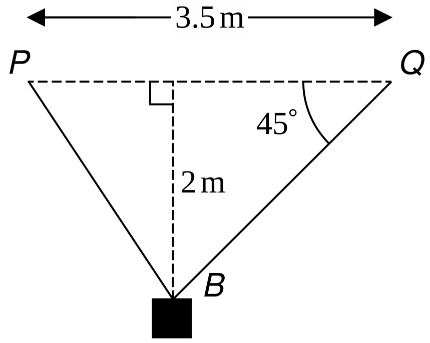

Figure 3

A small metal box of mass 6 kg is attached at B to two ropes BP and BQ. The fixed points P and Q are on a horizontal ceiling and PQ = 3.5 m. The box hangs in equilibrium at a vertical distance of 2 m below the line PQ, with the ropes in a vertical plane and with angle BQP = 45°, as shown in Figure 3. The box is modelled as a particle and the ropes are modelled as light inextensible strings. Find

(i) the tension in BP,

(ii) the tension in BQ.

(10)

(Total 10 marks)

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5. A train travels for a total of 270 s along a straight horizontal track between two stations A and B. The train starts from rest at A and moves with constant acceleration for 60 s until it reaches a speed of V m s^{-1}. The train then travels at this constant speed V m s^{-1} before it moves with constant deceleration for 30 s, coming to rest at B.

(*a*) Sketch below a speed-time graph for the journey of the train between the two stations A and B.

(2)

Given that the distance between the two stations is 4.5 km,

(*b*) find the value of V,

(3)

(*c*) find how long it takes the train to travel from station A to the point that is exactly halfway between the two stations.

(4)

The train is travelling at speed $\frac{1}{4}V$ m s^{-1} at times T_1 seconds and T_2 seconds after leaving station A.

(*d*) Find the value of T_1 and the value of T_2

(5)

(Total 14 marks)

6.

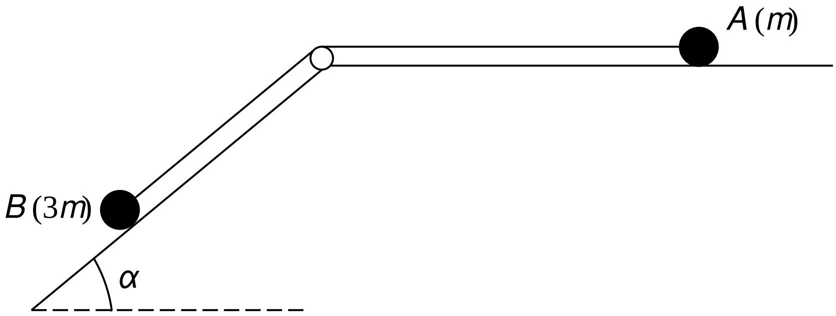

Figure 4

Two particles A and B have masses m and 3 m respectively. The particles are attached to the ends of a light inextensible string. Particle A is held at rest on a rough horizontal table.

The coefficient of friction between particle A and the table is $\frac{1}{5}$. The string lies along the table and passes over a small smooth light pulley that is fixed at the edge of the table. Particle B is at rest on a rough plane that is inclined to the horizontal at an angle α, where $\tan \alpha = \frac{4}{3}$, as shown in Figure 4. The coefficient of friction between particle B and the inclined plane is $\frac{1}{3}$. The string lies in the vertical plane that contains the pulley and a line of greatest slope of the inclined plane. The system is released from rest with the string taut and B slides down the inclined plane. Given that A does not reach the pulley,

(*a*) find the tension in the string,

(11)

(*b*) state where in your working you have used the fact that the string is modelled as being light,

(1)

(*c*) find the magnitude of the force exerted on the pulley by the string.

(4)

(Total 16 marks)

7.. A particle moves along the x-axis. At time t seconds, $t \geq 0$, the velocity of the particle is v m s^{-1} in the direction of x increasing, where $v = 2t^{\frac{3}{2}} - 6t + 2$

At time $t = 0$ the particle passes through the origin O. At the instant when the acceleration of the particle is zero, the particle is at the point A.

Find the distance OA.

(8)

(Total 8 marks)

8.

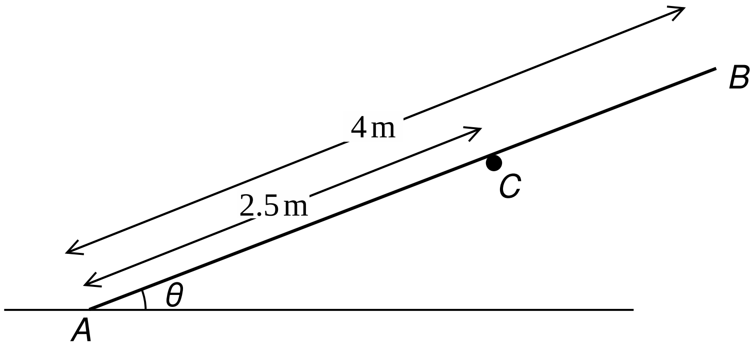

Figure 5

A plank AB rests in equilibrium against a fixed horizontal pole. The plank has length 4 m and weight 20 N and rests on the pole at C, where AC = 2.5 m. The end A of the plank rests on rough horizontal ground and AB makes an angle θ with the ground, as shown in Figure 5. The coefficient of friction between the plank and the ground is $\frac{1}{4}$.

The plank is modelled as a uniform rod and the pole as a rough horizontal peg that is perpendicular to the vertical plane containing AB.

Given that $\cos \theta = \frac{4}{5}$ and that the friction is limiting at both A and C,

(*a*) find the magnitude of the normal reaction on the plank at C,

(3)

(*b*) find the coefficient of friction between the plank and the pole.

(8)

(Total 11 marks)

TOTAL FOR PAPER: 75 MARKS