Name:

Total Marks:

A level Applied Mathematics

Paper 3B Mechanics

Practice Paper J11

Time: 2 hours

Information for Candidates

- This practice paper is an adapted legacy old paper for the Edexcel GCE A Level Specifications
- There are 9 questions in this question paper
- The total mark for this paper is 100.
- The marks for **each** question are shown in brackets.
- Full marks may be obtained for answers to ALL questions

Advice to candidates:

- You must ensure that your answers to parts of questions are clearly labelled.
- You must show sufficient working to make your methods clear to the Examiner
- Answers without working may not gain full credit

Question 1

A car accelerates uniformly from rest for 20 seconds. It moves at constant speed v m s^{-1} for the next 40 seconds and then decelerates uniformly for 10 seconds until it comes to rest.

(a) For the motion of the car, sketch

(i) a speed-time graph,
(ii) an acceleration-time graph. **(6)**

Given that the total distance moved by the car is 880 m,

(b) find the value of v. **(4)**

(Total 10 marks)

Question 2

A ball is thrown vertically upwards with speed u m s^{-1} from a point P at height h metres above the ground. The ball hits the ground 0.75 s later. The speed of the ball immediately before it hits the ground is 6.45 m s^{-1}. The ball is modelled as a particle.

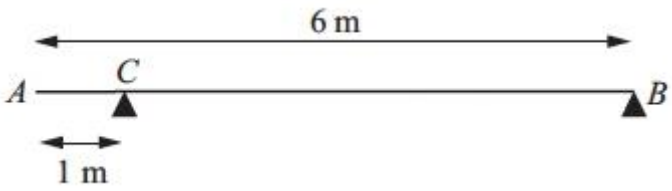
(a) Show that $u = 0.9$ **(3)**

(b) Find the height above P to which the ball rises before it starts to fall towards the ground again. **(2)**

(c) Find the value of h. **(3)**

(Total 8 marks)

Question 3



A uniform beam AB has mass 20 kg and length 6 m. The beam rests in equilibrium in a horizontal position on two smooth supports. One support is at C, where $AC = 1$ m, and the other is at the end B, as shown in the figure above. The beam is modelled as a rod.

(a) Find the magnitudes of the reactions on the beam at B and at C. **(5)**

A boy of mass 30 kg stands on the beam at the point D. The beam remains in equilibrium. The magnitudes of the reactions on the beam at B and at C are now equal. The boy is modelled as a particle.

(b) Find the distance AD. **(5)**

(Total 10 marks)

Question 4

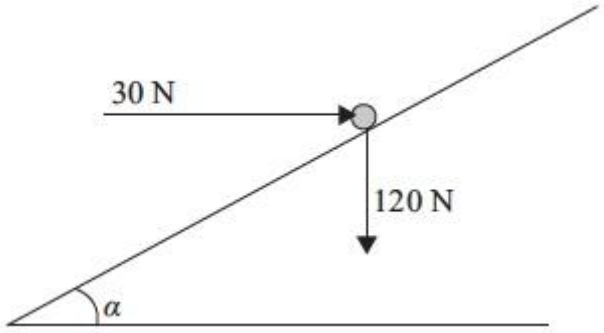


Figure 1

A particle of weight 120 N is placed on a fixed rough plane which is inclined at an angle α to the horizontal,

where $\tan \alpha = \frac{3}{4}$

The coefficient of friction between the particle and the plane is $\frac{1}{2}$.

The particle is held at rest in equilibrium by a horizontal force of magnitude 30 N, which acts in the vertical plane containing the line of greatest slope of the plane through the particle, as shown in Figure 1.

(a) Show that the normal reaction between the particle and the plane has magnitude 114 N **(4)**

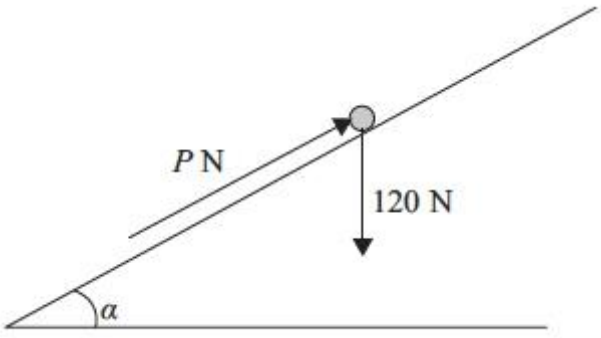


Figure 2

The horizontal force is removed and replaced by a force of magnitude P newtons acting up the slope along the line of greatest slope of the plane through the particle, as shown in Figure 2. The particle remains in equilibrium.

(b) Find the greatest possible value of P. **(8)**

(c) Find the magnitude and direction of the frictional force acting on the particle when $P = 30$. **(3)**

(Total 15 marks)

Question 5

A particle P of mass 2 kg is moving under the action of a constant force **F** newtons. The velocity of P is $(2\mathbf{i} - 5\mathbf{j})$ m s^{-1} at time $t = 0$, and $(7\mathbf{i} + 10\mathbf{j})$ m s^{-1} at time $t = 5$ s.

Find

(a) the speed of P at $t = 0$,

(2)

(b) the vector **F** in the form $a\mathbf{i} + b\mathbf{j}$,

(5)

(c) the value of t when P is moving parallel to **i**.

(4)

(Total 11 marks)

Question 6

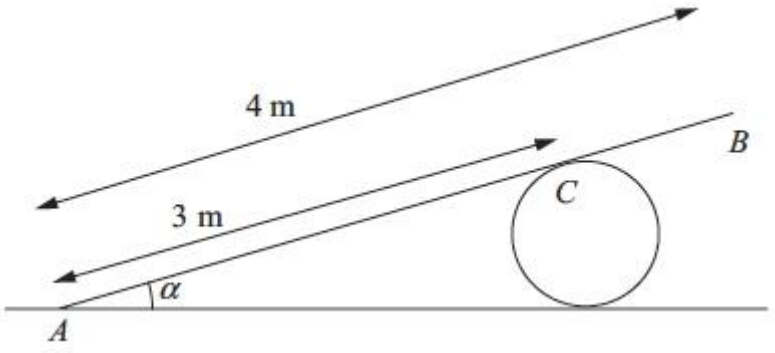


Figure 1

A uniform plank AB, of weight 100 N and length 4 m, rests in equilibrium with the end A on rough horizontal ground. The plank rests on a smooth cylindrical drum. The drum is fixed to the ground and cannot move. The point of contact between the plank and the drum is C, where $AC = 3$ m, as shown in Figure 1. The plank is resting in a vertical plane which is perpendicular to the axis of the drum, at an angle α to the horizontal, where $\sin\alpha = \frac{1}{3}$. The coefficient of friction between the plank and the ground is μ. Modelling the plank as a rod, find the least possible value of μ. **(10)**

(Total 10 marks)

Question 7

A particle moves along the x-axis. At time $t = 0$ the particle passes through the origin with speed 8 m s^{-1} in the positive x-direction. The acceleration of the particle at time t seconds, $t \geqslant$ is $(4t^3 - 12t)$ m s^{-2} in the positive x-direction.

Find

(a) the velocity of the particle at time t seconds, **(3)**

(b) the displacement of the particle from the origin at time t seconds, **(2)**

(c) the values of t at which the particle is instantaneously at rest. **(3)**

(Total 8 marks)

Question 8

*[In this question, the unit vectors **i** and **j** are in a vertical plane, **i** being horizontal and **j** being vertically upwards.]*

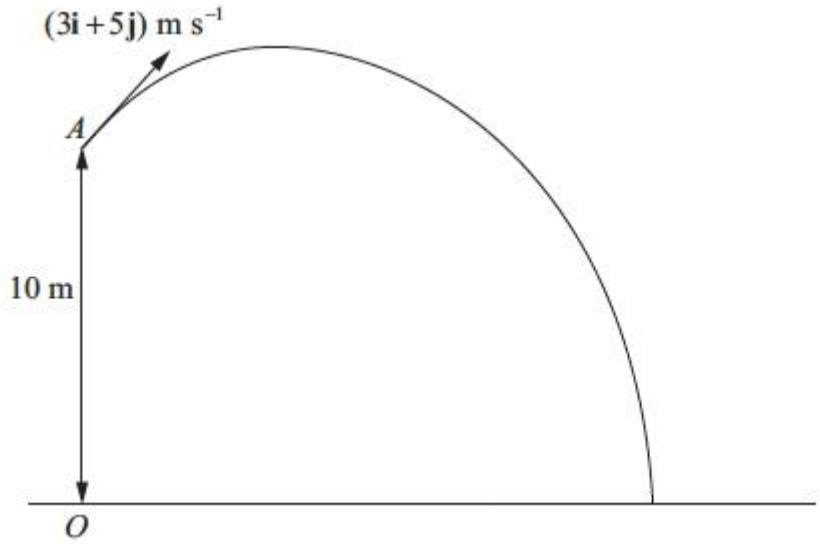


Figure 1

At time $t = 0$, a particle P is projected from the point A which has position vector 10**j** metres with respect to a fixed origin O at ground level. The ground is horizontal. The velocity of projection of P is (3**i** + 5**j**) m s^{-1}, as shown in Figure 1. The particle moves freely under gravity and reaches the ground after T seconds.

(a) For $0 \leqslant t \leqslant T$, show that, with respect to O, the position vector, **r** metres, of P at time t seconds is given by

$$\mathbf{r} = 3t\mathbf{i} + (10 + 5t - 4.9t^2)\mathbf{j}$$ **(3)**

(b) Find the value of T. **(3)**

(c) Find the velocity of P at time t seconds ($0 \leqslant t \leqslant T$). **(2)**

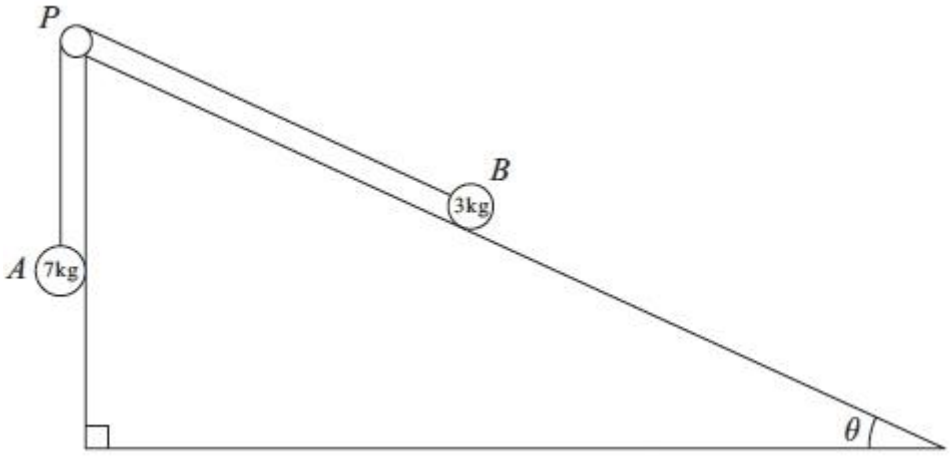
When P is at the point B, the direction of motion of P is 45° below the horizontal.

(d) Find the time taken for P to move from A to B. **(2)**

(e) Find the speed of P as it passes through B. **(2)**

(Total 12 marks)

Question 9



Two particles *A* and *B*, of mass 7 kg and 3 kg respectively, are attached to the ends of a light inextensible string. Initially *B* is held at rest on a rough fixed plane inclined at angle θ to the horizontal, where $\tan\theta = \frac{5}{12}$. The part of the string from *B* to *P* is parallel to a line of greatest slope of the plane. The string passes over a small smooth pulley, *P*, fixed at the top of the plane. The particle *A* hangs freely below *P*, as shown in above. The coefficient of friction between *B* and the plane is $\frac{2}{3}$. The particles are released from rest with the string taut and *B* moves up the plane.

(a) Find the magnitude of the acceleration of *B* immediately after release. **(10)**

(b) Find the speed of *B* when it has moved 1 m up the plane. **(2)**

When *B* has moved 1 m up the plane the string breaks. Given that in the subsequent motion *B* does not reach *P*,

(c) find the time between the instants when the string breaks and when *B* comes to instantaneous rest. **(4)**

(Total 16 marks)

TOTAL FOR PAPER IS 100 MARKS