Rewarding Learning

Centre Number

Candidate Number

General Certificate of Secondary Education
2024

Further Mathematics

Unit 2 **(With calculator)**
Mechanics

[GFM21]

GFM21

MONDAY 10 JUNE, MORNING

TIME

1 hour.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
You must answer the questions in the spaces provided.
Do not write outside the boxed area on each page.
Complete in black ink only. **Do not write with a gel pen.**
All working **must** be clearly shown in the spaces provided. Marks may be awarded for partially correct solutions.
Where rounding is necessary give answers correct to **2 decimal places** unless stated otherwise.
Take $\mathbf{g = 10\ m/s^2}$ when required.
Answer **all six** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 50.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
You may use a calculator.
The Formula Sheet is on page 2.

FORMULA SHEET

MECHANICS

Quadratic equations: If $ax^2 + bx + c = 0$ $(a \neq 0)$

then $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Vectors: Magnitude of $x\mathbf{i} + y\mathbf{j}$ is given by $\sqrt{x^2 + y^2}$

Angle between $x\mathbf{i} + y\mathbf{j}$ and $\mathbf{i}$ is given by $\tan^{-1}\left(\dfrac{y}{x}\right)$

Uniform Acceleration: $v = u + at$ $\quad s = \frac{1}{2}(u + v)t$

$v^2 = u^2 + 2as$ $\quad s = ut + \frac{1}{2}at^2$

where u is initial velocity, v is final velocity, a is acceleration, t is time, s is change in displacement

Newton's Second Law: $F = ma$

where F is resultant force, a is acceleration, m is mass

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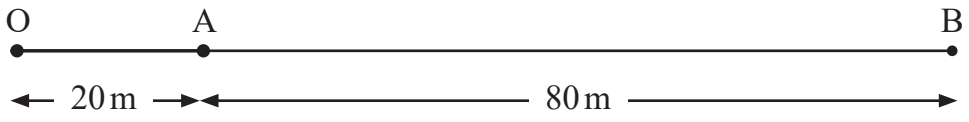
(Questions start overleaf)

1 The points O, A and B all lie on the same straight line, with OA = 20 m and AB = 80 m, as shown in the diagram below.



A body started at O and travelled to B at constant speed, taking 30 seconds.

The body then stopped for 10 seconds at B.

It then changed direction and travelled to A at constant speed, taking 20 seconds.

(i) On the axes below, draw the displacement/time graph showing the journey taken by the body.

[2]

(ii) Calculate the average speed of the body for the journey.

Answer _____ m/s [2]

[Turn over

2 (Throughout this question, **i** and **j** denote unit vectors parallel to a set of standard x–y axes.)

A body is acted upon by three forces **a**, **b** and **c**, where

$$\mathbf{a} = (p\mathbf{i} + 3q\mathbf{j})\,\text{N}, \quad \mathbf{b} = (-4q\mathbf{i} + p\mathbf{j})\,\text{N} \quad \text{and} \quad \mathbf{c} = (2\mathbf{i} + 3\mathbf{j})\,\text{N}.$$

(i) Given that $2\mathbf{a} - 3\mathbf{b} = 4\mathbf{c}$, calculate the values of p and q.

Answer p = _____ , q = _____ [5]

The forces **a** and **b** are now removed and replaced by a force **d**, where

$$\mathbf{d} = (-4\mathbf{i} - 6\mathbf{j})\,\text{N}.$$

Calculate

(ii) the **magnitude** of the vector $\mathbf{c} - \mathbf{d}$,

Answer _____ N [3]

(iii) the angle the vector $\mathbf{c} - \mathbf{d}$ makes with the positive x-axis.

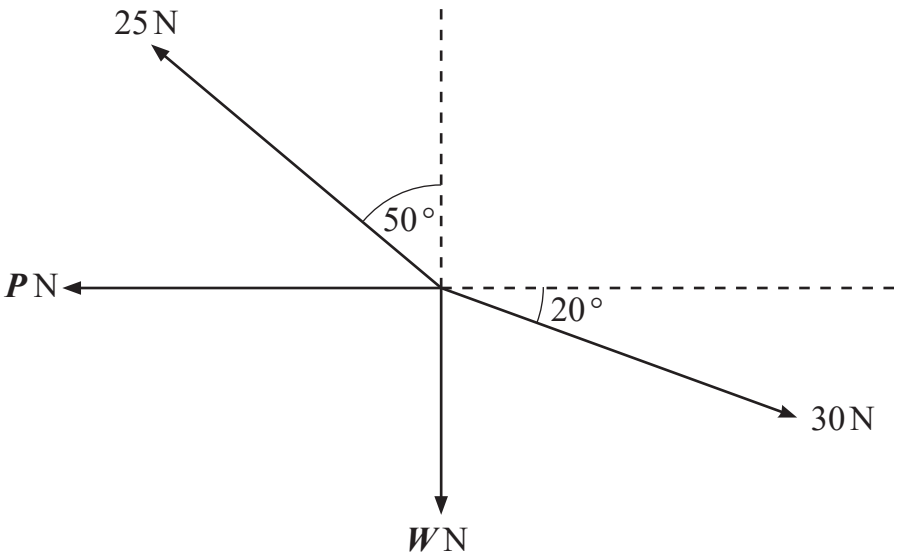
Answer _____ ° [2]

[Turn over

3 Four forces act at a point, as shown in the diagram below.

A force of ***P*** newtons acts horizontally and a force of ***W*** newtons acts vertically downwards.

A force of 25 N acts at an angle of 50° to the vertical and a force of 30 N acts at an angle of 20° to the horizontal.



The system is in equilibrium.

Calculate

(i) the value of ***W***,

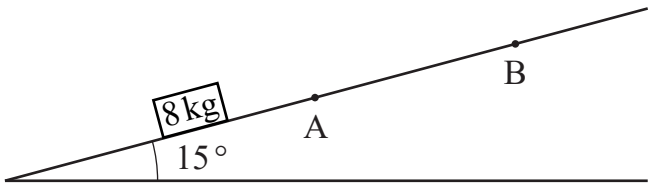
Answer _____ [3]

(ii) the value of ***P***.

Answer _____ [3]

[Turn over

4 A box of mass 8 kg is moving up a rough slope, which is inclined at an angle of 15° to the horizontal, as shown in the diagram below.



The box passes the point A with a velocity of 10 m/s and comes to rest at the point B.

The force due to friction acting on the box is 11.3 N.

(i) Show that the deceleration between A and B is 4 m/s^2, to the nearest whole number.

[3]

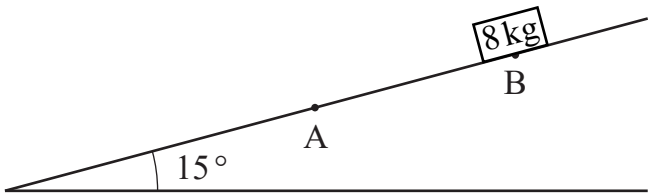
(ii) Hence calculate the distance AB.

Answer _____ m [2]

[Turn over

After the box comes to rest at B, it then starts to slide down the slope.

(iii) Mark on the diagram below all the forces now acting on the box.



[2]

(iv) Calculate the acceleration of the box down the slope.

Answer _____ m/s^2 [3]

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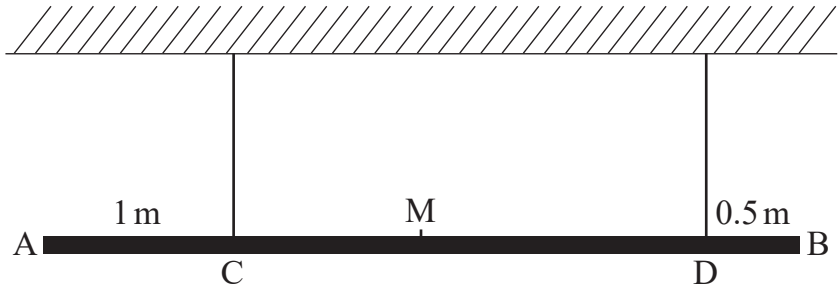
(Questions continue overleaf)

5 A uniform rod AB, of length 4 m and mass 20 kg, is attached to two fixed points on a ceiling by two light, inextensible strings, as shown in the diagram below.

The strings are vertical.

One string is attached to the rod at the point C, where the distance AC is 1 m, and the other string is attached to the point D, where the distance DB is 0.5 m.

The point M is the midpoint of the rod.



A mass of 15 kg is attached to the rod at the end A and a mass of 18 kg is attached at the end B.

The rod remains horizontal and in equilibrium.

(i) Mark, on the diagram above, all the forces acting on the rod. [2]

(ii) Calculate the tension in each of the strings at C and D.

Answer Tension in string at C = _____ N

Tension in string at D = _____ N [6]

[Turn over

6 A car of mass 900 kg is towing a trailer of mass M kg by means of a light, horizontal towbar.

The tractive force produced by the car's engine is 3015 N.

The car and trailer are travelling along a straight, horizontal road, as shown in the diagram below.

The resistance to the motion of the car is 0.8 N/kg.

The resistance to the motion of the trailer is 0.6 N/kg.

The car and trailer accelerate uniformly from rest at 1.5 m/s^2

(i) Calculate the tension in the towbar.

Answer _____ N [4]

(ii) Show that the value of M is 450

[3]

[Turn over

When the car and trailer are travelling at a speed of 9 m/s, the towbar breaks.

(iii) (a) Calculate the deceleration of the trailer after the towbar breaks.

Answer _____ m/s^2 [3]

(b) Calculate the distance the trailer travels from when the towbar breaks until it comes to rest.

Answer _____ m [2]

THIS IS THE END OF THE QUESTION PAPER

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For Examiner's use only	
Question Number	**Marks**
1	
2	
3	
4	
5	
6	
Total Marks	

Examiner Number