



Rewarding Learning

General Certificate of Secondary Education
2019

Centre Number

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Candidate Number

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Further Mathematics

Unit 2

Mechanics



[GFM21]

GFM21

TUESDAY 18 JUNE, AFTERNOON

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 $g = 10 \text{ m/s}^2$ 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.

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16GFM2101

FORMULA SHEET

MECHANICS

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

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

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 $\tan^{-1}\left(\frac{y}{x}\right)$

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

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

Newton's Second Law: $F = ma$

where F is resultant force m is mass
 a is acceleration



1 (i) Define a vector quantity. Include an example in your answer.

Definition A vector quantity has magnitude and direction
_____ [1]

Example acceleration _____ [1]

(ii) Define a scalar quantity. Include an example in your answer.

Definition A scalar has magnitude only
_____ [1]

Example speed. _____ [1]

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16GFM2103

- 2 A body is initially at an origin O and is travelling with an initial velocity of $(-3\mathbf{i} + 2\mathbf{j})$ m/s.

It moves with a constant acceleration of $(4\mathbf{i} - 6\mathbf{j})$ m/s² for 4 seconds.

Calculate

- (i) the displacement of the body from O, in vector form, after the 4 seconds,

$$S =$$

$$u = (-3\mathbf{i} + 2\mathbf{j})$$

$$v =$$

$$a = (4\mathbf{i} - 6\mathbf{j})$$

$$t = 4$$

$$s = ut + \frac{1}{2}at^2$$

$$= 4 \times (-3\mathbf{i} + 2\mathbf{j}) + \frac{1}{2} \times (4\mathbf{i} - 6\mathbf{j}) \times 4^2$$

$$= -12\mathbf{i} + 8\mathbf{j} + 32\mathbf{i} - 48\mathbf{j}$$

$$= (20\mathbf{i} - 40\mathbf{j}) \text{ m}$$

Answer 20i - 40j m [3]



(ii) the speed of the body after the 4 seconds,

$$s = 20i - 40j$$

$$u = -3i + 2j$$

$$v =$$

$$a = 4i - 6j$$

$$t = 4$$

Find v first.

$$v = u + at$$

$$= (-3i + 2j) + 4 \times (4i - 6j)$$

$$= 13i - 22j$$

$$\text{Velocity} = 13i - 22j$$

$$\text{Speed} = \sqrt{(13)^2 + (22)^2}$$

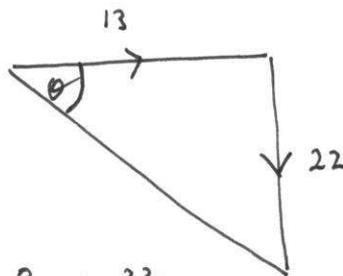
$$= 25.55 \text{ ms}^{-1}$$

Answer 25.55 m/s [4]

(iii) the angle the velocity makes with the positive x -axis after the 4 seconds.

$$v = 13i - 22j$$

→ ↓



$$\tan \theta = \frac{o}{A} = \frac{22}{13}$$

$$\theta = \tan^{-1}\left(\frac{22}{13}\right)$$

$$\theta = 59.42$$

Answer 59.42 ° [2]

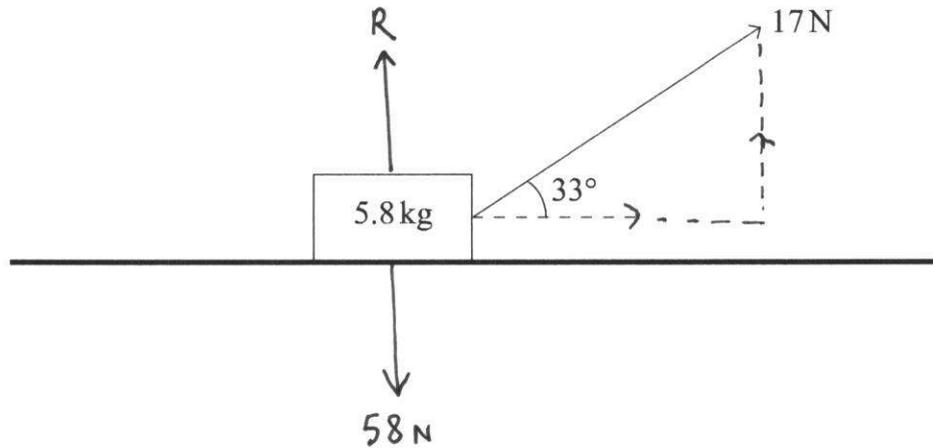
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3 A block of mass 5.8 kg is initially at rest on a smooth horizontal table.

No friction

The block is then pulled along the table by a string with a force of 17 N. The string makes an angle of 33° to the horizontal, as shown in the diagram below.



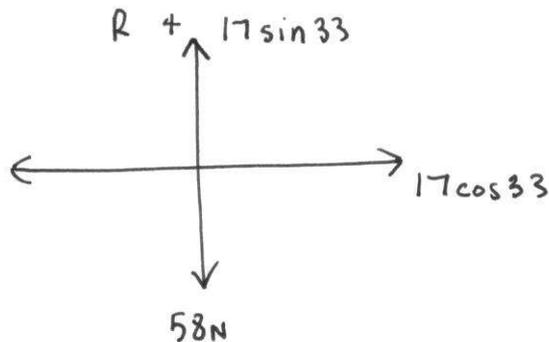
(i) Mark, on the diagram above, the other forces acting on the block. [1]

(Mark Normal reaction, R

and weight, 58 N, acting downwards)

Calculate

(ii) the normal reaction between the block and the table,



Resolve (\updownarrow)

$$R + 17 \sin 33 = 58$$

$$R = 58 - 17 \sin 33$$

$$R = 48.74 \text{ N}$$

Answer 48.74 N [4]



(iii) the acceleration of the block,

No friction \rightarrow No resistance acting against Forward force, F.

$$F = m a$$



$$17 \cos 33 = 5.8 \times a$$

$$a = 17 \cos 33 \div 5.8$$

$$a = 2.46 \text{ m s}^{-2}$$

Answer 2.46 m/s² [3]

(iv) the speed v of the block after 5 seconds.

$$s =$$

$$u = 0$$

$$v = ?$$

$$a = 2.46$$

$$t = 5$$

$$v = u + at$$

$$= 0 + 2.46 \times 5$$

$$= 12.3 \text{ m s}^{-1}$$

Answer 12.3 m/s [1]

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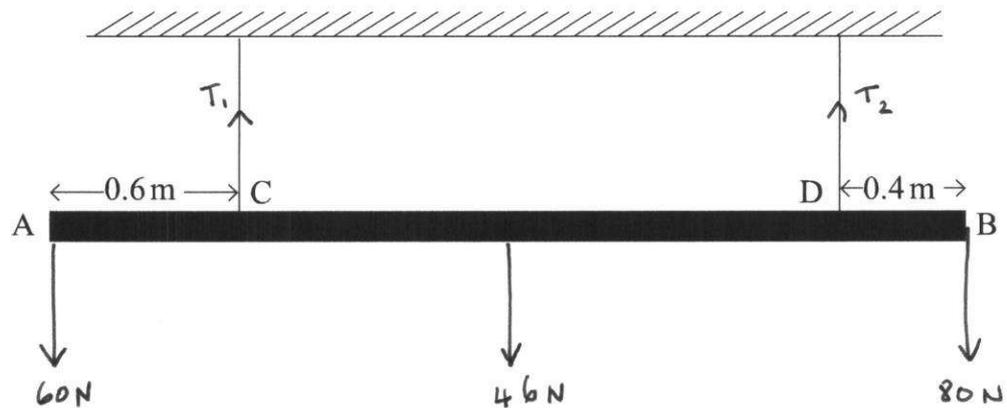


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4 A uniform rod AB has length 3.2 m and mass 4.6 kg.

It is suspended from a ceiling by two inextensible strings attached to points C and D on the rod.

The distance AC is 0.6 m and the distance DB is 0.4 m, as shown in the diagram below.



A mass of 6 kg is attached to the rod at the end A and a mass of 8 kg is attached to the rod at the end B.

The rod remains horizontal and in equilibrium.

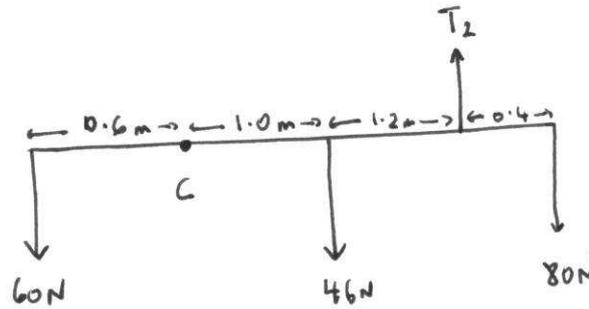
(i) Mark, on the diagram above, all the forces acting on the rod.

[2]



(ii) Calculate the tensions in the strings at C and D.

Moments about C



$$\text{CW} \downarrow (46 \times 1.0) + (80 \times 2.6) = (T_2 \times 2.2) + (60 \times 0.6) \text{ ACW} \downarrow$$

$$T_2 = 99.091 \text{ N}$$

$$R \uparrow = \downarrow$$

$$T_1 + T_2 = 60 + 46 + 80$$

$$T_1 = 186 - 99.091$$

$$T_1 = 86.91$$

Answer Tension in string at C 86.91 N

Tension in string at D 99.09 N [6]

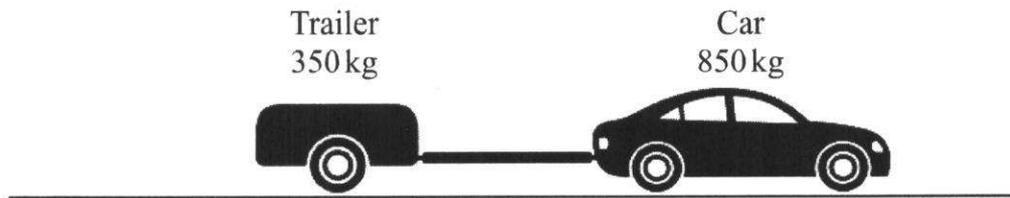
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16GFM2109

- 5 A car of mass 850 kg tows a trailer of mass 350 kg along a straight horizontal road. The car and trailer are connected by a light horizontal towbar.



The resistance to motion of the car is 1.2 N per kg.

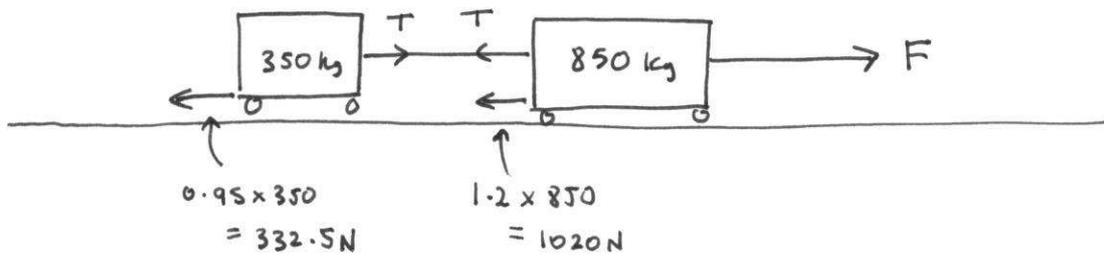
The resistance to motion of the trailer is 0.95 N per kg.

The car and trailer travel at a constant acceleration of 0.9 m/s^2

Calculate

- (i) the tension in the towbar,

$\rightarrow \rightarrow 0.9 \text{ m/s}^2$



Trailer: (Resultant) $F = m \times a$

$$T - 332.5 = 350 \times 0.9$$

$$T = 647.5 \text{ N}$$

Answer 647.5 N [3]



(ii) the tractive force of the engine of the car.

Car :
$$F = m \times a$$

$$F - (T + 1020) = 850 \times 0.9$$

$$F - 1667.5 = 765$$

$$F = 2432.5 \text{ N}$$

Answer 2432.5 N [3]

The car and trailer started from rest.

Eight seconds later the towbar breaks.

(iii) Calculate the speed of the car when the towbar breaks.

$$s =$$

$$u = 0$$

$$v =$$

$$a = 0.9$$

$$t = 8$$

$$\begin{aligned} v &= u + at \\ &= 0 + 0.9 \times 8 \\ &= 7.2 \text{ m s}^{-1} \end{aligned}$$

Answer 7.2 m/s [2]

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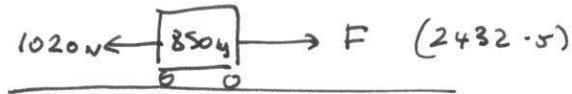
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- (iv) Calculate the speed of the car 12 seconds after the towbar breaks, given that the tractive force of the car and the resistance to motion of the car remain unchanged.

When Towbar breaks ...



$$F - 1020 = 850 a$$

$$2432.5 - 1020 = 850 a$$

$$a = 1.662$$

New value for
acceleration!

$$s =$$

$$u = 7.2 \text{ (from final } v \text{ with towbar)}$$

$$v = ?$$

$$a = 1.662$$

$$t = 12$$

$$v = u + at$$

$$= 7.2 + 1.662 \times 12$$

$$= 27.14 \text{ m s}^{-1}$$

Answer 27.14 m/s [5]





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- 6 A block of mass 7kg lies on a rough surface inclined at an angle of 27° to the horizontal.

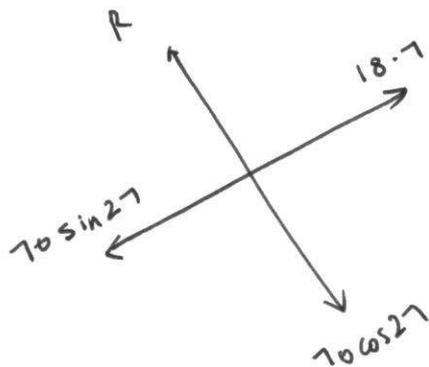
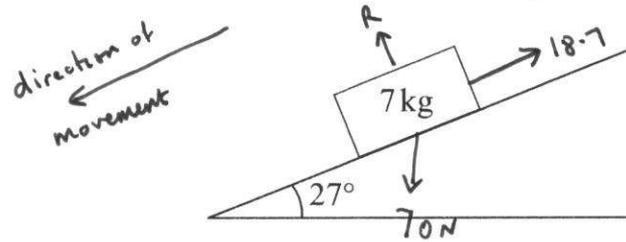
The force due to friction is 18.7N.

Which of the following options would produce the greatest acceleration of the block?

You must show working to support your answer.

Option A The block is allowed to slide down the slope. → FRICTION ACTS UP

THE PLANE



$$F = ma$$

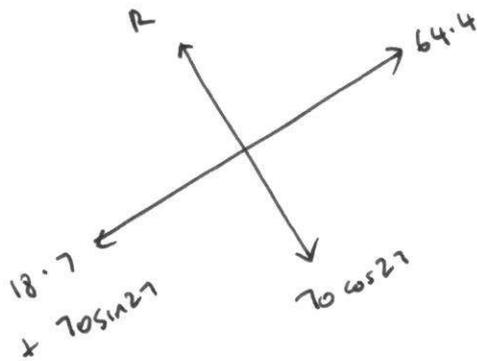
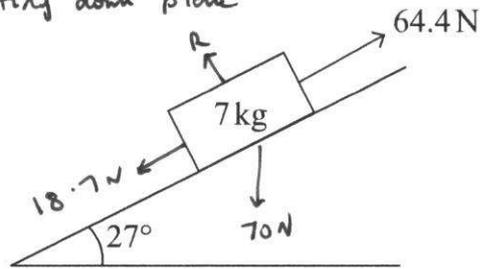
$$70 \sin 27 - 18.7 = 7a$$

$$a = 1.087 \text{ ms}^{-2}$$



Option B The block is pulled up the slope with a force of 64.4 N.

↳ Friction acting down plane



$$F = ma$$

$$64.4 - (18.7 + 70 \sin 27) = 7a$$

$$a = 1.99 \text{ ms}^{-2}$$

Answer Option B [7]

OPTION A $\rightarrow a = 1.87 \text{ ms}^{-2}$

OPTION B $\rightarrow a = 1.99 \text{ ms}^{-2}$

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Question Number	Marks
1	
2	
3	
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Total Marks	
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Examiner Number

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