Centre No.						Paper Reference							Surname	Initial(s)
Candidate No.						6	6	7	7	/	0	1	Signature	

Paper Reference(s)

6677/01

Edexcel GCE

Mechanics M1

Advanced/Advanced Subsidiary

Wednesday 12 January 2005 – Afternoon

Time: 1 hour 30 minutes

Solutions

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
1	
2	
3	
4	
5	
6	
7	
Total	

Materials required for examination	**Items included with question papers**
Mathematical Formulae (Lilac or Green)	Nil

Candidates may use any calculator EXCEPT those with facility for symbolic algebra, differentiation and/or integration. Thus candidates may NOT use calculators such as the Texas Instruments T1 89, T1 92, Casio CFX 9970G, Hewlett Packard HP 48G.

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initial(s) and signature.
You must write your answer to each question in the space following the question.
If you need more space to complete your answer to any question, use additional answer sheets.
Whenever a numerical value of g is required, take $g = 9.8 \text{ms}^{-2}$.
When a calculator is used, the answer should be given to an appropriate degree of accuracy.

Information for Candidates

A booklet 'Mathematical Formulae and Statistical Tables' is provided.
Full marks may be obtained for answers to ALL questions.
This paper has seven questions. There are no blank pages.
The total mark for this paper is 75.

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 gain no credit.

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1. A particle P of mass 1.5 kg is moving along a straight horizontal line with speed 3 m s^{-1}. Another particle Q of mass 2.5 kg is moving, in the opposite direction, along the same straight line with speed 4 m s^{-1}. The particles collide. Immediately after the collision the direction of motion of P is reversed and its speed is 2.5 m s^{-1}.

(a) Calculate the speed of Q immediately after the impact.

(3)

(b) State whether or not the direction of motion of Q is changed by the collision.

(1)

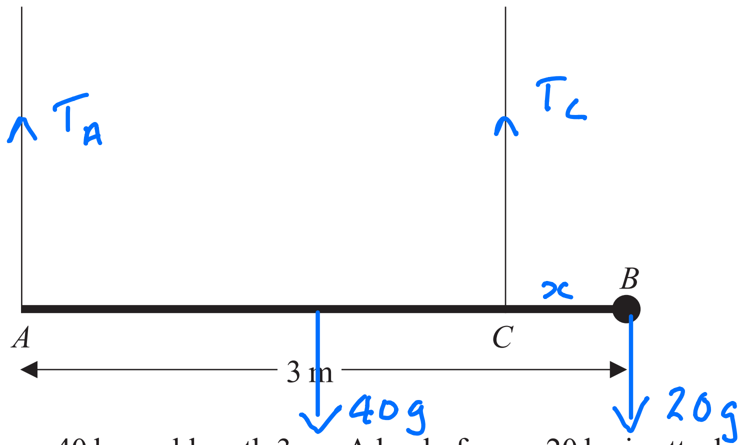
(c) Calculate the magnitude of the impulse exerted by Q on P, giving the units of your answer.

(3)

Leave blank

2.

Figure 1



A plank AB has mass 40 kg and length 3 m. A load of mass 20 kg is attached to the plank at B. The loaded plank is held in equilibrium, with AB horizontal, by two vertical ropes attached at A and C, as shown in Figure 1. The plank is modelled as a uniform rod and the load as a particle. Given that the tension in the rope at C is three times the tension in the rope at A, calculate

(a) the tension in the rope at C,

(2)

(b) the distance CB.

(5)

a) ↕ $T_A + T_C = 60g$

$\frac{1}{3}T_C + T_C = 60g$

$\frac{4}{3}T_C = 60g$

$T_C = 60g \times \frac{3}{4} = 45g = 441\text{ N}$

b) Moments about B

$T_C \times x + T_A \times 3 = 40g \times 1.5$

$45gx + 15g \times 3 = 60g$

$45gx = 15g$ $\qquad x = \frac{15g}{45g} = \frac{1}{3}\text{ m}$

$CB = \frac{1}{3}\text{ m}$

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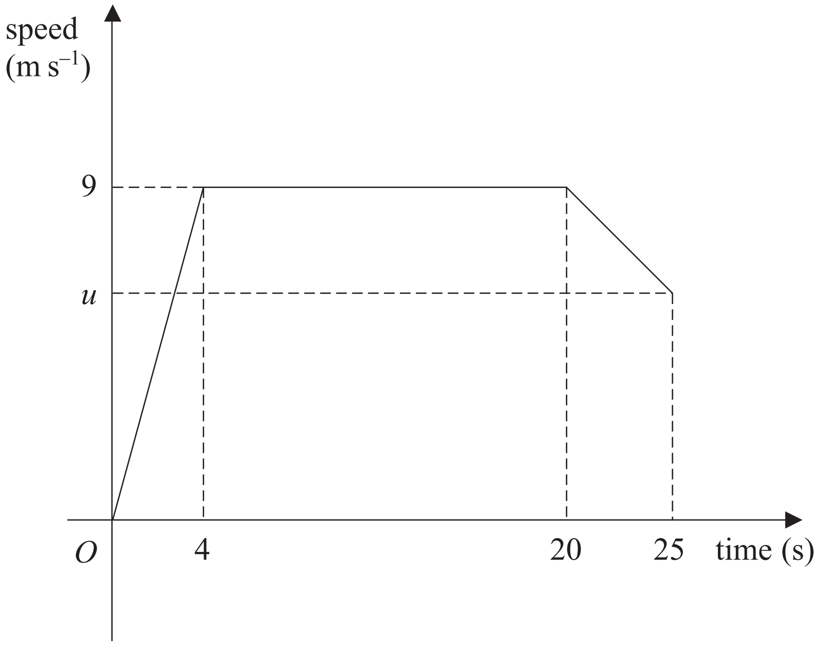
3. **Figure 2**



A sprinter runs a race of 200 m. Her total time for running the race is 25 s. Figure 2 is a sketch of the speed-time graph for the motion of the sprinter. She starts from rest and accelerates uniformly to a speed of 9 m s^{-1} in 4 s. The speed of 9 m s^{-1} is maintained for 16 s and she then decelerates uniformly to a speed of u m s^{-1} at the end of the race. Calculate

(a) the distance covered by the sprinter in the first 20 s of the race,

(2)

(b) the value of u,

(4)

(c) the deceleration of the sprinter in the last 5 s of the race.

(3)

a) Area of trapezium $\frac{1}{2}(20+16) \times 9 = 162$m

b) Remaining area $= 200 - 162 = 38$m

$\frac{1}{2}(9+u) \times 5 = 38$

$5(9+u) = 76$

$45 + 5u = 76$

Leave blank

Question 3 continued

$5u = 31$

$u = 6.2 \text{ ms}^{-1}$

c) Deceleration $= \frac{9-u}{5} = \frac{9-6.2}{5}$

$= 0.56 \text{ ms}^{-2}$

Q3

(Total 9 marks)

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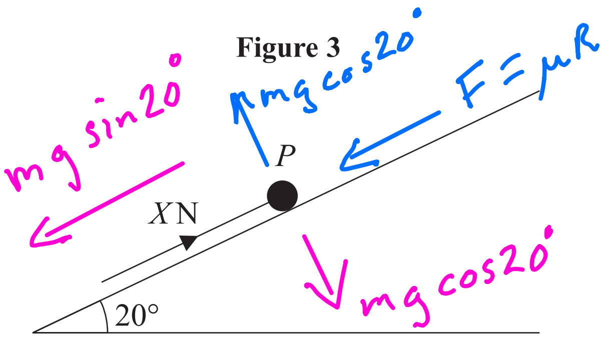
4.

Figure 3



A particle P of mass 2.5 kg rests in equilibrium on a rough plane under the action of a force of magnitude X newtons acting up a line of greatest slope of the plane, as shown in Figure 3. The plane is inclined at 20° to the horizontal. The coefficient of friction between P and the plane is 0.4. The particle is in limiting equilibrium and is on the point of moving up the plane. Calculate

(a) the normal reaction of the plane on P,

(2)

(b) the value of X.

(4)

The force of magnitude X newtons is now removed.

(c) Show that P remains in equilibrium on the plane.

(4)

a) $R = 2.5g\cos 20° = 23.0\text{ N}$

b) $X = 2.5g\sin 20° + \mu R$

$X = 2.5g\sin 20° + 0.4 \times 2.5g\cos 20°$

$X = 17.6\text{ N}$

c) Max friction $= \mu R = 0.4 \times 2.5g\cos 20°$

$= 9.21\text{ N}$

$mg\sin 20 = 2.5 \times 9.8\sin 20 = 8.38\text{ N}$

Since $8.38 < 9.21$ P remains in equilibrium

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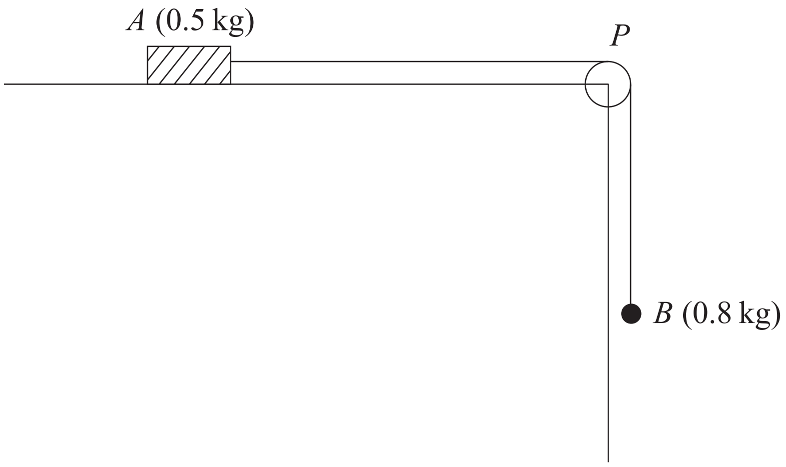
5. **Figure 4**



A block of wood A of mass 0.5 kg rests on a rough horizontal table and is attached to one end of a light inextensible string. The string passes over a small smooth pulley P fixed at the edge of the table. The other end of the string is attached to a ball B of mass 0.8 kg which hangs freely below the pulley, as shown in Figure 4. The coefficient of friction between A and the table is μ. The system is released from rest with the string taut. After release, B descends a distance of 0.4 m in 0.5 s. Modelling A and B as particles, calculate

(a) the acceleration of B, **(3)**

(b) the tension in the string, **(4)**

(c) the value of μ. **(5)**

(d) State how in your calculations you have used the information that the string is inextensible. **(1)**

a) For B $s = ut + \frac{1}{2}at^2$

$0.4 = 0 + \frac{1}{2}a(\frac{1}{2})^2$

$0.4 = \frac{1}{8}a$

$3.2 = a$

$a = 3.2 \text{ ms}^{-2}$

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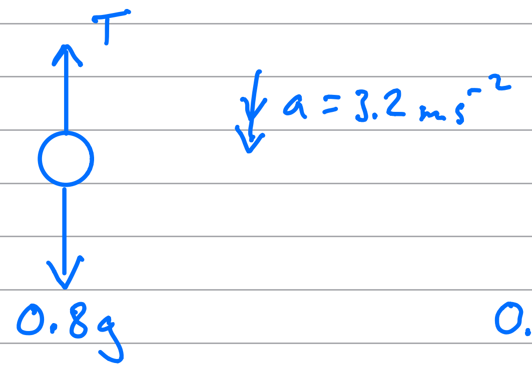
Question 5 continued

b)



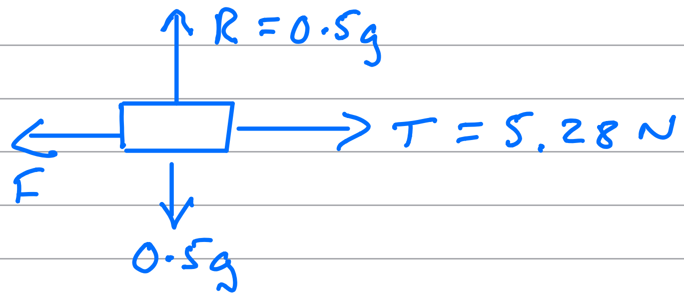
N2L
$F = ma$

$0.8g - T = 0.8 \times 3.2$

$0.8g - 0.8 \times 3.2 = T$

$\underline{T = 5.28 \text{ N}}$

c)



N2L $F = ma$

$5.28 - F = 0.5 \times 3.2$

$5.28 - 1.6 = F$

$F = \mu R$

$3.68 = \mu R$

$3.68 = \mu \times 0.5g$

$\frac{3.68}{0.5g} = \mu$

$\underline{\mu = 0.751}$

Q5

d) acceleration same for A and B

(Total 13 marks)

Leave blank

6. A stone S is sliding on ice. The stone is moving along a straight horizontal line ABC, where $AB = 24$ m and $AC = 30$ m. The stone is subject to a constant resistance to motion of magnitude 0.3 N. At A the speed of S is 20 m s^{-1}, and at B the speed of S is 16 m s^{-1}. Calculate

(a) the deceleration of S,

(2)

(b) the speed of S at C.

(3)

(c) Show that the mass of S is 0.1 kg.

(2)

At C, the stone S hits a vertical wall, rebounds from the wall and then slides back along the line CA. The magnitude of the impulse of the wall on S is 2.4 Ns and the stone continues to move against a constant resistance of 0.3 N.

(d) Calculate the time between the instant that S rebounds from the wall and the instant that S comes to rest.

(6)

Leave blank

Question 6 continued

(Total 13 marks)

Q6

Leave blank

7. Two ships P and Q are travelling at night with constant velocities. At midnight, P is at the point with position vector $(20\mathbf{i} + 10\mathbf{j})$ km relative to a fixed origin O. At the same time, Q is at the point with position vector $(14\mathbf{i} - 6\mathbf{j})$ km. Three hours later, P is at the point with position vector $(29\mathbf{i} + 34\mathbf{j})$ km. The ship Q travels with velocity $12\mathbf{j}$ km h^{-1}. At time t hours after midnight, the position vectors of P and Q are $\mathbf{p}$ km and $\mathbf{q}$ km respectively. Find

(a) the velocity of P, in terms of $\mathbf{i}$ and $\mathbf{j}$,

(2)

(b) expressions for $\mathbf{p}$ and $\mathbf{q}$, in terms of t, $\mathbf{i}$ and $\mathbf{j}$.

(4)

At time t hours after midnight, the distance between P and Q is d km.

(c) By finding an expression for $\overrightarrow{PQ}$, show that

$$d^2 = 25t^2 - 92t + 292.$$

(5)

Weather conditions are such that an observer on P can only see the lights on Q when the distance between P and Q is 15 km or less. Given that when $t = 1$, the lights on Q move into sight of the observer,

(d) find the time, to the nearest minute, at which the lights on Q move out of sight of the observer.

(5)

a) For P $\quad \underline{v} = \dfrac{\begin{pmatrix}29\\34\end{pmatrix} - \begin{pmatrix}20\\10\end{pmatrix}}{3} = \dfrac{\begin{pmatrix}9\\24\end{pmatrix}}{3}$

$\underline{v} = \begin{pmatrix}3\\8\end{pmatrix} = 3\underline{i} + 8\underline{j}$ km/h

b) For P $\quad \underline{s} - \underline{s_0} = \underline{u}t + \frac{1}{2}\underline{a}t^2$

$\underline{p} - \begin{pmatrix}20\\10\end{pmatrix} = \begin{pmatrix}3\\8\end{pmatrix}t + \underline{0}$

$\underline{p} = \begin{pmatrix}20\\10\end{pmatrix} + \begin{pmatrix}3\\8\end{pmatrix}t$

Leave blank

Question 7 continued

$$\underline{p} = (20+3t)\underline{i} + (10+8t)\underline{j}$$

For Q $\quad \underline{s} - \underline{s}_0 = \underline{u}t + \frac{1}{2}\underline{a}t^2$

$$\underline{q} - \begin{pmatrix}14\\-6\end{pmatrix} = \begin{pmatrix}0\\12\end{pmatrix}t + \underline{0}$$

$$\underline{q} = \begin{pmatrix}14\\-6\end{pmatrix} + \begin{pmatrix}0\\12\end{pmatrix}t$$

$$\underline{q} = 14\underline{i} + (-6+12t)\underline{j}$$

c) $\quad \overrightarrow{PQ} = -\underline{p} + \underline{q}$

$$= -(20+3t)\underline{i} - (10+8t)\underline{j} + 14\underline{i} + (-6+12t)\underline{j}$$

$$= (-6-3t)\underline{i} + (-16+4t)\underline{j}$$

$$d^2 = (-6-3t)^2 + (-16+4t)^2$$

$$d^2 = 36 + 36t + 9t^2 + 256 - 128t + 16t^2$$

$$d^2 = 292 - 92t + 25t^2$$

d) $\quad d = 15\text{ km} \Rightarrow d^2 = 225$

Q7

(Total 16 marks)

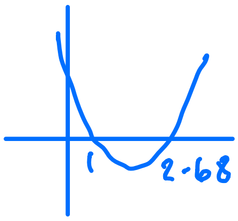
TOTAL FOR PAPER: 75 MARKS

END

$225 \geq 292 - 92t + 25t^2$

$0 \geq 25t^2 - 92t + 67$

By calc $t = 2.68$ or $t = 1$



Visible when

$1 \leq t \leq 2.68$

2.68 hrs = 2 hrs 40.8 min

Out of sight at 2.41 am