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

Tuesday 7 June 2005 – Afternoon

Time: 1 hour 30 minutes

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
1	
2	
3	
4	
5	
6	
7	
8	
Total	

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

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

Solutions

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.
Whenever a numerical value of g is required, take $g = 9.8\ \text{m s}^{-2}$.
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.
The marks for individual questions and the parts of questions are shown in round brackets: e.g. **(2)**.
There are 8 questions in this question paper. The total mark for this paper is 75.
There are 20 pages in this question paper. Any blank pages are indicated.

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.

Printer's Log. No.
N20911A
W850/R6677/57570 4/7/3/3/3/3/3/2

N 2 0 9 1 1 A 0 1 2 0

Turn over

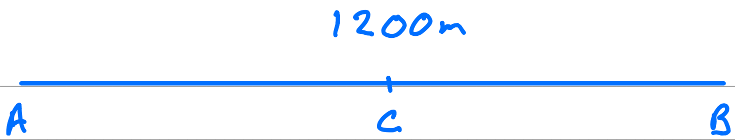
edexcel

Leave blank

1. In taking off, an aircraft moves on a straight runway AB of length 1.2 km. The aircraft moves from A with initial speed 2 m s^{-1}. It moves with constant acceleration and 20 s later it leaves the runway at C with speed 74 m s^{-1}. Find

(a) the acceleration of the aircraft, **(2)**

(b) the distance BC. **(4)**



a) $v = u + at$ $\qquad \dfrac{v-u}{t} = a$

$\dfrac{74-2}{20} = a$

$a = 3.6 \text{ ms}^{-2}$

b) AC $\qquad s = ut + \frac{1}{2}at^2$

$s = 2(20) + \frac{1}{2} \times 3.6 \times 20^2$

$s = 760\text{m}$

$BC = 1200 - AC$

$= 1200 - 760$

$BC = 440\text{m}$

Leave blank

2. Two small steel balls A and B have mass 0.6 kg and 0.2 kg respectively. They are moving towards each other in opposite directions on a smooth horizontal table when they collide directly. Immediately before the collision, the speed of A is 8 m s^{-1} and the speed of B is 2 m s^{-1}. Immediately after the collision, the direction of motion of A is unchanged and the speed of B is twice the speed of A. Find

(a) the speed of A immediately after the collision,

(5)

(b) the magnitude of the impulse exerted on B in the collision.

(3)

Leave blank

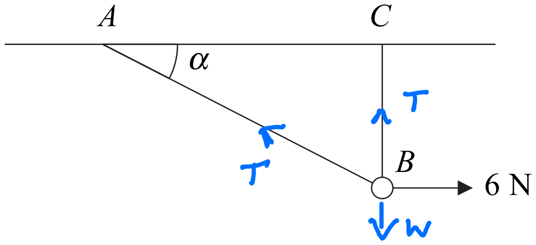
3.

Figure 1

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

$\Rightarrow \sin\alpha = \frac{3}{5}$

$\cos\alpha = \frac{4}{5}$



A smooth bead B is threaded on a light inextensible string. The ends of the string are attached to two fixed points A and C on the same horizontal level. The bead is held in equilibrium by a horizontal force of magnitude 6 N acting parallel to AC. The bead B is vertically below C and $\angle BAC = \alpha$, as shown in Figure 1. Given that $\tan\alpha = \frac{3}{4}$, find

(a) the tension in the string,

(3)

(b) the weight of the bead.

(4)

a) $T\cos\alpha = 6$

$T = \frac{6}{\cos\alpha} = \frac{6}{\frac{4}{5}} = 7.5\text{ N}$

Tension $= 7.5$ N

b) Tension the same throughout string

$T + T\sin\alpha = W$

$7.5 + 7.5 \times \frac{3}{5} = W$

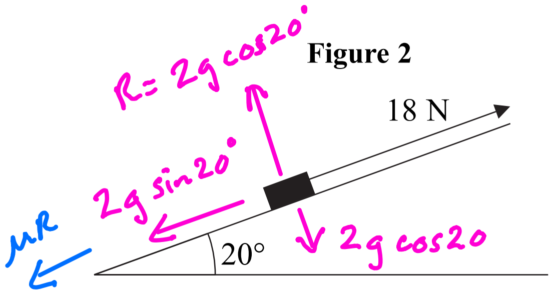
Weight $= 12$ N

N 2 0 9 1 1 A 0 6 2 0

Leave blank

4.

Figure 2



A box of mass 2 kg is pulled up a rough plane face by means of a light rope. The plane is inclined at an angle of 20° to the horizontal, as shown in Figure 2. The rope is parallel to a line of greatest slope of the plane. The tension in the rope is 18 N. The coefficient of friction between the box and the plane is 0.6. By modelling the box as a particle, find

(a) the normal reaction of the plane on the box,
(3)

(b) the acceleration of the box.
(5)

a) Reaction $= 2 \times 9.8 \times \cos 20° = 18.4\text{ N}$

b) N2L $F = ma$

$$18 - 2g\sin 20° - \mu 2g\cos 20° = 2a$$

$$\frac{18 - 2\times 9.8\sin 20° - 0.6\times 2\times 9.8\cos 20°}{2} = a$$

$$a = 0.123\text{ ms}^{-2}$$

N 2 0 9 1 1 A 0 8 2 0

Leave blank

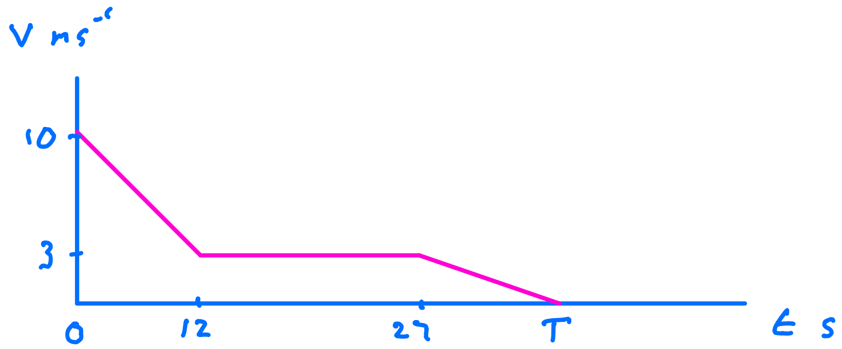
5. A train is travelling at 10 m s^{-1} on a straight horizontal track. The driver sees a red signal 135 m ahead and immediately applies the brakes. The train immediately decelerates with constant deceleration for 12 s, reducing its speed to 3 m s^{-1}. The driver then releases the brakes and allows the train to travel at a constant speed of 3 m s^{-1} for a further 15 s. He then applies the brakes again and the train slows down with constant deceleration, coming to rest as it reaches the signal.

(a) Sketch a speed-time graph to show the motion of the train, **(3)**

(b) Find the distance travelled by the train from the moment when the brakes are first applied to the moment when its speed first reaches 3 m s^{-1}. **(2)**

(c) Find the total time from the moment when the brakes are first applied to the moment when the train comes to rest. **(5)**

a)



b) Area of trapezium $\frac{1}{2}(10+3)\times 12 = 78$ m

Distance travelled $= 78$ m

c)

$78 + 3(27-12) + \frac{1}{2}(T-27)\times 3 = 135$

$78 + 45 + \frac{3T}{2} - \frac{81}{2} = 135$

$\frac{3T}{2} = 135 - 78 - 45 + \frac{81}{2} = 52.5$

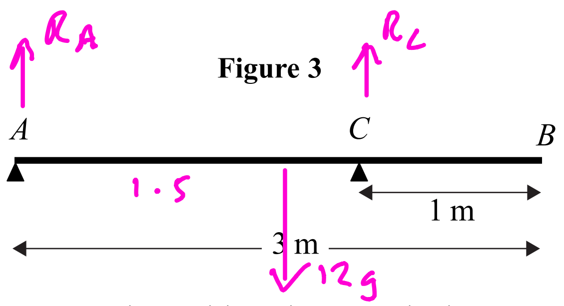
$T = 52.5 \times \frac{2}{3} = 35$ s

N 2 0 9 1 1 A 0 1 0 2 0

Leave blank

6.

Figure 3



A uniform beam AB has mass 12 kg and length 3 m. The beam rests in equilibrium in a horizontal position, resting on two smooth supports. One support is at the end A, the other at a point C on the beam, where $BC = 1$ m, as shown in Figure 3. The beam is modelled as a uniform rod.

(a) Find the reaction on the beam at C.

(3)

A woman of mass 48 kg stands on the beam at the point D. The beam remains in equilibrium. The reactions on the beam at A and C are now equal.

(b) Find the distance AD.

(7)

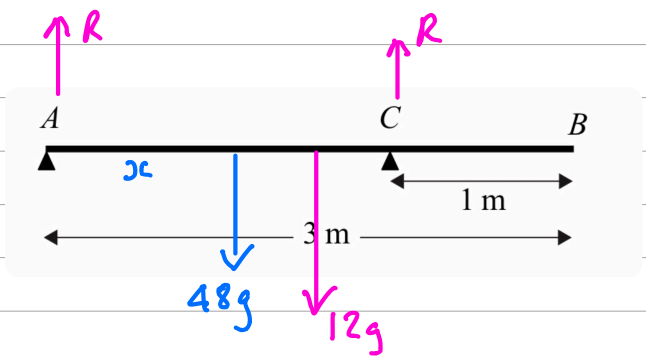
a) Moments about A

$$12g \times 1.5 = R_c \times 2$$

$$\frac{12 \times 9.8 \times 1.5}{2} = R_c$$

$$R_c = 88.2 \text{ N}$$

b)



$$R + R = 48g + 12g = 60g$$

Each $R = 30g$

N 2 0 9 1 1 A 0 1 2 2 0

Leave blank

Question 6 continued

Moments about A

$48g x + 12g \times 1.5 = 30g \times 2$

$48x + 18 = 60$

$48x = 42$

$x = \frac{42}{48}$

$x = 0.875$ m

Q6

(Total 10 marks)

Leave blank

7.

Figure 4

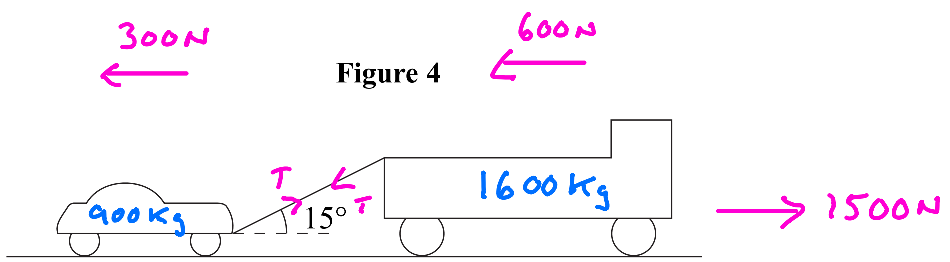


Figure 4 shows a lorry of mass 1600 kg towing a car of mass 900 kg along a straight horizontal road. The two vehicles are joined by a light towbar which is at an angle of 15° to the road. The lorry and the car experience constant resistances to motion of magnitude 600 N and 300 N respectively. The lorry's engine produces a constant horizontal force on the lorry of magnitude 1500 N. Find

(a) the acceleration of the lorry and the car, **(3)**

(b) the tension in the towbar. **(4)**

When the speed of the vehicles is 6 m s^{-1}, the towbar breaks. Assuming that the resistance to the motion of the car remains of constant magnitude 300 N,

(c) find the distance moved by the car from the moment the towbar breaks to the moment when the car comes to rest. **(4)**

(d) State whether, when the towbar breaks, the normal reaction of the road on the car is increased, decreased or remains constant. Give a reason for your answer. **(2)**

a) N2L Whole system $F = ma$

$$1500 - 600 - 300 = (1600 + 900)a$$

$$600 = 2500a$$

$$a = \frac{600}{2500} = 0.24 \text{ ms}^{-2}$$

b) For car N2L

$$T\cos 15 - 300 = 900 \times 0.24$$

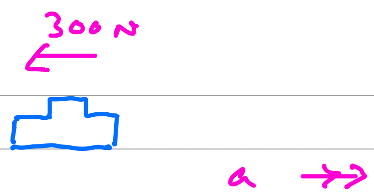
$$T = \frac{900 \times 0.24 + 300}{\cos 15°} = 534 \text{ N}$$

N 2 0 9 1 1 A 0 1 4 2 0

Leave blank

Question 7 continued

c)



N2L for car

$$-300 = 900a$$

$$-\frac{300}{900} = a$$

$$a = -\frac{1}{3}\ \mathrm{m\,s^{-2}}$$

$$v^2 = u^2 + 2as$$

$$0 = 6^2 + 2\left(-\tfrac{1}{3}\right)s$$

$$\frac{2}{3}s = 36$$

$$s = 36 \times \frac{3}{2} = 54\ \mathrm{m}$$

d) Normal reaction on car increases because tow bar had a vertical component which supported part of weight of car.

Leave blank

8. [*In this question, the unit vectors* **i** *and* **j** *are horizontal vectors due east and north respectively.*]

At time $t = 0$, a football player kicks a ball from the point A with position vector $(2\mathbf{i} + \mathbf{j})$ m on a horizontal football field. The motion of the ball is modelled as that of a particle moving horizontally with constant velocity $(5\mathbf{i} + 8\mathbf{j})$ m s^{-1}. Find

(a) the speed of the ball,

(2)

(b) the position vector of the ball after t seconds.

(2)

The point B on the field has position vector $(10\mathbf{i} + 7\mathbf{j})$ m.

(c) Find the time when the ball is due north of B.

(2)

At time $t = 0$, another player starts running due north from B and moves with constant speed v m s^{-1}. Given that he intercepts the ball,

(d) find the value of v.

(6)

(e) State one physical factor, other than air resistance, which would be needed in a refinement of the model of the ball's motion to make the model more realistic.

(1)

a) Speed $= \sqrt{5^2 + 8^2} = 9.43 \text{ ms}^{-1}$

b) $\underline{s} - \underline{s}_0 = \underline{u}t + \frac{1}{2}\underline{a}t^2$

$\underline{s} - \begin{pmatrix} 2 \\ 1 \end{pmatrix} = \begin{pmatrix} 5 \\ 8 \end{pmatrix} t$

$\underline{s} = \begin{pmatrix} 2 \\ 1 \end{pmatrix} + \begin{pmatrix} 5 \\ 8 \end{pmatrix} t$

$\underline{s} = (2 + 5t)\underline{i} + (1 + 8t)\underline{j}$

c) North of B when $\underline{i}$ component $= 10$

$2 + 5t = 10 \Rightarrow 5t = 8 \Rightarrow t = 1.6$ s

Leave blank

Question 8 continued

d) At $t = 1.6$ s $\quad \underset{\sim}{s} = 10\underset{\sim}{i} + (1 + 8 \times 1.6)\underset{\sim}{j}$

$\underset{\sim}{s} = 10\underline{i} + 13.8\underline{j}$ m

Position of B $= 10\underline{i} + 7\underline{j}$ m

Distance from B $= 13.8 - 7 = 6.8$ m

Player travels 6.8 m in 1.6 s

$v = \dfrac{6.8}{1.6} = 4.25 \text{ ms}^{-1}$

e) Friction slowing speed of ball

Q8

(Total 13 marks)

TOTAL FOR PAPER: 75 MARKS

END

N20911A02020