OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

MATHEMATICS

4728

Mechanics 1

QUESTION PAPER

Candidates answer on the Printed Answer Book

OCR Supplied Materials:
- Printed Answer Book 4728
- List of Formulae (MF1)

Other Materials Required:
- Scientific or graphical calculator

Tuesday 15 June 2010
Morning

Duration: 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

These instructions are the same on the Printed Answer Book and the Question Paper.

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the spaces provided on the Printed Answer Book.
- **The questions are on the inserted Question Paper.**
- **Write your answer to each question in the space provided in the Printed Answer Book.** Additional paper may be used if necessary but you must clearly show your Candidate Number, Centre Number and question number(s).
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- You are permitted to use a graphical calculator in this paper.
- Give non-exact numerical answers correct to 3 significant figures unless a different degree of accuracy is specified in the question or is clearly appropriate.
- The acceleration due to gravity is denoted by g m s^{-2}. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.

INFORMATION FOR CANDIDATES

This information is the same on the Printed Answer Book and the Question Paper.

- The number of marks is given in brackets **[ ]** at the end of each question or part question on the Question Paper.
- **You are reminded of the need for clear presentation in your answers.**
- The total number of marks for this paper is **72**.
- The Printed Answer Book consists of **12** pages. The Question Paper consists of **4** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER / INVIGILATOR

- Do not send this Question Paper for marking; it should be retained in the centre or destroyed.

1 A block B of mass 3 kg moves with deceleration $1.2\,\text{m s}^{-2}$ in a straight line on a rough horizontal surface. The initial speed of B is $5\,\text{m s}^{-1}$. Calculate

(i) the time for which B is in motion, **[2]**

(ii) the distance travelled by B before it comes to rest, **[2]**

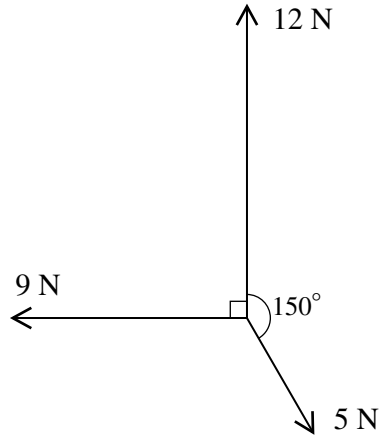
(iii) the coefficient of friction between B and the surface. **[4]**

2 Two particles P and Q are moving in opposite directions in the same straight line on a smooth horizontal surface when they collide. P has mass 0.4 kg and speed $3\,\text{m s}^{-1}$. Q has mass 0.6 kg and speed $1.5\,\text{m s}^{-1}$. Immediately after the collision, the speed of P is $0.1\,\text{m s}^{-1}$.

(i) Given that P and Q are moving in the same direction after the collision, find the speed of Q. **[4]**

(ii) Given instead that P and Q are moving in opposite directions after the collision, find the distance between them 3 s after the collision. **[5]**

3



Three horizontal forces of magnitudes 12 N, 5 N, and 9 N act along bearings 000°, 150° and 270° respectively (see diagram).

(i) Show that the component of the resultant of the three forces along bearing 270° has magnitude 6.5 N. **[2]**

(ii) Find the component of the resultant of the three forces along bearing 000°. **[2]**

(iii) Hence find the magnitude and bearing of the resultant of the three forces. **[5]**

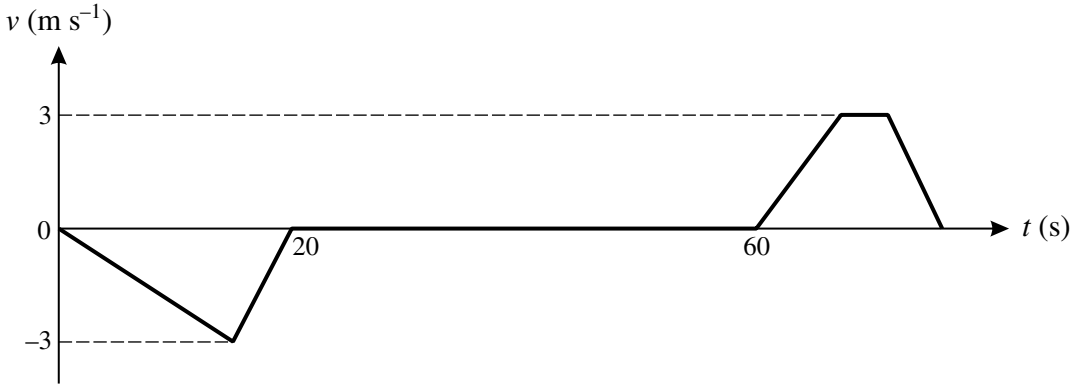
4 A particle P moving in a straight line has velocity $v\,\text{m s}^{-1}$ at time t s after passing through a fixed point O. It is given that $v = 3.2 - 0.2t^2$ for $0 \leqslant t \leqslant 5$. Calculate

(i) the value of t when P is at instantaneous rest, **[2]**

(ii) the acceleration of P when it is at instantaneous rest, **[3]**

(iii) the greatest distance of P from O. **[5]**

5



The diagram shows the (t, v) graph for a lorry delivering waste to a recycling centre. The graph consists of six straight line segments. The lorry reverses in a straight line from a stationary position on a weighbridge before coming to rest. It deposits its waste and then moves forwards in a straight line accelerating to a maximum speed of $3\,\text{m s}^{-1}$. It maintains this speed for 4 s and then decelerates, coming to rest at the weighbridge.

(i) Calculate the distance from the weighbridge to the point where the lorry deposits the waste. **[2]**

(ii) Calculate the time which elapses between the lorry leaving the weighbridge and returning to it. **[4]**

(iii) Given that the acceleration of the lorry when it is moving forwards is $0.4\,\text{m s}^{-2}$, calculate its final deceleration. **[3]**

6 A block B of mass 0.85 kg lies on a smooth slope inclined at 30° to the horizontal. B is attached to one end of a light inextensible string which is parallel to the slope. At the top of the slope, the string passes over a smooth pulley. The other end of the string hangs vertically and is attached to a particle P of mass 0.55 kg. The string is taut at the instant when P is projected vertically downwards.

(i) Calculate

(a) the acceleration of B and the tension in the string, **[5]**

(b) the magnitude of the force exerted by the string on the pulley. **[2]**

The initial speed of P is $1.3\,\text{m s}^{-1}$ and after moving 1.5 m P reaches the ground, where it remains at rest. B continues to move up the slope and does not reach the pulley.

(ii) Calculate the total distance B moves up the slope before coming instantaneously to rest. **[6]**

[Question 7 is printed overleaf.]

7

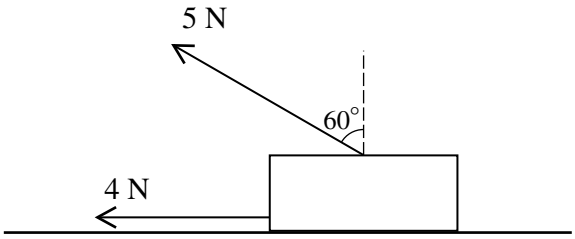


Fig. 1

A rectangular block B of weight 12 N lies in limiting equilibrium on a horizontal surface. A horizontal force of 4 N and a coplanar force of 5 N inclined at 60° to the vertical act on B (see Fig. 1).

(i) Find the coefficient of friction between B and the surface. **[6]**

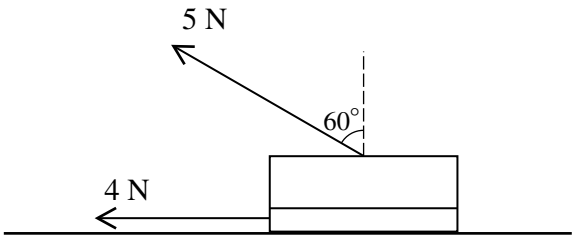


Fig. 2

B is now cut horizontally into two smaller blocks. The upper block has weight 9 N and the lower block has weight 3 N. The 5 N force now acts on the upper block and the 4 N force now acts on the lower block (see Fig. 2). The coefficient of friction between the two blocks is μ.

(ii) Given that the upper block is in limiting equilibrium, find μ. **[2]**

(iii) Given instead that $\mu = 0.1$, find the accelerations of the two blocks. **[6]**

1 i	t = 5/1.2 t = 4.17 s	M1 A1 [2]	5=1.2t or 0=5-1.2t 4 1/6 s, 4.166 or better, 4.16 recurring.
ii	$s = (-5)^2/2x1.2$ s = 10.4 m *OR (using(i))* $s = 5x4.17 – 1.2x4.17^2/2$ s = 10.4 m *OR (using(i))* s = (5 (+ 0))/2 x 4.17 s = 10.4 m	M1 A1 [2] M1 A1 M1 A1	$s = 5^2/2x1.2$ or $5^2 = 2x1.2s$ or $0 = 5^2 - 2x1.2s$ Accept 10 5/12, but not 10 Time must be > 0. Accept |t| from (i) Award if |-4.17| used.
iii	Fr = 3x1.2 R = 3x9.8 μ = (3x)1.2/(3x)9.8 μ = 0.122 *OR* R = 3x9.8 Mass x acceleration = +/- 3x1.2 +/-μ x29.4 = +/- 3x1.2 μ = 0.122	B1 B1 M1 A1 [4] B1 B1 M1 A1	Accept 3.6, +/- Accept 3g, +/- Ratio of 2 positive numerical force terms Not 0.12 Accept 3g, +/- Either both positive or both negative.

2 i	+/-(0.4x3 - 0.6x1.5) +/-(0.4x0.1 + 0.6v) (0.4x3 - 0.6x1.5) = +/-(0.4x0.1 + 0.6v) speed |v| = 0.433 ms^{-1} *OR* +/- (0.4x3 – 0.4x0.1) = +/- 1.16 (0.6v + 0.6x1.5) = 0.6v + 0.9 1.16 = +/-(0.6v + 0.9) speed |v| = 0.433 ms^{-1}	B1 B1 M1 A1 [4] B1 B1 M1 A1	+/- 0.3 Nb the terms have same signs Equating their total mom before & after Accept 13/30 or 0.43 recurring, but not 0.43 Momentum change of P Momentum change of Q Equating momentum changes 0.26/0.6 = v
ii	+/-(0.4x0.1 - 0.6v) (0.4x3 - 0.6x1.5) = +/-(0.6v - 0.4x0.1) v = 0.567 PQ = 0.1x3 +0.567x3 PQ = 2 m *OR* +/- 0.4x3 + 0.4x0.1 and +/- 0.6v + 0.6x1.5 1.24 = +/- 0.6v + 0.9 v = 0.567 etc	B1 M1 A1 M1 A1 [5] B1 M1 A1	Nb the terms have different signs Must use +/- same before momentum as in (i) May be implied, or in any format (0.1 + 0.567)x3 Accept 2.00(1), 2.0, 2.00 Both must be correct Equating change in momentum May be implied, or in any format

3 i	H = +/-(9 - 5cos60) H = 6.5 N AG	M1 A1 [2]	+/-(9 + 5cos120)
ii	V = +/-(12 - 5sin60) V = 7.67 N	M1 A1 [2]	+/-(12 + 5cos150) Accept 7.666 or better, or 7.6 recurring
iii	$R^2 = 6.5^2 + 7.67^2$ R = 10.1 N tan A = 6.5/7.67 or 7.67/6.5 A = 40(.3) or 49.7 Bearing = 320°	M1 A1 M1 A1 A1 [5]	Uses Pythagoras on forces V(ii) and 6.5 10.053.. Uses trigonometry in relevant triangle May be implied by final answer As this is not a final answer, exact accuracy is not an issue Or better

4 i	$3.2 - 0.2t^2 = 0$ $t = 4$ s	M1 A1 [2]	Puts 0 for v and attempts to solve QE Accept dual solution +/-4
ii	$a = -2x0.2t$ $a = -0.4x4$ $a = -1.6$ ms^{-2}	M1* D*M1 A1 [3]	Differentiates v Substitutes +ve t(i) in derivative of v Negative only
iii	$s= 3.2t - 0.2t^3/3$ (+c) $t = 0$, $s = 0$ so $c = 0$ $s(4) = 3.2x4 -0.2x4^3/3$ $s = 8.53$ m	M1* A1 B1 D*M1 A1 [5]	Integrates v, not multiplication by t Or correct use of limits 0 and 4 Accept without/loss of c 8 8/15 Accept with/without c

5 i	+/-3x20/2 30 m	M1 A1 [2]	Use area of <u>scalene</u> triangle(s). Not suvat. Accept -30
ii	$(t+4)x3/2 = 30$ or $3t/2 = 30 - 4x3$ $t = 16$ or $t = 12$ $T = 76$	M1 A1 A1 A1 [4]	Equates <u>scalene</u> trapezium area to distance (i) [(T-60)+4]x3/2 =30, award A2
iii	T(accn) = 3/0.4 (=7.5 s) decn = 3/([76-60] - 4 - 7.5) decn = (+/-) 2/3 ms^{-2} *OR* S(accn) = 3^2/(2x0.4) (= 11.25 m) decn = 3^2 / [2x(30 – 3x4 – 11.25)] decn = (+/-) 2/3 ms^{-2}	B1 M1 A1 [3] B1 M1 A1	 Or 3 = decn x ([76-60] - 4 - 7.5) (+/-) 0.667 or better - accept 0.6 recurring (+/-) 0.667 or better - accept 0.6 recurring

6 i a	T - 0.85g sin30 = 0.85a 0.55g - T = 0.55a a = 1.225/1.4 a = 0.875 T = 4.91	B1 B1 M1 A1 A1 [5]	Either equation correct Both eqns correct and consistent ‘a’ direction Solves 2 sim eqn 4.908 or better – has to be positive
b	F = 2Tcos30 F = 8.5(02..)	M1 A1ft [2]	Or Pythagoras or cosine rule cv(4.91)x√3
ii	$v^2 = 1.3^2 + 2x0.875x1.5$ (=4.315) $a = +/-g\sin30$ $0 = 4.315 -2x4.9s$ (s = 0.44…) S = 1.94	M1 A1ft B1 M1 A1 A1 [6]	Uses $v^2 = u^2 + 2a(1.5)$, u non-zero, a from (i) v = 2.077....(v^2 =1.69+3xcv(0.875)) a = +/-4.9 Uses $0^2 = u^2 +/-2as$, with a not g or (i), u not1.3 May be implied – need not be 3sf

7 i	Fr = 4 + 5sin60 Fr = 8.33 R = 12 - 5cos60 R = 9.5 μ = (4 + 5sin60)/(12 - 5cos60) μ = 0.877	M1 A1 M1 A1 M1 A1 [6]	All 4 + component 5 (4 + 4.333(01)) May be implied +/-(All 12 – component 5 (12 – 2.5)) May be implied, +ve from correct work Friction/Reaction, Fr>4, R<12, both positive
ii	Upper block μ = 5sin60/(9-5cos60) (=4.3/6.5) μ = 0.666	 M1 A1 [2]	 (Component 5)/(9-component 5)
iii	Upper mass = 9/g (9/g)a = 5sin60 - 0.1(9 - 5cos60) a = 4.01 Lower mass Tractive force = 4 + 0.1(9-5cos60) (= 4.65) Max Friction = 0.877(3+(9-5cos60) (= 8.33) Tractive force < Max Friction a = 0 *OR for Lower Mass* ma = 4+0.1(9-5cos60)-0.877(3+9-5cos60) -ve a caused by friction impossible, hence a = 0	B1 M1 A1 M1 A1 A1 [6] M1 A1 A1	0.918(36..) N2L 0.918(36..)a= 4.33(01..) – 0.1x6.5 where friction = 0.1x(9-component 5) Compares TF (tractive force) and max friction N2L with 3 force terms: