OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

MATHEMATICS 4728

Mechanics 1

Candidates answer on the Answer Booklet

OCR Supplied Materials:
- 8 page Answer Booklet
- List of Formulae (MF1)

Other Materials Required:
None

Monday 19 January 2009
Afternoon

Duration: 1 hour 30 minutes

* 4 7 2 8 *

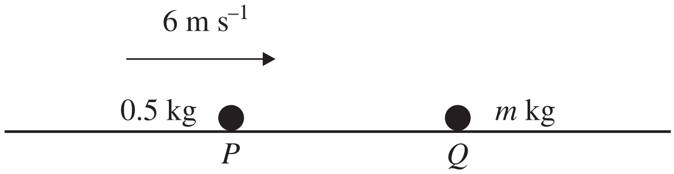
INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the spaces provided on the Answer Booklet.
- 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.
- 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 $g\,\mathrm{m\,s^{-2}}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.
- You are permitted to use a graphical calculator in this paper.

INFORMATION FOR CANDIDATES

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

1



A particle P of mass 0.5 kg is travelling with speed $6\,\mathrm{m\,s^{-1}}$ on a smooth horizontal plane towards a stationary particle Q of mass m kg (see diagram). The particles collide, and immediately after the collision P has speed $0.8\,\mathrm{m\,s^{-1}}$ and Q has speed $4\,\mathrm{m\,s^{-1}}$.

(i) Given that both particles are moving in the same direction after the collision, calculate m. **[3]**

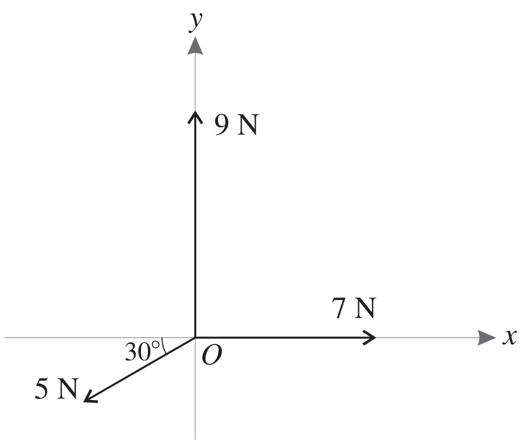
(ii) Given instead that the particles are moving in opposite directions after the collision, calculate m. **[3]**

2 A trailer of mass 500 kg is attached to a car of mass 1250 kg by a light rigid horizontal tow-bar. The car and trailer are travelling along a horizontal straight road. The resistance to motion of the trailer is 400 N and the resistance to motion of the car is 900 N. Find both the tension in the tow-bar and the driving force of the car in each of the following cases.

(i) The car and trailer are travelling at constant speed. **[3]**

(ii) The car and trailer have acceleration $0.6\,\mathrm{m\,s^{-2}}$. **[6]**

3

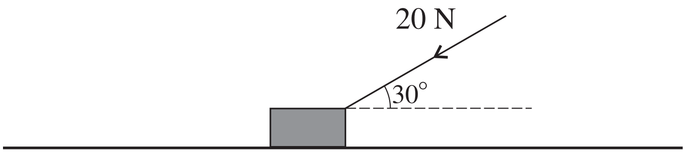


Three horizontal forces act at the point O. One force has magnitude 7 N and acts along the positive x-axis. The second force has magnitude 9 N and acts along the positive y-axis. The third force has magnitude 5 N and acts at an angle of 30° below the negative x-axis (see diagram).

(i) Find the magnitudes of the components of the 5 N force along the two axes. **[2]**

(ii) Calculate the magnitude of the resultant of the three forces. Calculate also the angle the resultant makes with the positive x-axis. **[6]**

4



A block of mass 3 kg is placed on a horizontal surface. A force of magnitude 20 N acts downwards on the block at an angle of 30° to the horizontal (see diagram).

(i) Given that the surface is smooth, calculate the acceleration of the block. **[3]**

(ii) Given instead that the block is in limiting equilibrium, calculate the coefficient of friction between the block and the surface. **[5]**

5 A car is travelling at $13\,\mathrm{m\,s^{-1}}$ along a straight road when it passes a point A at time $t = 0$, where t is in seconds. For $0 \leqslant t \leqslant 6$, the car accelerates at $0.8t\,\mathrm{m\,s^{-2}}$.

(i) Calculate the speed of the car when $t = 6$. **[5]**

(ii) Calculate the displacement of the car from A when $t = 6$. **[5]**

(iii) Three (t, x) graphs are shown below, for $0 \leqslant t \leqslant 6$.

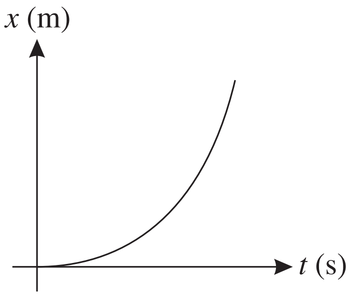


Fig. 1

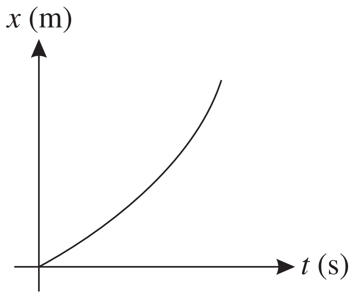


Fig. 2

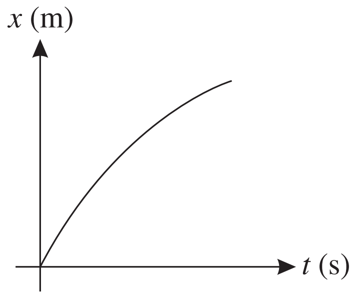


Fig. 3

(a) State which of these three graphs is most appropriate to represent the motion of the car. **[1]**

(b) For each of the two other graphs give a reason why it is not appropriate to represent the motion of the car. **[2]**

[Questions 6 and 7 are printed overleaf.]

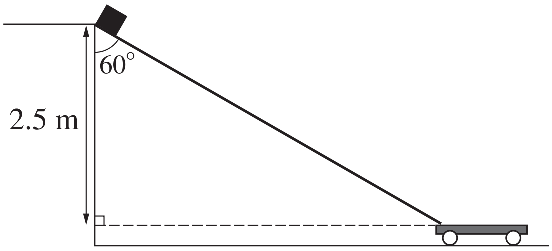
6 Small parcels are being loaded onto a trolley. Initially the parcels are 2.5 m above the trolley.

(i) A parcel is released from rest and falls vertically onto the trolley. Calculate

(a) the time taken for a parcel to fall onto the trolley, **[2]**

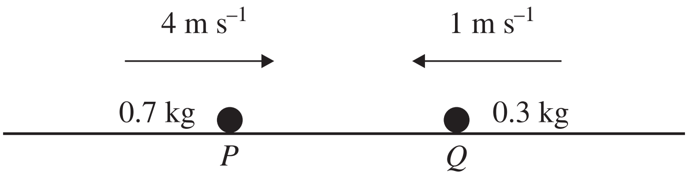
(b) the speed of a parcel when it strikes the trolley. **[2]**

(ii)



Parcels are often damaged when loaded in the way described, so a ramp is constructed down which parcels can slide onto the trolley. The ramp makes an angle of 60° to the vertical, and the coefficient of friction between the ramp and a parcel is 0.2. A parcel of mass 2 kg is released from rest at the top of the ramp (see diagram). Calculate the speed of the parcel after sliding down the ramp. **[9]**

7



Two particles P and Q have masses 0.7 kg and 0.3 kg respectively. P and Q are simultaneously projected towards each other in the same straight line on a horizontal surface with initial speeds of 4 m s^{-1} and 1 m s^{-1} respectively (see diagram). Before P and Q collide the only horizontal force acting on each particle is friction and each particle decelerates at 0.4 m s^{-2}. The particles coalesce when they collide.

(i) Given that P and Q collide 2 s after projection, calculate the speed of each particle immediately before the collision, and the speed of the combined particle immediately after the collision. **[6]**

(ii) Given instead that P and Q collide 3 s after projection,

(a) sketch on a single diagram the (t, v) graphs for the two particles in the interval $0 \leqslant t < 3$, **[3]**

(b) calculate the distance between the two particles at the instant when they are projected. **[6]**

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1 (i)	 0.5x6 = 0.5x0.8 + 4m m = 0.65	M1 A1 A1 [3]	Uses CoLM If g used throughout, possible 3 marks
(ii)	 0.5x6 = - 0.5x0.8 + 4m m = 0.85	M1 A1 A1 [3]	After momentums opposite signs If g used throughout, 0 marks
2 (i)	T = 400 N D = 400 + 900 = 1300 N	B1 M1 A1 [3]	Order immaterial Or T + 900; sign correct
(ii)	 500x0.6 = T - 400 T = 700 N 1250x0.6 = D - 900 -700 D = 2350 N *OR* (500 + 1250)x0.6 = D - 400 - 900 D = 2350 N	 M1 A1 A1 M1 A1ft A1 M1 A1 A1 [6]	(Award M marks even if g included in ma terms. M marks require correct number forces) Uses N2L one object only Uses N2L other object ft cv(T from (ii)); allow T instead of its value Uses N2L for both objects
3 (i)	5cos30 or 5 sin 60 or 4.33 5cos 60 or 5sin30 or 2.5	B1 B1 [2]	Order immaterial, accept +/-. May be awarded in (ii) if no attempt in (i)
(ii)	 7-4.33 (= 2.67) and 9 - 2.5 (= 6.5) $R^2 = 2.67^2 + 6.5^2$ R = 7.03 tanθ = 6.5/2.67 θ = 67.6, 67.7degrees	M1* A1 D*M 1 A1 D*M 1 A1 [6]	Subtracts either component from either force 3sf or better Valid trig for correct angle 3sf or better
4 (i)	20cos 30 20cos30 = 3a a = 5.77 ms^{-2}	M1 M1 A1 [3]	Resolves 20 (accept 20 sin30) Uses N2L horizontally, accept g in ma term
(ii)	 R = 3x9.8 + 20 sin 30 (= 39.4) F = 20cos 30 (= 17.3) 17.3 = 39.4μ μ = 0.44	M1 A1 B1 M1 A1 [5]	Resolves vertically (accept -, cos if sin in i); correct no. terms Correct (Neither R nor *F* need be evaluated) Uses F = μR

5 (i)	$V = \int 0.8t\,dt$ $v = 0.8t^2/2$ (+c) t = 0, v =13, (c = 13) $v = 0.4 \times 6^2$ (+c) v = 27.4 ms^{-1}	M1* A1 M1 D*M1 A1 [5]	Attempt at integration Award if c omitted
(ii)	$s = \int 0.4t^2$ (+c)dt $s = 0.4t^3/3 + 13t$ (+k) t=0, s=0, (k=0) $s = 0.4 \times 6^3/3 + 13 \times 6$ s = 106.8 m	M1* A1ft M1 D*M1 A1 [5]	Attempt at integration of v(t) ft cv(v(t) in (i)) Allow if k=0 assumed. Accept 107 m.
(iii)	Fig. 2 Fig.1 has zero initial velocity/gradient Fig. 3 does not have a increasing velocity/gradient	B1 [1] B1 B1 [2]	
6 (i) a **b**	$2.5 = 9.8t^2/2$ t = 0. 714 s or better or 5/7 $v^2 = 2 \times 9.8 \times 2.5$ *OR* v = 9.8 x 0.714 v = 7 ms^{-1} or 6.99 or art 7.00	M1 A1 [2] M1 A1 [2]	Uses s = 0 +/- $gt^2/2$ Not awarded if - sign "lost" Uses v^2 = 0 +/-2gs or v = u +/- gt Not awarded if - sign "lost"
(ii)	R = 2x9.8sin60 (= 16.97 = 17) F = 0.2x16.97 (=3.395 or 3.4) Cmpt weight = 2x9.8cos60 (= 9.8) 2a = 9.8 - 3.395 a = 3.2 ms^{-2} Distance down ramp = 5 m v^2 = 2x3.2x5 v = 5.66 or 5.7	B1 M1 A1ft B1 M1 A1ft B1 M1 A1ft [9]	With incorrect angle, e.g R = 2x9.8cos60 (=9.8) B0 F = 0.2x9.8 (=1.96) M1A1√ Cmpt wt = 2x9.8sin60 (=16.97) B0 2a = 16.97 - 1.96 M1 a = 7.5 A1√ ft cv(R and Cmpt weight) v^2 = 2x7.5x5 v = 8.66 or 8.7 A1√ ft cv(√ (10a))
7 (i)	 p = 4 - 2x0.4 (= 3.2) q = 1 - 2x0.4 (= 0.2) 0.7x3.2 - 0.3x0.2 = (1x)v v = 2.18 ms^{-1}	M1 A1 A1 M1 A1 A1 [6]	Use of v = u - 0.4t Accept q = -0.2 from -1+2*0.4 Uses CoLM on reduced velocities

(ii) **a**		B1 B1 B1 [3]	Straight line with larger y intercept slopes towards t axis, but does not reach it. Straight line with negative y intercept slopes towards t axis, and gets to t axis before other line ends. **SR** if t=2 in ii give B1 if line stops before axis
b	$0 = 1 - 0.4t$ $t = 2.5$ s $P = 4x3 - 0.5x0.4x3^2$ $Q = 1x2.5 - 0.5x0.4x2.5^2$ $PQ = 10.2 + 1.25 = 11.45$ m	M1 A1 M1 A1 A1 A1 [6]	Finds when Q comes to rest (any method) Uses $s = ut - 0.4t^2/2$ (nb $0^{(2)} = 1^{(2)} - 0.4Q^2/2$ B1; convincing evidence (graph to scale, or calculation that Q comes to rest and remains at rest at t less than 3, M1A1;graph A1 needs –ve v intercept) **SR** if t=2 in iib, allow M1 for $s= ut - 0.4t^2/2$ And A1 for PQ=8.4

Alternative for Q3 where 7 N and 9N forces combined initially

3 (i)	5cos30 or 5 sin 60 or 4.33 5cos 60 or 5sin30 or 2.5	B1 B1 [2]	Order immaterial, accept +/-. May be awarded in (ii) if no attempt in (i)
(ii)	$Z^2 = 7^2 + 9^2$ (= 130, Z = 11.4017...) cos(angle of Z with y axis) = 9/11.4017.. angle of Z with y axis = 37.8746... Angle opposite R in triangle of forces = 180 -(37.8746+90+30) = 22.125 (Accept 22) $R^2 = 5^2 + 11.4017^2 - 2x5x11.4017\cos22.125$ R (= 7.0269) = 7.03 N $11.4017^2 = 5^2 + 7.0269^2 - 2x5x7.0269\cos A$ (A = 142.33) Angle between R and y axis = 142.33-30-90 (=22.33) θ (= 90-22.33) =67.7 degrees	 M1* A1 D*M1 A1 D*M1 A1 [6]	Z is resultant of 7N and 9N forces only R is resultant of all 3 forces Complete method Cosine rule to find R Or Sine Rule. A is angle between R and 5N forces Complete method θ is angle between R and x axis