OCR
Oxford Cambridge and RSA

Tuesday 9 June 2015 – Morning

AS GCE MATHEMATICS

4728/01 Mechanics 1

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:
- Printed Answer Book 4728/01
- List of Formulae (MF1)

Other materials required:
- Scientific or graphical calculator

Duration: 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

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

- The Question Paper will be found inside the Printed Answer Book.
- Write your name, centre number and candidate number in the spaces provided on the Printed Answer Book. Please write clearly and in capital letters.
- **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. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Do **not** write in the bar codes.
- You are permitted to use a scientific or 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 recycled. Please contact OCR Copyright should you wish to re-use this document.

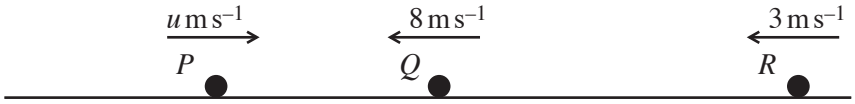
1 A particle P is projected vertically downwards with speed $14\,\text{m s}^{-1}$ from a point 30 m above the ground.

(i) Calculate the speed of P when it reaches the ground. **[2]**

(ii) Find the distance travelled by P in the first 0.4 s of its motion. **[2]**

(iii) Calculate the time taken for P to travel the final 15 m of its descent. **[3]**

2



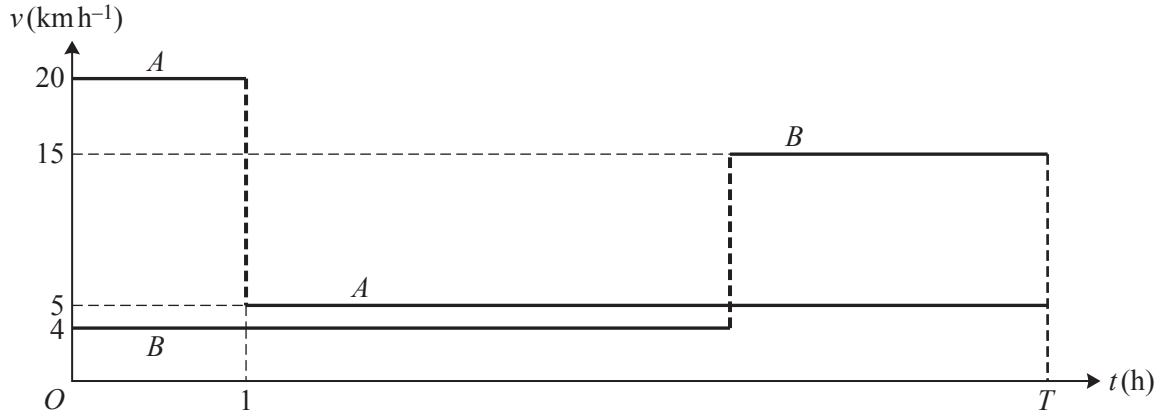
Three particles P, Q and R with masses 0.4 kg, 0.3 kg and m kg are moving along the same straight line on a smooth horizontal surface. P and Q are moving towards each other with speeds $u\,\text{m s}^{-1}$ and $8\,\text{m s}^{-1}$ respectively. R has speed $3\,\text{m s}^{-1}$ and is moving in the same direction as Q (see diagram).

(i) Immediately after the collision between P and Q their directions of motion have been reversed, but their speeds are unchanged. Calculate u. **[4]**

The next collision is between Q and R. After the collision between Q and R, particle Q is at rest and R has speed $9\,\text{m s}^{-1}$.

(ii) Calculate m. **[4]**

3



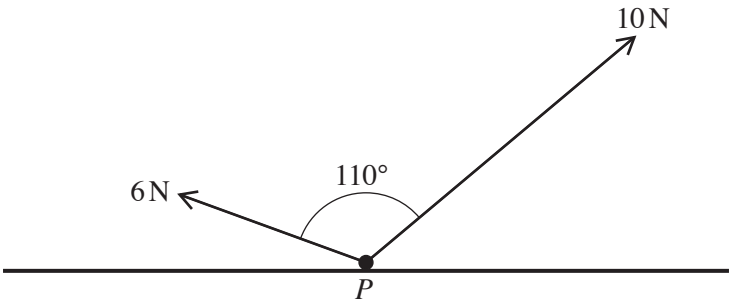
Two travellers A and B make the same journey on a long straight road. Each traveller walks for part of the journey and rides a bicycle for part of the journey. They start their journeys at the same instant, and they end their journeys simultaneously after travelling for T hours. A starts the journey cycling at a steady $20\,\text{km h}^{-1}$ for 1 hour. A then leaves the bicycle at the side of the road, and completes the journey walking at $5\,\text{km h}^{-1}$. B begins the journey walking at a steady $4\,\text{km h}^{-1}$. When B finds the bicycle where A left it, B cycles at $15\,\text{km h}^{-1}$ to complete the journey (see diagram).

(i) Calculate the distance A cycles, and hence find the period of time for which B walks before finding the bicycle. **[3]**

(ii) Find T. **[3]**

(iii) Calculate the distance A and B each travel. **[2]**

4



Two forces of magnitudes 6 N and 10 N separated by an angle of 110° act on a particle P, which rests on a horizontal surface (see diagram).

(i) Find the magnitude of the resultant of the 6 N and 10 N forces, and the angle between the resultant and the 10 N force. **[6]**

The two forces act in the same vertical plane. The particle P has weight 20 N and rests in equilibrium on the surface. Given that the surface is smooth, find

(ii) the magnitude of the force exerted on P by the surface, **[1]**

(iii) the angle between the surface and the 10 N force. **[2]**

5 A particle P of mass 0.4 kg is at rest on a horizontal surface. The coefficient of friction between P and the surface is 0.2. A force of magnitude 1.2 N acting at an angle of $\theta°$ above the horizontal is then applied to P. Find the acceleration of P in each of the following cases:

(i) $\theta = 0$; **[3]**

(ii) $\theta = 20$; **[3]**

(iii) $\theta = 70$; **[3]**

(iv) $\theta = 90$. **[2]**

6 A particle P moves in a straight line on a horizontal surface. P passes through a fixed point O on the line with velocity $2\,\text{m s}^{-1}$. At time t s after passing through O, the acceleration of P is $(4 + 12t)\,\text{m s}^{-2}$.

(i) Calculate the velocity of P when $t = 3$. **[4]**

(ii) Find the distance OP when $t = 3$. **[4]**

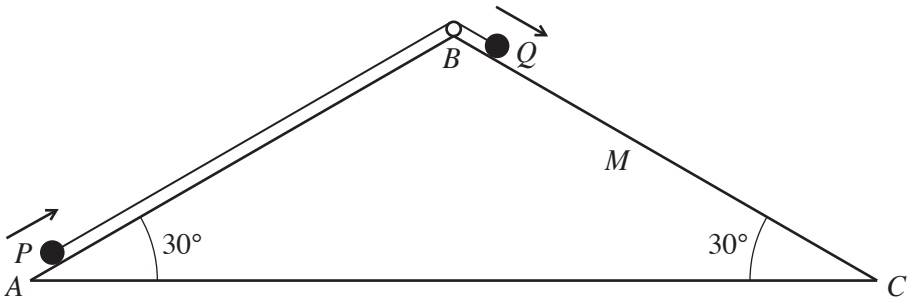
A second particle Q, having the same mass as P, moves along the same straight line. The displacement of Q from O is $(k - 2t^3)$ m, where k is a constant. When $t = 3$ the particles collide and coalesce.

(iii) Find the value of k. **[1]**

(iv) Find the common velocity of the particles immediately after their collision. **[5]**

Question 7 begins on page 4.

7



AB and *BC* are lines of greatest slope on a fixed triangular prism, and *M* is the mid-point of *BC*. *AB* and *BC* are inclined at 30° to the horizontal. The surface of the prism is smooth between *A* and *B*, and between *B* and *M*. Between *M* and *C* the surface of the prism is rough. A small smooth pulley is fixed to the prism at *B*. A light inextensible string passes over the pulley. Particle *P* of mass 0.3 kg is fixed to one end of the string, and is placed at *A*. Particle *Q* of mass 0.4 kg is fixed to the other end of the string and is placed next to the pulley on *BC*. The particles are released from rest with the string taut. *P* begins to move towards the pulley, and *Q* begins to move towards *M* (see diagram).

(i) Show that the initial acceleration of the particles is $0.7\,\mathrm{m\,s^{-2}}$, and find the tension in the string. **[5]**

The particle *Q* reaches *M* 1.8 s after being released from rest.

(ii) Find the speed of the particles when *Q* reaches *M*. **[2]**

After *Q* passes through *M*, the string remains taut and the particles decelerate uniformly. *Q* comes to rest between *M* and *C* 1.4 s after passing through *M*.

(iii) Find the deceleration of the particles while *Q* is moving from *M* towards *C*. **[2]**

(iv) **(a)** By considering the motion of *P*, find the tension in the string while *Q* is moving from *M* towards *C*. **[3]**

(b) Calculate the magnitude of the frictional force which acts on *Q* while it is moving from *M* towards *C*. **[3]**

END OF QUESTION PAPER

Question			Answer	Marks	Guidance	
1	(i)		$v^2 = 14^2 + 2g \times 30$ $v = 28$ m s^{-1}	M1 A1 **[2]**	$v^2 = u^2$ +/– $2gs$	Using $v^2 = u^2 + 2as$
1	(ii)		$s = 14 \times 0.4 + g \times 0.4^2 /2$ $s = 6.384$ m	M1 A1 **[2]**	Accept 6.38	
1	(iii)		$15 = 28t - gt^2 /2$ $4.9t^2 - 28t + 15 = 0$ $t = (5.12)\ 0.598$ s *OR* $28^2 = u^2 + 2g \times 15$ $28 = \sqrt{(490)} + gt$ $t = 0.598$ s *OR* $15 = 14t + gt^2 /2$ $30 = (14 + 28)t/2$ $t = 0.598$ s	M1* D*M1 A1 **[3]** M1* D*M1 A1 M1* D*M1 A1	Uses $s = vt$ +/– $gt^2/2$ Attempts to solve 3 term QE Ignore 5.12 if seen $v^2 = 14^2 + 2g \times 15$ Attempts to solve 3 term QE Finding total time.	Accept cv(28) but not v = 0 Accept cv(28) but not $v = 0$ Accept cv(28) but not v = 0
2	(i)		Before momentum = +/–$(0.4u - 0.3 \times 8)$ $0.4u - 0.3 \times 8 = -0.4u + 0.3 \times 8$ $u = 6$	B1 M1 A1ft A1 **[4]**	Uses momentum cons. 4 non-zero terms ft candidates "before" expression	Accept inclusion of g, including final A1
2	(ii)		After momentum = +/–$9m$ $0.3 \times 8 - 3m = 9m$ $m = 0.2$	B1 M1 A1ft A1 **[4]**	Uses momentum conservation 3 non-zero terms ft candidates "after" expression	No marks if g included, even if apparently cancelled

Question			Answer	Marks	Guidance	
3	(i)		A cycles (= 20 × 1) = 20 km B walks = 20/4 h Time = 5 hours	B1 M1 A1 **[3]**		
3	(ii)		$20 \times 1 + 5(T - 1)$ $= 4 \times 5 + 15(T - 5)$ $T = 7$ *OR* $5(T - 1)$ $= 15(T - 5)$ $T = 7$	B1 M1 A1 **[3]** B1 M1 A1	Total A or B distance correct Equates total distances for A and B A walking distance Equates A walking and B cycling distances	Accept cv(5) for time Using t instead of $(T - 5)$ and finding $t = 2$ gets B1 M1 Needs consistency of T (or t) for M1
3	(iii)		Total distance (A) = 20 × 1 + 5(7 – 1) J = 50 km	M1 A1 **[2]**	Or (B) 4 × 5 + 15 × (7 – 5)	cv(7) and, for B cv(5)
4	(i)		x = +/–(10 – 6cos70) , y = 6sin70 *OR* +/–(10cos70 – 6) , 10sin70 *OR* correct resolving in 2 perpendicular directions $R^2 = \{+/-(10 - 6\cos 70)\}^2 + (6\sin 70)^2 = \{+/-(10\cos 70 - 6)\}^2 + (10\sin 70)^2$ R = 9.74 N Tanα = (6cos20)/(10 – 6sin20) α = 35.4°	B1,B1 M1 A1 M1 A1 **[6]**	10cos55 + 6cos55 (= 9.177) B1 +/–(10sin55 – 6sin55) (= +/–3.2766) B1 $R^2 = (10\cos 55 + 6\cos 55)^2 + (10\sin 55 - 6\sin 55)^2$ R = 9.74 N www	Uses cosine rule M1 $R^2 = 6^2 + 10^2 - 2 \times 6 \times 10 \cos$ B1 Uses angle of 70 B1 R = 9.74 N A1 Sinα /6 = sin70/9.744 M1 α = 35.4° A1

Question			Answer	Marks	Guidance	
4	(ii)		Force = (20 – 9.74) = 10.3 N	B1ft **[1]**	Difference of weight and Resultant ft 20 – cv(9.74)	
4	(iii)		Tanθ = +/–(10 – 6cos70) /6sin70 *OR* Tanφ = +/–(6sin70) /(10 – 6cos70) Angle = 54.6°	M1 A1 **[2]**	Uses resultant is vertical	Angle = 90 – cv(35.4) M1 Angle = 54.6° A1
5	(i)		$Fr = 0.2 \times 0.4g$ $1.2 – 0.2 \times 0.4g = 0.4a$ $a = 1.04$ m s^{-2}	B1 M1 A1 **[3]**	N2L, 2 forces	
5	(ii)		$R = 0.4g – 1.2\sin20$ $1.2\cos20 – 0.2(0.4g – 1.2\sin20) = 0.4a$ $a = 1.06$ m s^{-2}	B1 M1 A1 **[3]**	N2L, 2 forces, cmpt of 1.2 and *Fr* not *Fr***(i)**	SC $R = 0.4g + 1.2\sin20$ $1.2\cos20–0.2(0.4g +1.2\sin20) = 0.4a$ $a = 0.654$ m s^{-2} Give B1M1A1
5	(iii)		$1.2\cos70 – 0.2(0.4g – 1.2\sin70)$ (Total is negative,) friction not overcome by (tractive) force $a = 0$ m s^{-2}	M1 A1 A1 **[3]**	Difference of two relevant forces, neither used earlier (or find and compare)	SC $1.2\cos70 – 0.2(0.4g + 1.2\sin70)$ Mark as correct case Only finding a negative acceleration scores maximum M1 in both cases.
5	(iv)		$1.2 < 0.4g$ (oe, soi) P cannot rise from table *or* $a = 0$ m s^{-2}	M1 A1 **[2]**	Comparison of weight and 1.2 without involving R Only finding a negative acceleration scores M0	SC Sum of weight and 1.2 P can't go through the table *or* a = 0 B1 only

Question			Answer	Marks	Guidance	
6	(i)		$v = \int 4 + 12t \text{ dt}$ $v = 4t + 12t^2/2 \ (+ c)$ $(t = 0, v = 2)\ c = 2$ and $v(3) = 4 \times 3 + 12 \times 3^2/2 \ (+ 2)$ $v = 68 \text{ m s}^{-1}$	M1* A1 D*M1 A1 **[4]**	Integrates acceleration Award without $(+ c)$ Evaluates constant	Must see one term correct.
6	(ii)		$\int 4t + 6t^2 (+2) \text{d}t$ $x = 4t^2/2 + 6t^3/3 + 2t \ (+ d)$ $x(3) = 4 \times 3^2/2 + 6 \times 3^3/3 \ (+ 3 \times 2)$ $x = 78 \text{ m}$	M1* A1ft D*M1 A1 **[4]**	Integrates velocity accept omission of d for all subsequent marks	ft on incorrect (non-zero) c from (i)
6	(iii)		$k = 132$	B1ft **[1]**	ft cv(78) + 54	
6	(iv)		$v = \text{d}(k - 2t^3)/\text{d}t$ $v = -2 \times 3t^2$ $v(3) = -6 \times 3^2 \ (= -54)$ $68m - 54m = 2mv$ $v = 7 \text{ m s}^{-1}$	M1* A1 D*M1 M1 A1 **[5]**	Differentiates displacement Award even if k wrong earlier Substitutes $t = 3$ Conservation of momentum, must have $2m$, cv(68)	No marks if g included, even if apparently cancelled

Question			Answer	Marks	Guidance	
7	(i)		$T - 0.3g\sin30 = 0.3a$ *OR* $0.4g\sin30 - T = 0.4a$ $0.4g\sin30 - 0.3g\sin30 = 0.7a$ $a = 0.7$ m s^{-2} AG $T = 0.3g\sin30 + 0.3 \times 0.7$ $T = 1.68$ N	B1 M1 A1 M1 A1 **[5]**	Either correct N2L for one particle May be awarded later in (i) Allow combined approach as "method", must be components of weight, allow $mg($cos/sin$)30$ Allow $0.3g($cos/sin$)30$. Accept cv(0.7)	Putting $a = 0.7$ into correct equation for a single particle and working out T correctly gets B1M0A0M1A1. Consult TL if this is done for both particles. May use the other equation.
7	(ii)		$V = 1.8 \times 0.7$ $V = 1.26$ m s^{-1}	M1 A1 **[2]**	Accept cv(0.7)	
7	(iii)		Dec $= 1.26 / 1.4$ Dec $= 0.9$ m s^{-2}	M1 A1 **[2]**	Accept $1.8 \times 0.7 / 1.4$ Or $a = +/-0.9$	cv(1.26)
7	(iv)	(a)	$T - 0.3g\sin30 = -0.3 \times 0.9$ $T = 1.2$	M1 A1ft A1 **[3]**	N2L, 2 forces including cmpt of weight cv(0.9) but signs must be consistent with the direction of motion	Allow $mg($cos/sin$)30$
7	(iv)	(b)	$-0.4 \times 0.9 = 0.4g\sin30 - T - F_r$ $-0.4 \times 0.9 = 0.4g\sin30 - 1.2 - F_r$ $F_r = 1.12$ N	M1 A1ft A1 **[3]**	N2L, 3 forces including cmpt of weight cv(0.9) and cv(1.2) but signs must be consistent with the direction of motion	Allow $mg($cos/sin$)30$