OCR
RECOGNISING ACHIEVEMENT

Friday 25 January 2013 – Afternoon

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

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INSTRUCTIONS TO CANDIDATES

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

- The Question Paper will be found in the centre of 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 $g\,\text{m}\,\text{s}^{-2}$. 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 **16** 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.

Turn over

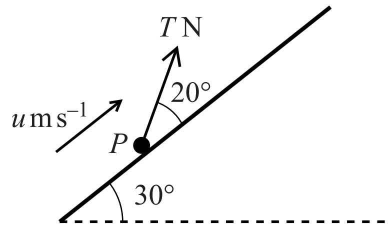
1 Three horizontal forces, acting at a single point, have magnitudes 12 N, 14 N and 5 N and act along bearings 000°, 090° and 270° respectively. Find the magnitude and bearing of their resultant. **[5]**

2 A particle P moves in a straight line. The displacement of P from a fixed point on the line is $(t^4 - 2t^3 + 5)$ m, where t is the time in seconds. Show that, when $t = 1.5$,

(i) P is at instantaneous rest, **[3]**

(ii) the acceleration of P is $9\,\text{m}\,\text{s}^{-2}$. **[3]**

3



A particle P of mass 0.25 kg moves upwards with constant speed $u\,\text{m}\,\text{s}^{-1}$ along a line of greatest slope on a smooth plane inclined at 30° to the horizontal. The pulling force acting on P has magnitude T N and acts at an angle of 20° to the line of greatest slope (see diagram). Calculate

(i) the value of T, **[3]**

(ii) the magnitude of the contact force exerted on P by the plane. **[3]**

The pulling force T N acting on P is suddenly removed, and P comes to instantaneous rest 0.4 s later.

(iii) Calculate u. **[4]**

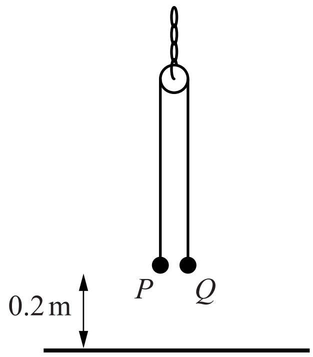
4 The acceleration of a particle P moving in a straight line is $(t^2 - 9t + 18)\,\text{m}\,\text{s}^{-2}$, where t is the time in seconds.

(i) Find the values of t for which the acceleration is zero. **[2]**

(ii) It is given that when $t = 3$ the velocity of P is $9\,\text{m}\,\text{s}^{-1}$. Find the velocity of P when $t = 0$. **[4]**

(iii) Show that the direction of motion of P changes before $t = 1$. **[2]**

5



A small smooth pulley is suspended from a fixed point by a light chain. A light inextensible string passes over the pulley. Particles P and Q, of masses 0.3 kg and m kg respectively, are attached to the opposite ends of the string. The particles are released from rest at a height of 0.2 m above horizontal ground with the string taut; the portions of the string not in contact with the pulley are vertical (see diagram). P strikes the ground with speed $1.4\,\text{m s}^{-1}$. Subsequently P remains on the ground, and Q does not reach the pulley.

(i) Calculate the acceleration of P while it is in motion and the corresponding tension in the string. **[4]**

(ii) Find the value of m. **[3]**

(iii) Calculate the greatest height of Q above the ground. **[4]**

(iv) It is given that the mass of the pulley is 0.5 kg. State the magnitude of the tension in the chain which supports the pulley

(a) when P is in motion, **[2]**

(b) when P is at rest on the ground and Q is moving upwards. **[1]**

6 Particle P of mass 0.3 kg and particle Q of mass 0.2 kg are 3.6 m apart on a smooth horizontal surface. P and Q are simultaneously projected directly towards each other along a straight line. Before the particles collide P has speed $4\,\text{m s}^{-1}$ and Q has speed $5\,\text{m s}^{-1}$.

(i) Given that the particles coalesce in the collision, calculate their common speed after they collide. **[3]**

(ii) It is given instead that one particle is at rest immediately after the collision.

(a) State which particle is in motion after the collision and find the speed of this particle. **[4]**

(b) Find the time taken after the collision for the moving particle to return to its initial position. **[4]**

(c) On a single diagram sketch the (t, v) graphs for the two particles, with $t = 0$ as the instant of their initial projection. **[4]**

7 A and B are two points on a line of greatest slope of a plane inclined at 45° to the horizontal and $AB = 2$ m. A particle P of mass 0.4 kg is projected from A towards B with speed $5\,\text{m s}^{-1}$. The coefficient of friction between the plane and P is 0.2.

(i) Given that the level of A is above the level of B, calculate the speed of P when it passes through the point B, and the time taken to travel from A to B. **[7]**

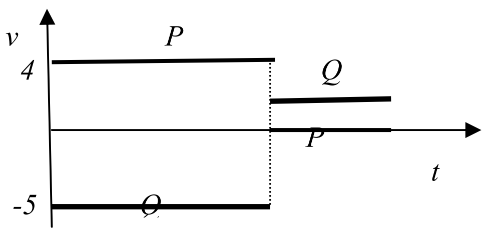
(ii) Given instead that the level of A is below the level of B,

(a) show that P does not reach B, **[3]**

(b) calculate the difference in the momentum of P for the two occasions when it is at A. **[4]**

Question			Answer	Marks	Guidance
1			$X = 14 - 5$ $R^2 = (14 - 5)^2 + 12^2$ $R = 15$ N $\tan\theta = (14 - 5)/12$ $\theta = 36.9°$	B1 M1 A1 M1 A1 **[5]**	Or 5 – 14 Pythagoras, R as hypotenuse, 3 squared terms Any correct trig, angle between 12 and R targetted. Accept 37, 037
2	(i)		$v = \mathrm{d}(t^4 - 2t^3 + 5)/\mathrm{d}t$ $v = 4 \times 1.5^3 - 6 \times 1.5^2$ $v = 0$ AG	M1* D*M1 A1 **[3]**	Differentiates displacement, one wrong term max, ignore +c Substitutes $t = 1.5$ in $v(t)$ OR solves $4t^3$-$6t^2$=0 for a +ve root 0+c is A0 unless c is discarded
2	(ii)		$a = \mathrm{d}(4t^3 - 6t^2)/\mathrm{d}t$ $a(1.5) = 12 \times 1.5^2 - 12 \times 1.5$ $a = 9$ m s^{-2} AG	M1* D*M1 A1 **[3]**	Differentiates velocity, one wrong term max, ignore +c Substitutes $t = 1.5$ in $a(t)$ OR solves $12t^2$ -$12t$=9 for a +ve root 9+c is A0 unless c is discarded
3	(i)		TCorS20 = 0.25gCorS30 Tcos20 = 0.25$g$sin30 $T = 1.3(0)$	M1 A1 A1 **[3]**	Equates cmpt T and cmpt wt // plane (doubt, see diagram and/or (ii)) 1.225
3	(ii)		R +/– TCorS20 =+/- 0.25gCorS30 R + 1.3sin 20 = 0.25$g$cos30 R = 1.68 N	M1 A1 ft A1 **[3]**	Resolves perp plane, accept letter T ft(cv(T))
3	(iii)		(m)accn = +/– (m)9.8sin30 a = +/–4.9 u = +/–9.8sin30 × 0.4 u = 1.96	M1* A1 D*M1 A1 **[4]**	N2L with single force a cmpt wt (accept cos) Must be +ve (accept loss of – sign)

Question			Answer	Marks	Guidance
4	(i)		$(t-3)(t-6)=0$ $t = 3, 6$	M1 A1 **[2]**	Solve 3 term QE, 2 correct coefficients if factorising, or using formula $9 +/- \sqrt{9}\ /2$ "By inspection" both values M1A1, one value M0A0
4	(ii)		$v = \int (t^2 - 9t + 18)\,dt$ $v = t^3/3 - 9t^2/2 + 18t\ (+ c)$ $3^3/3 - 9 \times 3^2/2 + 18 \times 3 + c = 9$ $(v =) -13.5$ m s^{-1}	M1* A1 D*M1 A1 **[4]**	Attempts integration of $a(t)dt$, maximum one wrong term Accept omission of $+ c$ Uses $v(3) = 9$ Must be negative, and goes beyond c=-13.5
4	(iii)		$v(1) = 1/3 - 9/2 + 18 - 13.5 = 0.333$ Changed sign so direction of motion has changed	M1 A1 **[2]**	Finds $v(1)$ (=1/3) Accurate values (v(0)= -13.5, v(0.5)=-5.58, v(0.9)=-0.702)
5	(i)		$1.4^2 = 2 \times a \times 0.2$ *OR* $0.2=(0+1.4)t\ /2$ and $1.4=0+at$ $a = 4.9$ m s^{-2} $0.3g - T = +/- 0.3 \times 4.9$ $T = 1.47$ N	M1 A1 M1 A1 **[4]**	Any use of $a = g$ is M0 $t=2/7$ hence $1.4=a \times 2/7$ N2L diff of weight and tension. Any use of $a = g$ is M0
5	(ii)		$+/-4.9m = 1.47 - mg$ $4.9m = 1.47 - mg$ $m = 0.1$	M1 A1ft A1 **[3]**	N2L for Q using values from (i), a not g; accept $a = g\Delta M/\Sigma M$ Diff cv(T) and mg correct way round; ft cv(T,a) $4.9 = g(0.3 - m)/(0.3 + m)$ M1A1; ftcv(a)
5	(iii)		$1.4^2 = 2gs$ $s = 0.1$ $H = 0.2 + 0.2 + 0.1$ $H = 0.5$ m	M1 A1 M1 A1 **[4]**	Accn = g may be implied (eg $H = 0.3$) BoD sign uncertainty Needs 0.2 twice

Question			Answer	Marks	Guidance
5	(iv)	(a)	Tension = $0.5g + 2 \times 1.47$ Tension = 7.84 N	M1 A1 **[2]**	
5	(iv)	(b)	Tension (= $0.5g$) = 4.9 N	B1 **[1]**	
6	(i)		 0.3x4 - 0.2x5 = +/- (0.3+0.2)v v = 0.4 m s^{-1}	M1 A1 A1 **[3]**	Cons of momentum, no g*, common v "after" term 0.3x4 + 0.2x5 = +/- (0.3+0.2)v is M1A0A0 Must be positive *Allow g if fully cancelled in first line BOD
6	(ii)	(a)	Q (or P at rest) 0.3x4 – 0.2x5 = 0.2v v = 1 m s^{-1}	B1 M1 A1 A1 **[4]**	If P moves, allow 0.3vwhen considering M1 Cons of momentum, no g*, one "after" term 0.3x4 + 0.2x5 = 0.2v is M1A0A0 *Allow g if fully cancelled in first line BOD
6	(ii)	(b)	$4t + 5t = 3.6$ $t = 0.4$ x_Q = 5x0.4 (=2) T = (2/1 =) 2 s *OR* (Time =) $x/5 = (3.6 - x)/4$ x = 2 m T = 2/1 = 2 s	M1 A1 A1 A1 **[4]** M1 A1 A1 A1	Or $9t = 3.6$, Or both $3.6-x = 4t$ and $x= 5t$ Finds initial Q distance. 3.6 x 5 /(4+5) is M1A1A1 Equates pre-collision times x is distance Q travels before collision
6	(ii)	(c)		B1 B1 B1 B1 **[4]**	One horizontal, +ve v intercept One horizontal, –ve v intercept, terminates at same t One along t-axis, starts at same t as +ve line ends, label P One horizontal above t-axis, starts at same t as –ve line ends. (Ignore any values put on graphs)