

Monday 14 January 2013 – Morning

A2 GCE MATHEMATICS

4729/01 Mechanics 2

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:

- Printed Answer Book 4729/01
- 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 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 $g \text{ ms}^{-2}$. 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 **8** 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 block is being pushed in a straight line along horizontal ground by a force of 18 N inclined at 15° below the horizontal. The block moves a distance of 6 m in 5 s with constant speed. Find

(i) the work done by the force, [3]

(ii) the power with which the force is working. [2]

2 A car of mass 1500 kg travels along a straight horizontal road. The resistance to the motion of the car is $kv^{\frac{1}{2}}$ N, where $v \text{ m s}^{-1}$ is the speed of the car and k is a constant. At the instant when the engine produces a power of 15 000 W, the car has speed 15 m s^{-1} and is accelerating at 0.4 m s^{-2} .

(i) Find the value of k . [4]

It is given that the greatest steady speed of the car on this road is 30 m s^{-1} .

(ii) Find the greatest power that the engine can produce. [3]

3 A particle A is released from rest from the top of a smooth plane, which makes an angle of 30° with the horizontal. The particle A collides 2 s later with a particle B , which is moving up a line of greatest slope of the plane. The coefficient of restitution between the particles is 0.4 and the speed of B immediately before the collision is 2 m s^{-1} . B has velocity 1 m s^{-1} down the plane immediately after the collision. Find

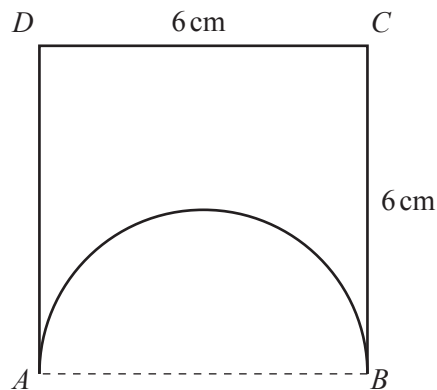
(i) the speed of A immediately after the collision, [4]

(ii) the distance A moves up the plane after the collision. [2]

The masses of A and B are 0.5 kg and m kg, respectively.

(iii) Find the value of m . [3]

4



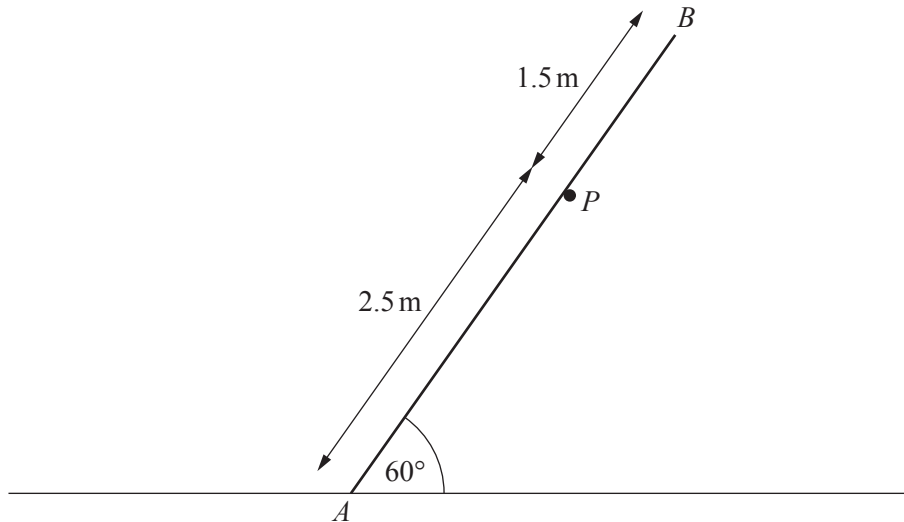
A uniform square lamina $ABCD$ of side 6 cm has a semicircular piece, with AB as diameter, removed (see diagram).

(i) Find the distance of the centre of mass of the remaining shape from CD . [6]

The remaining shape is suspended from a fixed point by a string attached at C and hangs in equilibrium.

(ii) Find the angle between CD and the vertical. [2]

5



A uniform rod AB , of mass 3 kg and length 4 m, is in limiting equilibrium with A on rough horizontal ground. The rod is at an angle of 60° to the horizontal and is supported by a small smooth peg P , such that the distance AP is 2.5 m (see diagram). Find

(i) the force acting on the rod at P , [3]

(ii) the coefficient of friction between the ground and the rod. [5]

6 A particle of mass 0.5 kg is held at rest at a point P , which is at the bottom of an inclined plane. The particle is given an impulse of 1.8 N s directed up a line of greatest slope of the plane.

(i) Find the speed at which the particle starts to move. [2]

The particle subsequently moves up the plane to a point Q , which is 0.3 m above the level of P .

(ii) Given that the plane is smooth, find the speed of the particle at Q . [4]

It is given instead that the plane is rough. The particle is now projected up the plane from P with initial speed 3 m s^{-1} , and comes to rest at a point R which is 0.2 m above the level of P .

(iii) Given that the plane is inclined at 30° to the horizontal, find the magnitude of the frictional force on the particle. [4]

- 7 A particle is projected with speed $u \text{ m s}^{-1}$ at an angle of θ above the horizontal from a point O . At time t s after projection, the horizontal and vertically upwards displacements of the particle from O are x m and y m respectively.

(i) Express x and y in terms of t and θ and hence obtain the equation of trajectory

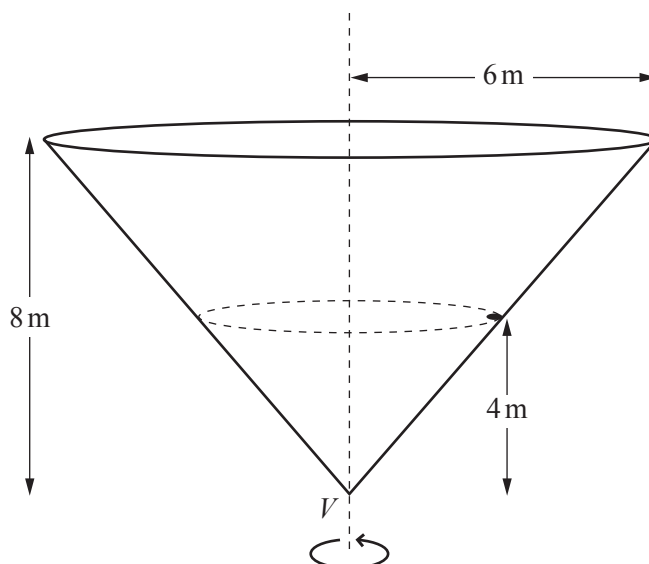
$$y = x \tan \theta - \frac{gx^2 \sec^2 \theta}{2u^2}. \quad [4]$$

In a shot put competition, a shot is thrown from a height of 2.1 m above horizontal ground. It has initial velocity of 14 m s^{-1} at an angle of θ above the horizontal. The shot travels a horizontal distance of 22 m before hitting the ground.

(ii) Show that $12.1 \tan^2 \theta - 22 \tan \theta + 10 = 0$, and find the value of θ . [5]

(iii) Find the time of flight of the shot. [2]

8



A conical shell has radius 6 m and height 8 m. The shell, with its vertex V downwards, is rotating about its vertical axis. A particle, of mass 0.4 kg, is in contact with the rough inner surface of the shell. The particle is 4 m above the level of V (see diagram). The particle and shell rotate with the same constant angular speed. The coefficient of friction between the particle and the shell is μ .

(i) The frictional force on the particle is $F\text{N}$, and the normal force of the shell on the particle is $R\text{N}$. It is given that the speed of the particle is 4.5 m s^{-1} , which is the smallest possible speed for the particle not to slip.

(a) By resolving vertically, show that $4F + 3R = 19.6$. [2]

(b) By finding another equation connecting F and R , find the values of F and R and show that $\mu = 0.336$, correct to 3 significant figures. [6]

(ii) Find the largest possible angular speed of the shell for which the particle does not slip. [6]

Question		Answer	Marks	Guidance
1	(i)	$18\cos 15 \times 6$ 104 J	M1 A1 A1 [3]	Force component x distance
1	(ii)	$18\cos 15 \times 6/5$ or $\text{ans(i)}/5$ 20.9 W	M1 A1 [2]	Force component x distance/5 Allow 20.8
2	(i)	$DF = 15000/15$ $DF - k \times 15^{1/2} = 1500 \times 0.4$ $k = 103$	B1 M1 A1 A1 [4]	N2L, 3 terms and attempt at DF. Numerical DF Allow $80\sqrt{15}/3$
2	(ii)	$P/30 = k30^{1/2}$ $P = 17000W$	M1 A1 A1 [3]	Using $cv(k)$ Allow 17(.0)kW, 16900W, 16.9kW, $12000\sqrt{2}W$
3	(i)	$a = g\sin 30$ $1+u = 0.4(2+2g\sin 30)$ $u = 3.72 \text{ ms}^{-1}$	B1 M1 A1 A1 [4]	Using NEL with u_A from $cv(a)$, $u_A \neq 0$ cwo
3	(ii)	Use $v^2 = u^2 - 2(g\sin 30)s$ $s = 1.41 \text{ m}$	M1 A1 [2]	Using $v = 0$, $cv(a)$ from (i) or correct a SC If a not found in (i), allow $a=g$ for M1A0.
3	(iii)	Use of conservation of momentum $0.5 \times 2g\sin 30 - 2m = m - 0.5 \times 3.72$ $m = 2.25$	M1 A1ft A1 [3]	Using $cv(a)$ ft $cv(u)$ from (i) Aef(raction) eg $2^{19/75}$ or $169/75$

Question		Answer	Marks	Guidance
4	(i)	$(2 \times 3\sin(\pi/2))/(3\pi/2)$ or equivalent 3×6^2 $-(\pi \times 3^2/2) \times (6 - 4/\pi)$ $= (6^2 - \pi \times 3^2/2)x_G$ $x_G = 1.88 \text{ cm}$	B1 M1 A1 A1 A1 A1 [6]	Centre of mass of semicircle; $4/\pi$ Table of moments idea about any axis.
4	(ii)	$\tan\theta = 1.88/3$ $\theta = 32.1^\circ$	M1 A1ft [2]	Attempt at a relevant angle allow $180-\theta$ & radians (0.561 or 0.560)
5	(i)	Use of moments $2.5R = 3g\cos 60 \times 2$ $R = 11.76 \text{ N}$	M1 A1 A1 [3]	Trig with $3g$, no trig with R unless using 2 components. Allow 11.8
5	(ii)	$R' + R\cos 60 = 3g$ $F = R\cos 30$ Use $F = \mu R'$ $\mu = 0.433$	M1 A1ft B1ft M1 A1 [5]	Resolve vertically, 3 terms, comp (R). Using $\cos(R)$ Using $\cos(R)$ Not $R' = 3g$ for method Allow 0.435 from use of $R = 11.8$
6	(i)	Use $I = mv$ 3.6 ms^{-1}	M1 A1 [2]	-3.6 gets A0
6	(ii)	$\pm(\frac{1}{2} \times 0.5 \times 3.6^2 - \frac{1}{2} \times 0.5 \times v^2)$ $0.5 \times g \times 0.3$ Use of conservation of energy $v = 2.66 \text{ ms}^{-1}$	B1 B1 M1 A1 [4]	Three terms

Question		Answer	Marks	Guidance
	OR	$a = -g\sin\theta$ $s = 0.3/\sin\theta$ Use $v^2 = u^2 + 2as$ $v = 2.66 \text{ ms}^{-1}$	B1 B1 M1 A1	θ angle of plane to horizontal $a \neq -g, s \neq 0.3.$
6	(iii)	Change in energy = $\pm(\frac{1}{2} \times 0.5 \times 3^2 - 0.5 \times g \times 0.2)$ Equate to force \times distance 3.175 N	M1 A1 M1 A1 [4]	Difference of KE and PE Attempt at $0.2/\sin 30$ for dist, 3 terms Allow 3.18
	OR	Using $v^2 = u^2 + 2as$ to find a Resolve parallel to plane $0.5g\cos 60 + F = 0.5 \times cv(11.25)$ $F = 3.175$	M1 M1 A1 A1	Use $v = 0$, attempt at $s = 0.2/\sin 30$ N2L used with $cv(11.25)$, 3 terms Consistent signs Allow 3.18
7	(i)	$x = u\cos\theta t$ $y = u\sin\theta t - \frac{1}{2}gt^2$ Eliminate t Get $y = x\tan\theta - gx^2\sec^2\theta/2u^2$ [AG]	B1 B1 M1 A1 [4]	www
7	(ii)	Substitute $x = 22, y = -2.1$ and $u = 14$ Use $\sec^2\theta = 1 + \tan^2\theta$ Tidy to $12.1\tan^2\theta - 22\tan\theta + 10 = 0$ [AG] Solve QE for $\tan\theta$ $\theta = 42.3$	M1 B1 A1 M1 A1 [5]	May start again of course www allow in radians (0.738)
7	(iii)	$t = 22/14\cos\theta$ $t = 2.12s$	M1 A1 [2]	May work vertically, but must solve for t to get M1

Question			Answer	Marks	Guidance
8	(i)	(a)	$0.8F + 0.6R = 0.4g$ $4F + 3R = 19.6$ [AG]	M1 A1 [2]	Attempt to resolve vertically www
8	(i)	(b)	$0.8R - 0.6F = 0.4 \times 4.5^2/3$ Solve for R or F $F = 1.516$ $R = 4.512$ Use $\mu = F/R$ to get $\mu = 0.336$ [AG]	M1 A1 M1 A1 A1 B1 [6]	Attempt with three terms. aef including cos, sin correct angle Use 2 relevant resolutions.
8	(ii)		$0.6R - 0.8F = 0.4g$ $R = 11.8$ or $F = 3.98$ $0.8R + 0.6F = 0.4 \times 3 \times \omega^2$ $\omega = 3.14 \text{ rad s}^{-1}$	M1 A1 A1 M1 A1 A1 [6]	Resolve vertically, three terms N2L, resolve horizontally, three terms