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Examiners' Report

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GCE

Mechanics M2 (6678)

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Introduction

Despite the more challenging aspects of some questions, this paper proved to be accessible to the candidates with many correct and succinct solutions on offer and only a small number of blank responses. The best work was clearly set out and accompanied by clearly labelled diagrams. Candidates should be advised to pay attention to the presentation of their answers: work where there is no diagram, more than one force is referred to as "F", all unknown velocities are "v" and all unknown distances "x" is very difficult to follow and these candidates invariably manage to confuse themselves and the examiners.

In calculations the numerical value of g which should be used is 9.8, as advised on the front of the question paper. Final answers should then be given to 2 (or 3) significant figures - more accurate answers will be penalised once per question. Candidates should also be aware that marks are usually only given for work that is in the appropriate part of the question.

If a candidate runs out of space in which to give his/her answer then he/she is advised to use a supplementary sheet - if a centre is reluctant to supply extra paper then it is crucial for the candidate to say whereabouts in the script the extra working is going to be done.

Report on individual questions

Question 1

The majority of candidates offered confident responses to this opening question. Most of them successfully integrated the given velocity to find out the displacement of the particle. When it came to finding out the time of minimum velocity, most candidates used calculus again to find acceleration and made it equal to zero but some preferred to complete the square or use the expression for the turning point of a parabola. A few candidates attempted to find the time when the velocity of the particle was zero, believing this to be the minimum. A common error was find the minimum velocity and substitute this, rather than the time, into the displacement equation.

Question 2

This question was very well answered by the majority of candidates. The momentum and impact equations were often correct - the most common error was lack of consistency in signs between their equations. A surprising number of candidates did not draw a diagram which possibly made it more difficult to avoid these sign errors. Only a small number of candidates quoted the impact law the wrong way round.

A significant number of candidates had P going to the left after the collision, obtaining a velocity of $u(e - 1)$. However, they almost always failed to realise that this was a negative answer, ignoring the fact that the question had asked for speed.

A number of candidates, who started with two correct equations, went on to lose marks at the end due to algebraic errors in solving the simultaneous equations.

Question 3

Most candidates showed a sound understanding of the mechanics involved in this question and gave a completely correct solution. Although candidates were allowed the choice of method, the work energy method was by far the most popular approach. Some candidates went wrong by considering both the change in potential energy and the work done against the weight. Some were clearly confused, and

offered inconsistent equations involving forces and energy, usually because they had omitted the distance when considering the work done against the resistance.
The alternative method of finding the acceleration and then using $F = ma$ was equally successful. The most common error was an incorrect sign in the equation of motion.

Question 4

Many candidates did not recognise this as a question on the impulse-momentum principle in vector form. Many of the weaker candidates simply worked with the given magnitudes. Some realised the need to resolve, but resolved and used only the component in the initial direction. Those candidates who resolved correctly had no problems with finding the magnitude of the impulse, though some left their answer as a vector.
Most candidates with an impulse (or change in velocity) in component form went on to find an angle. Unfortunately the majority of them found the supplementary angle, the angle to *BA* instead of *AB*, often without reference to a diagram with a marked angle.
Some candidates who struggled to find the impulse made a fresh start to find the angle, often drawing a correct vector triangle and using trigonometry to find the correct angle (or its supplement) without realising that the same diagram could have helped them with the impulse.

Question 5

Very few students were unable to find the magnitude of the resistance to motion in (a) although some did produce some lengthy arguments before achieving the required solution. Others omitted to justify that the resistance had the same magnitude as the driving force.
In part (b) most candidates were able to attempt the equation of motion, although some failed to notice or to take correct account of the fact that this cyclist is moving down the road, rather than up, resulting in several sign errors. Most candidates were able to manipulate the equation, successfully incorporating $F = \frac{24}{u}$ (or equivalent) and going on to obtain and solve a quadratic equation.

Question 6

There were very few correct solutions to this question that did not involve taking moments about *B*. Many candidates seemed to assume that the lack of any information about the direction of the force at *B* was an omission rather than a hint on how to proceed.
Those candidates who started by taking moments about *B* usually reached the required answer without difficulty. The most common errors involved confusion between sine and cosine, and inappropriate accuracy in the final answer after using a decimal approximation for g.
Alternative methods involving the force at *B* rarely produced a complete solution. Many candidates assumed that the direction of this force involved the angle α, thus simplifying the algebraic manipulation of their force and moment equations. Those who introduced an unknown angle usually struggled to reach a valid answer, although a handful of concise, correct solutions were seen.

Question 7

(a) The method was understood by most candidates and there was no problem in forming a moments equation for the centre of mass. Common errors included simplifying $\frac{4 \times 3}{3\pi}$ to 4π rather than $\frac{4}{\pi}$, using the area of a circle rather than a semicircle, and the use of 6 for the radius of the semicircle. From a correct table, accuracy marks were often lost in the moments equation because of a sign error. In general, those candidates who set out the masses and distances in a table tended to make fewer errors.
Many candidates made it more difficult to obtain the given answer by taking their measurements from *PQ* and attempting to subtract their result from $2x$, although this was often successfully completed.

One advantage of this approach was that they were less likely to make a sign error in their moments equation.
Candidates very rarely justified the modulus sign at all, with most candidates simply writing the final answer after their last line of working. Students who had a negative coefficient for the x^2 term in the numerator were more likely to deal with this.
(b) The fact that the answer was given did guide some candidates to the correct result, indicating that they clearly appreciated the 'show that' nature of the question. Most candidates substituted $x = 2$ correctly into the given result and went on to find the tangent of an angle. Many candidates did identify the correct triangle although some went to great lengths to find the distance of the centre of mass from *SP* as an expression in x, not realising that it could be found by symmetry. Furthermore, they often did not then realise that their expression cancelled to 6.
Many of those who made progress with this part found the angle to the vertical, with quite a few unconvincingly converting to the given result or simply leaving it as the reciprocal.

Question 8

(a) Many correct solutions were seen, with the majority of candidates clearly familiar with the method for deriving the equation of the parabolic path. However some candidates substituted into all the *suvat* equations and were clearly struggling to find a way forward.

(b) Those candidates who were not able to complete (a) started afresh at this point, and were often successful in earning marks in this part. Most candidates used the given formula to find R having identified this as the value of x when $y = 0$. Some candidates used the fact that maximum height occurs when $x = \frac{R}{2}$, but many preferred to work with the initial information and to use $v^2 = u^2 + 2as$ to find H.

(c) Only a few candidates made a concerted attempt at this part with a correct solution a rarity. Most attempts used a vector approach rather than calculus. Several candidates demonstrated an understanding of perpendicular vectors, and the partially correct velocity $\begin{pmatrix} cu \\ -u \end{pmatrix}$ in place of the correct answer $\begin{pmatrix} u \\ \frac{-u}{c} \end{pmatrix}$ was quite common. Diagrams were rarely seen, possibly accounting for the common incorrect answer $\begin{pmatrix} u \\ -cu \end{pmatrix}$. Confusion between distances and velocities often marred any work beyond this stage.

Grade Boundaries

The table below gives the lowest raw marks for the award of the stated uniform marks (UMS).

Module	80	70	60	50	40
6663 Core Mathematics C1	63	54	46	38	30
6664 Core Mathematics C2	54	47	40	33	27
6665 Core Mathematics C3	59	52	45	39	33
6666 Core Mathematics C4	61	53	46	39	32
6667 Further Pure Mathematics FP1	64	56	49	42	35
6674 Further Pure Mathematics FP1 (legacy)	62	54	46	39	32
6675 Further Pure Mathematics FP2 (legacy)	52	46	40	35	30
6676 Further Pure Mathematics FP3 (legacy)	59	52	45	38	32
6677 Mechanics M1	61	53	45	38	31
6678 Mechanics M2	53	46	39	33	27
6679 Mechanics M3	57	51	45	40	35
6683 Statistics S1	65	58	51	45	39
6684 Statistics S2	65	57	50	43	36
6689 Decision Maths D1	67	61	55	49	44

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