Examiners' Report/
Principal Examiner Feedback

Summer 2010

GCE

Mechanics M2 (6678)

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Introduction

This paper proved to be accessible to the majority of candidates, many of whom offered confident responses to all questions.

Much of the work was presented in a clear and logical order with clearly annotated diagrams, making it straight forward for the examiners to follow. However, candidates need to be reminded that a jumbled layout makes it difficult to mark their work - some candidates are writing their answers in only a very small amount of space frequently using columns within a page and squashing everything up. There is generally plenty space provided and it is frustrating to try to decipher a squashed up solution on less than a page (frequently with crossings out and arrows) and then find 2 or 3 blank pages immediately afterwards. In particular, candidates are advised not to overwrite errors as this makes their work difficult to read. Poor writing makes it difficult to distinguish between numbers and letters, eg. 4, 9, a and u.

Despite comments in previous reports, it was disappointing to find that many candidates lost marks through inappropriate rounding of answers either during the working or for the final answer. Final answers to questions involving g should always be given to 2 (or at most 3) significant figures but full values should be used during calculations.

Report on individual questions

Question 1

This question proved very accessible and gave most candidates a confident start to the paper. There were very few incorrect answers, with the overwhelming majority integrating the given acceleration correctly. Any errors in the integration were mostly when $3t^2$ was not divided by 2. There was some confusion about the constant of integration in a few cases, often taken in error to be zero. Nearly all candidates set their velocity expressions equal to 6 and attempted to solve the resulting quadratic equation. There were some basic algebraic or arithmetical slips resulting in incorrect equations. A method was not always shown in the solution of a quadratic. This should be discouraged as credit can be given for correct working if it is seen.

There were a small number of candidates who tried to apply "*suvat*" to the motion, losing 5 out of the 6 marks available.

Question 2

This question proved to be straightforward for well-prepared candidates.

In part (a) it was pleasing to see many candidates tackling this using the work-energy method, and there was less evidence this year of candidates double counting by including both the change in GPE and the work done against the weight, but candidates sometimes confused work done with just potential energy lost, or just kinetic energy gained. The alternative method using *suvat* to find the acceleration and then using $F = ma$ was also common. In the final answers there was considerable confusion between work done against friction and the frictional force. Many lost the final A mark by leaving the answer as 30.48 despite having used g = 9.8.

In part (b) candidates frequently did not make the connection with part(a) and proceeded to start again from scratch. In this case, a common but expensive error was to omit the component of the weight from their equation of motion.

Question 3

Some candidates struggled with this question. Despite the question being explained clearly with reference to rods it was not uncommon to see the triangle treated as a lamina. Another common error was to treat the rods as being of equal mass.

The geometry of the symmetrical triangular figure was appreciated by nearly all candidates with the height of the triangle correctly calculated as 8 cm, although it was disappointing to find several candidates not recognising the 3,4,5 triangle and engaging in more work than expected to find the height of the triangle.

For part (a) those candidates who answered the question as set and worked with three rods had little difficulty in producing a relevant moments equation and arriving at the correct result. However it was disappointing to find a significant number of candidates treating the triangle as a lamina, and they were happy simply to write down the answer as $\frac{8}{3}$ cm.

For part (b) most candidates could either write down or calculate the distance of the new centre of mass from BC and proceed to find the required angle. 3 out of 4 marks were available for those who had treated the shape as a lamina. A number of candidates ignored the extra particle added to the framework and answered their own question. Very few students used the method of taking moments about B to find the angle.

Question 4

This question produced a very good response with many candidates scoring full marks. The connection between power, driving force and velocity is clearly understood.

In part (a) the given answer ensured that those who were uncertain how to proceed could review their work and find the correct approach. Candidates should be reminded to use the notation introduced in a question (R) and to be careful not to omit any steps when deriving a given answer.

In part (b) the most common error was the omission of either the weight component or the resistance when applying Newton's second law parallel to the slope.

Question 5

This question was well attempted by a majority of candidates.

In part (a) the most common incorrect answer was a sign error leading to an impulse of (5**i** + 12**j**)Ns rather than (5**i** - 12**j**). Some candidates failed to apply the impulse formula correctly – adding momentum rather than subtracting. Many students forgot to calculate the magnitude of their impulse. A few candidates started by finding the initial and final speeds of the ball and ignored the two dimensional nature of the problem, never producing a vector equation for the impulse or appropriate work using trigonometry.

In part (b) a common error was to find the angle for the initial velocity rather than the impulse. A minority of candidates were confused over which angle was required or made a trigonometric error, using the ratio $\frac{5}{12}$ rather than $\frac{12}{5}$ to find the angle.

For part (c) although there were many completely correct solutions, some candidates were unable to cope with using vectors to find speed and hence Kinetic Energy. The most common errors were, for example, to find $\sqrt{10^2 + 24^2}$ and then forget to square it or to attempt to square the vector velocity, treating $(10\mathbf{i} + 24\mathbf{j})^2$ as an algebraic expression and retaining **i** and **j** components in the answer.

Question 6

There were many correct responses to this question, some considerably more concise than others.

In part (a) many candidates took the direct route of the mark scheme, and most dealt confidently with the exact trig ratio. There were several who had initially made a false start, resolving vertically and horizontally and ignoring all or part of the reaction at the hinge, but they often went on to score full marks by later taking moments about *A* correctly. Some did not seem to understand the significance of requiring an exact answer and obtained the given answer in surd form from a decimal value of sin(33.69°).

In part (b) most candidates learned from their experience in (a) and started by taking moments about *A*. A minority tried several alternative options before deciding to take moments about *A*. Some candidates did not deal appropriately with the inequality, either by including it when taking moments or by simply inserting it in the final line.

Question 7

There were many confident solutions to this question, but over specification of answers following the use of g = 9.8 was a common problem, causing many candidates to throw away a mark.

In part (a) many students used correct methods for calculating the angle, although 22.54 rather than 22.5 was common. Very few went wrong here, though some took longer routes than necessary, failing to spot that they could use $v^2 = u^2 + 2as$ to obtain the angle in one step, and there were a few who attempted to use distances to find the angle.

In part (b) the quickest method here was to use a displacement of -36 in an equation to find time and then use this time in a horizontal equation to find displacement. Some took this in two stages – time to the highest point and then time to the bottom. It was pleasing to find very few resolution and both methods were used correctly in many solutions. The most common error was to consider only part of the flight and then use an incorrect time to find the horizontal displacement. The over-specified answer 173.4 rather than 173 was common.

In part (c) those candidates who used conservation of energy were usually successful but the most common method was to find horizontal and vertical components of velocity and hence find the speed using Pythagoras' Theorem. Unfortunately, those who used this method often found only the vertical component of the velocity and lost all the marks here.

Question 8

There were also a significant number of fully correct answers to this question. Most candidates completed parts (a) and (b) well but part (c) proved to be rather more demanding.

For part (a) the majority of candidates understood and applied the conservation of linear momentum and the law of restitution correctly. The equations were usually consistent despite the occasional lack of a clear diagram, and only a very small minority got the restitution equation the wrong way round. However, subsequent errors in the speed of *A* and *B* were common – these arose from simple sign errors in the initial equations or more commonly from minor processing errors. These basic errors can be costly – unexpected outcomes should be checked carefully to avoid continuing to work with unrealistic situations. A few candidates surprisingly failed to substitute ½ in for e and then struggled through with their answers for the rest of the question.

Full marks were usually scored for part (b) with only a minority of candidates with method errors in the use of the restitution equation. The question asked for the speed of B after the collision, so the final answer should have been positive, which was not always the case.

There were a wide variety of approaches to part (c). It was pleasing to see that some candidates could produce the given expression fluently with their methods clearly laid out. The most successful approach involved finding the separation of the two particles as *B* impacted with the wall and then to use the relative velocity to find the time taken to cover this separation. Some used the ratio of distances travelled or set up an equation in *T*.

Many could find the time to *B* hitting the wall and the distance travelled by *A* in this time, but got no further, having run out of time or having no idea how to proceed further.

A few solutions went off in entirely the wrong direction, either by thinking that another collision was needed (considering CLM and NEL again) or by attempting to use methods which implied non-zero acceleration. A worrying handful did not use the correct relationship between distance speed and time (e.g time = distance x speed was seen).

Expressions involving *a* and *u* were often badly written and these symbols would become interchanged during the rearrangement and simplification of terms. For example, a fractional term such as $\frac{5}{4}u$ was written without due care so that the *u* migrated to the bottom of the fraction during manipulation. Clear layout and a description of the symbols are vital in this kind of question to avoid these careless errors and to help examiners navigate through a candidates' work.

The given answer was helpful to some candidates who made a false start - realising their error they would often produce a better or correct solution. However, candidates working with incorrect values from part (a) were often misled into altering work displaying correct method in an attempt to derive the given answer. There were also some who tried to fudge incorrect processes to achieve the given answer.

Grade Boundary Statistics

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

Module		Grade	A*	A	B	C	D	E
		Uniform marks	90	80	70	60	50	40
AS	6663 Core Mathematics C1			59	52	45	38	31
AS	6664 Core Mathematics C2			62	54	46	38	30
AS	6667 Further Pure Mathematics FP1			62	55	48	41	34
AS	6677 Mechanics M1			61	53	45	37	29
AS	6683 Statistics S1			55	48	41	35	29
AS	6689 Decision Maths D1			61	55	49	43	38
A2	6665 Core Mathematics C3		68	62	55	48	41	34
A2	6666 Core Mathematics C4		67	60	52	44	37	30
A2	6668 Further Pure Mathematics FP2		67	60	53	46	39	33
A2	6669 Further Pure Mathematics FP3		68	62	55	48	41	34
A2	6678 Mechanics M2		68	61	54	47	40	34
A2	6679 Mechanics M3		69	63	56	50	44	38
A2	6680 Mechanics M4		67	60	52	44	36	29
A2	6681 Mechanics M5		60	52	44	37	30	23
A2	6684 Statistics S2		68	62	54	46	38	31
A2	6691 Statistics S3		68	62	53	44	36	28
A2	6686 Statistics S4		68	62	54	46	38	30
A2	6690 Decision Maths D2		68	61	52	44	36	28

Grade A*

Grade A* is awarded at A level, but not AS to candidates cashing in from this Summer.

- For candidates cashing in for GCE Mathematics (9371), grade A* will be awarded to candidates who obtain an A grade overall (480 UMS or more) *and* 180 UMS or more on the total of their C3 (6665) and C4 (6666) units.
- For candidates cashing in for GCE Further Mathematics (9372), grade A* will be awarded to candidates who obtain an A grade overall (480 UMS or more) *and* 270 UMS or more on the total of their best three A2 units.
- For candidates cashing in for GCE Pure Mathematics (9373), grade A* will be awarded to candidates who obtain an A grade overall (480 UMS or more) *and* 270 UMS or more on the total of their A2 units.
- For candidates cashing in for GCE Further Mathematics (Additional) (9374), grade A* will be awarded to candidates who obtain an A grade overall (480 UMS or more) *and* 270 UMS or more on the total of their best three A2 units.

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