Examiners' Report / Principal Examiner Feedback

Summer 2010

GCE

Mechanics M4 (6680)

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Introduction

The quality of responses to this paper varied greatly, with many candidates producing clear and accurate work but some demonstrating little understanding of the topics examined. The best work was usually accompanied by clearly annotated diagrams, with concise solutions including a high level of algebraic manipulation. All candidates should be aware of the potential benefits of identifying common numerical or algebraic factors in expressions and thus simplifying the algebraic demands of a question; there were many instances of algebra which could and should have been simplified early in the solution of the problem.

If work does need to be corrected, it is far better to start again than to overwrite the original. The latter course of action invariably produces an illegible mess which is very difficult to mark fairly. Candidates also need to be reminded that it is important to show sufficient working to demonstrate how they reached a conclusion or a given answer.

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.

If a candidate runs out of space in which to give his/her answer than 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

By far the most successful approach was to use the vector equation for relative velocity and equate the **j** component of the wind velocity vectors obtained. Candidates who took this approach tended to be successful in obtaining the correct answer.

It was rare for those candidates who attempted to form vector triangles to obtain a correct diagram showing both sets of information and even rarer for them to work correctly from their diagram to find the wind velocity.

A number of candidates spoiled their solutions by losing a factor of u or v from a term in one of their equations at some point, thus producing dimensionally inconsistent equations which could not give the correct answer.

Question 2

In part (a) many candidates were able to obtain correct equations by applying the conservation of momentum and Newton's experimental law parallel to the line of centres. A common mistake, however, was to solve the equations and give the speed of the spheres rather than the velocities as required in the question.

The need to move from a question posed in vectors to scalar equations caused difficulties for some candidates. Many produced a momentum equation in **i** and **j**, rather than confining themselves to consideration of the components parallel to the line of centres. The **j** component did not always cancel out. Those candidates who introduced vectors to Newton's Experimental law were penalised for this significant error.

In part (b) the majority of candidates were able to use the coefficient of restitution to find the velocity of the sphere after the collision with the wall and to find the angle between the wall and the path after impact. Far fewer identified and found the correct angle of deflection.

In part (c) the majority of candidates found the loss in kinetic energy correctly. Errors were usually due to failure to find v^2 correctly from their vectors, or the use of v rather than v^2 in attempting to find the kinetic energy.

Question 3

This is a fairly standard closest approach question and a great many candidates were able to draw correct diagrams and score full marks. Despite this, however, there were still a large number of candidates who have not understood how to approach such relative velocity questions and were unable to make much progress at all.

Those who attempted to express the relative position and relative velocity as vectors were very rarely successful, usually due to an error in their original diagram.

Finding a bearing still presents problems to a significant number of candidates, despite working from a correct diagram.

Some candidates did not realise that the relative velocity could be found simply from the 3, 4, 5 triangle, but it was pleasing to see so many candidates answering the question and giving an actual time of the clock as the answer.

Question 4

This question followed a standard format and was answered very well by a large proportion of candidates. A majority took the constant of integration approach rather than the use of definite integration, but generally did so successfully in both parts (a) and (b). A small number of candidates were confused about the directions involved and often tried to justify a change of sign part way through their working in order to arrive at the given answer in part (a).

A small number of candidates attempted to use their answer to part (a) to generate a differential equation in $\frac{\mathrm{d}x}{\mathrm{d}t}$ for part (b) rather than the simpler method of restarting from the beginning and using $v\frac{\mathrm{d}v}{\mathrm{d}x}$. These candidates were rarely able to obtain an expression for v correctly, or to integrate their expression successfully, and tended to grind to a halt with little progress made.

Question 5

For part (a) many candidates identified the need to find the distance of the mass below the pulley in terms of an unknown – the length of the string. These candidates found the distance from *B* to the pulley correctly and were able to proceed correctly to obtain an expression for the potential energy of the system which simplified to the given result. There were a disappointing number of candidates who could barely attempt this part of the question and either tried to fudge the result (including the sign of the term relating to the mass) or who offered no attempt to this part of the question at all. A small minority of candidates complained that they could not proceed without being told the length of the string.

For part (b) a large proportion of candidates knew they needed to differentiate the expression for potential energy and set it equal to zero. Many were able to go on to obtain the given equation correctly, but there were a number of algebraic errors and a few candidates were not able to achieve an expression in $\sin\theta$ alone.

For part (c) the majority of candidates understood that they should find the sign of $\frac{\mathrm{d}^2V}{\mathrm{d}\theta^2}$ in order to determine the stability of the system and most correctly interpreted the sign they obtained. Some candidates made errors in their differentiation but a large number coped very well with differentiating the complicated product/quotient. A significant number differentiated the equation obtained in part (b) rather than their expression for $\frac{\mathrm{d}V}{\mathrm{d}\theta}$. A small number of candidates opted for the alternative route of considering the sign of $\frac{\mathrm{d}V}{\mathrm{d}\theta}$ on either side of $\theta = \frac{\pi}{6}$.

Question 6

Part (a) was answered well, and candidates tended to be successful in applying Hooke's law and equating the tensions in order to find the distance *AP* at equilibrium.

In part (b) clear diagrams showing the point from which x was measured were an advantage here and were often lacking, resulting in tension being in the wrong directions and/or with the wrong magnitudes. With x defined in the question, candidates often had difficulty in obtaining correct expressions for the extension in each string in terms of x and fudges aimed at obtaining the given differential equation were very common. Some candidates struggled with the mechanics involved and did not include all the relevant terms in setting up their equation of motion.

In part (c) a great many candidates were able to solve the second order differential equation correctly, demonstrating a sound grasp of the pure mathematics involved, although a few were expecting a trigonometric solution and forced their auxiliary equation to produce one. Many candidates were able to use correct boundary conditions to find the unknowns and give a correct final result. The use of a or 0 in place of $0.5a$ for the initial displacement of *P* was surprisingly common. A few candidates overlooked the request to give the velocity of *P* as their final 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 <u>GCE Mathematics</u> (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 <u>GCE Further Mathematics</u> (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 <u>GCE Pure Mathematics</u> (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 <u>GCE Further Mathematics (Additional)</u> (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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