Examiners' Report

Summer 2015

Pearson Edexcel GCE in Mechanics M3 (6679/01)

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Mathematics Unit Mechanics 3

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General Introduction

The paper may have been slightly long for some students. Quite a few question 7s, even ones which were going well, stopped mid-equation and a few were either blank or did only part (a).

As always, "show that.." questions gave rise to the most problems. Leaps of faith that may be accepted in a question where the answer has not been given are never allowed when the answer is in the question; every step in the working must be written down clearly. Equations should be solved, not simply followed by the given answer. Quadratic equations generally have two answers both of which must be shown and the unacceptable one eliminated. Fiddling the working in order to arrive at the given answer will be spotted by the examiner with consequent loss of marks.

It is surprising how many Further Mathematics students display poor algebra skills or fail to cancel terms or numbers until the final stage of their working. Fewer letters and smaller numbers tend to lead to fewer errors in the processing.

There seems to be an increase in patterned handwriting which creates reading difficulties for both examiners and the students themselves. Curly 1s looking like 2s, 9s indistinguishable from *g*s and *h*s looking exactly like *k*s all led to student errors. When students cannot read their own writing they cannot criticise examiners who have similar problems.

Report on Individual Questions

Question 1

It was rare for part (a) to not be completed correctly. Part (b) however was more problematic with many students omitting an elastic energy term and so failing to score any marks. Some managed to obtain a correct extension but then added this to the wrong length.

Question 2

Part (a) was usually answered correctly although some students seemed to think that $(e^x)^2 = e^{x^2}$ or left out π. Almost all students knew the correct formula for the centre of mass and there seemed to be fewer instances than usual of lamina formulae being used. Nearly all students found the correct expression to integrate for the numerator and most went on to complete the question correctly. Almost all realised that integration by parts was required and used it correctly. The only real cause of difficulty arose from the coefficients. Many students took the 4 out without considering the fact that the integration was going to lead to halving. Whilst most managed to deal with this correctly, it did throw a few off course and certainly made their life harder. Some omitted the 4 altogether after setting up the correct integral and then forgot to put it back again.

Question 3

Part (a) presented very few problems and the majority earned full marks. There were a very few who tried to consider the two tensions separately and slightly more who didn't notice the isosceles triangle, assuming a right angle at P. There was very little sine/cosine confusion and the radius was almost always found correctly. The most obvious distinguishing factor between good and weaker students was the quality of the algebra. Those with the most succinct solutions arranged their two equations to give expressions for $T_A + T_B$ and $T_A - T_B$ and then added/subtracted. Others made it all stretch to pages of calculation (and sometimes errors) by substituting complicated fractions involving trigonometrical terms rather than their numerical values between the two equations.

Part (b) was answered less well overall but it caused little difficulty for the majority. It seems surprising that anyone can have prepared for M3 without being familiar with the necessary inequality for the lower tension but clearly some were not. $T_A > T_B$, $T_A + T_B > 0$ and
$(T_A + T_B \sin 30 > mv^2/r$ were all suggested. Some used > throughout, even though the question made it clear that $\geqslant$ was needed.

Question 4

The majority of students were able to reach the given answer in part (a) by means of indefinite integration and subsequent substitution of the boundary conditions although some were put off by the boundary conditions giving two simultaneous equations rather than direct values for *k* and *c*. A small number misread 63000; a very small number failed to divide 63000 by 900 correctly.

Parts (b) and (c) proved to be far more challenging. In part (b) the most common mistake was to focus on *t* approaching positive infinity and ignoring the fact that $v = 14$ could have occurred at any other time. In part (c) only very few students were able to even consider what definite integral they were supposed to approximate using the trapezium rule. Some solved for *x* by algebraic integration. Of those who used the trapezium rule, only a small minority used the correct *t* values. Some did not understand that 4 intervals needed 5 boundaries and consequently worked with only 3 intervals.

Question 5

Nearly all students had an acceptable strategy here. "Alt 2" was the most common method of solution. Somewhat disappointingly, only a small number simplified the mass ratio before substituting into the moments equation. Nearly all students knew that $\tan 30° = \frac{\bar{x}}{r}$ tan 30 = x / r. Those who spotted the difference of squares made the question very straightforward; once they had cancelled ($k + 1$), they could see how to obtain the answer. A very small number failed to include "k^2" in their moments equation, despite having the correct work in their table. A few, who didn't spot the difference of squares, used the quadratic formula and most of these succeeded.

Question 6

Part (a) was generally answered very well although the absence of clear diagrams was a problem for some students. Those who drew diagrams and labelled them clearly were less likely to have problems in both (a) and (b). It also makes it much easier for the examiner to follow their working. The main method was the most popular, although a great many formed their equation from 2 extensions and then slotted this into an $x_1 + x_2 = 2$ equation. Whichever approach was taken, nearly all were successful and correctly converted to the required distance. A few managed to divide the wrong way when presented with $20x = 24$, but then went on to finish correctly. Very few forgot to complete their solutions by finding *AO*. The other popular approach was to take *x* as *AO* and this was nearly always successful. A small number chose strange positions to measure *x* from, but again most managed to then produce the (not given) answer.

The proof of SHM in part (b) had the usual problems, but it seemed that more students were using the correct notation and in most cases equations were formed about the equilibrium position. Students must show the constant lengths that they are using in this equation. Simply stating that the extensions of the springs are $e_1 + x$ and $e_2 - x$ and then that the constant terms magically vanish will not gain any marks unless the values of these constants are defined (possibly in part a); it is safer to use numerical values here. There were still a lot of students either working with *ma*, or failing to put concluding statements. The acceleration must be given as $\ddot{x}$ which is in the direction of increasing *x*, as stated in the specification; *a* does not have a defined direction. Given that this is the most predictable, learnable and essentially undemanding question on the paper (just make the *x* terms negative!) this is rather frustrating. One problem that caught out too many students was a desire to include the impulse in their equation, leading to the loss of all marks. In general, it was clear that most students knew what was required of the final answer and made sure that any unwanted additional terms were subtly dropped. Part (c) was answered very well. Most had found a value of ω in (b) which they used. Most went straight to the required formula, although a few went for the general position and then set $x = 0$. The mark for finding *v* was earned by most students at some point, even if they did not use it, although a minority tried to use $F = ma$ rather than $I = m(v - u)$.

For part (d) almost all students knew what to do and very few had their calculators set in degrees or used cosine instead of sine. Most of those who did use cosine were unable to complete the solution correctly.

Question 7

Many different starting points for the GPE term in part (a) were used, most resulting in a correct equation and a clear proof. Almost all students multiplied through by 2 to eliminate the halves, yet those who spotted the 4 in the denominator of the final result did some forward planning and multiplied by 8 instead, so were able to prove the result with the minimum of algebra. The most common error was the incorrect squaring of $\frac{\sqrt{gr}}{2}$ and a subsequent manipulation of the working to obtain the given answer.

Part (b) was generally attempted well, again the amount of algebra required varying greatly. Most mentioned *R* and then there was a split in ability. Those who knew that $R = 0$ were able to find $\cos\alpha$ in just a couple of lines. Some, however, struggled on with an equation including *R*, before realising that to proceed they would have to make *R* equal to 0 and although they got there in the end, it became very long-winded. Among failed attempts the most common mistake was trying to resolve vertically. Another not uncommon mistake was to show $\frac{mv^2}{r}$ on the diagram as an outward force and then writing equilibrium equations. This assumption of equilibrium can lead to significant method errors.

Part (c) was an excellent discriminator which only the most able completed correctly. Many students were able to set up a quadratic equation, with a clear idea of the components of speed and the vertical distance required, even though clear, helpful diagrams seemed to be few and far between. A few forgot that they had found the square of the speed and then used that incorrect value in their calculations. Most managed to find the square root and then use the correct value. A surprising number forgot that they had been given a value of *r* in the question and retained this *r* either without ever substituting or not putting a value in until the end which made the algebra much more difficult and time consuming. The most significant factor causing low marks was a lack of detail in the attempted solutions. Students should remember that we are marking solutions, not answers, and that it is essential to show the detailed steps in their calculation, with numerical values wherever relevant. If they write everything algebraically and hold strings of numbers in their calculators until the final answer, that answer has to be right. Four method marks were available and these could obviously not be awarded unless there was evidence of a correct method having been used. The 2 most significant omissions were showing the vertical velocity simply as $v\sin\alpha$ instead of

$\sqrt{\frac{3g}{8}} \times \frac{\sqrt{7}}{4}$ and writing solutions to a quadratic equation without evidence that the

correct formula had been used. It now seems common practice to do the second of these. Students need to realise the importance of showing either the formula itself or a detailed substitution into it. The most common feature among the weaker attempts was to assume a vertical velocity of 0 when the particle reached the ground. A frequent mistake for those who reached the end was forgetting to add the previously travelled horizontal distance to their projectile calculation or to add r instead of $r\sin\alpha$.

Grade Boundaries

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