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International Advanced Level in Pure Mathematics P4

WMA14/ 01A

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General Comments

This WMA14_01A paper was an appropriate test of the specification. There were sufficient standard questions to satisfy the well- prepared learner with some of the later questions offering stretch and demand that tested the higher achievers. The paper was of appropriate length with little evidence of learners rushing to complete the paper. Centres would be well advised to inform learners of the following;

- where answers are given, learners should include all appropriate steps in their solutions
- when a question includes either of the following demands

In this question you must show all stages of your working.
Solutions relying entirely on calculator technology are not acceptable.
Or
In this question you must show all stages of your working.
Solutions relying entirely on calculator technology are not acceptable.

it is very important that learners do not use calculators to solve complex equations.

Question 1

Question 1 was on proof by contradiction. Whilst most learners understood the idea of contradiction there were many examples that did not include important aspects, such as:

- not including the condition that a and b had to be positive when setting up the argument
- using the inequality „ rather than < throughout the proof

- not using correct explanations when progressing through the proof. A common example of this was stating that $(3a-2b)^2 \geqslant 0$ rather than $(3a-2b)^2 \ldots 0$

Question 2

Question 2 involved integration by parts. Learners who were able to make a correct start and integrate the correct way around, generally went on to score at least 4 of the 6 marks. No marks were available for those who did not differentiate ln*x* or did not know how to integrate by parts. For those who made a good start to the question but did not to score full marks, common errors tended to be;

- sign errors on either the first stage or second stage of integration

  most notably $-\frac{1}{x}\ln x - \int \frac{1}{x^2}\,\mathrm{d}x$

- errors introduced when substituting in limits with expressions like ln 1 or ln e left in the final answer

Question 3

Some excellent answers were seen in Question 3, a question based on implicit differentiation. Success, or not, for many was dependent upon a whether learners differentiated 3^x. Various incorrect attempts were seen including $x3^{x-1}$ and $3^x \ln x$. Most learners knew that the product rule was required to differentiate $x\,y^2$ and many could successfully differentiate $6y$. For those learners who correctly differentiated the given function, yet did not gain full marks, did so due to;

- errors when attempting to make $\frac{dy}{dx}$ the subject
- leaving the answer in the form $\frac{6\ln 3-9}{8}$ rather than the form required by the question

Question 4

Questions on the binomial expansion are usually well received by learners and this was no exception.

Part (a) was straightforward with most learners scoring all 4 marks. Errors were rare but usually involved a lack of evidence in reaching the given answer. It is important to note that a line of working was required between $(2+3x)(1+x+\frac{3}{2}x^2+..$ and $2+5x+6x^2$

Part (b) was more discriminating with errors being a lot more common. Marks, when not obtained, could be summarised for the following reasons;

- only substituting $x=\frac{1}{20}$ into one side of the identity
- numerical or algebraic errors leading to an incorrect fraction for $\sqrt{10}$

Question 5

This was a very discriminating question. Whilst there were many fully correct solutions, there was a sizeable number of learners who made very little progress. Success depended upon being able to interpret the information given within the question and deduce expressions for $\frac{dA}{dt}=\frac{\pi}{20}$, $\frac{dA}{dx}=2\pi x$ and $\frac{dV}{dx}=18\pi x^2$. The

most common error was in finding $\frac{dA}{dx} = 28\pi x$. Other errors prevented progress more substantially. For example, some responses showed that $\frac{dA}{dt} = 2\pi x$ or some, having found $V = 6Ax$ showed that $\frac{dV}{dA} = 6x$

Generally, learners who found correct expressions for $\frac{dA}{dt}$ and $\frac{dV}{dx}$ along with an acceptable expression for $\frac{dA}{dx}$ went on to score at least 4 of the 6 marks. The most common ways of completing the question were;

- In one step using $\frac{dV}{dt} = \frac{dV}{dx} \times \frac{dx}{dA} \times \frac{dA}{dt}$
- In two steps by finding $\frac{dx}{dt}$ from $\frac{dA}{dt} = \frac{dA}{dx} \times \frac{dx}{dt}$ followed by finding $\frac{dV}{dt}$ from $\frac{dV}{dt} = \frac{dV}{dx} \times \frac{dx}{dt}$ or equivalent

Question 6

This was a two-part question set in the context of a volume of a solid of revolution of a curve given in parametric form.

In part (a) learners were required to show that volume could be found from a given integral. Whilst most learners knew the form $y^2 \times \frac{dx}{dt}$, errors in processing $y^2 = (2\sin 2t)^2$ were common with at least one of the 2's being omitted when $\sin 2t = 2\sin t \cos t$ was squared. Other common errors in part (a) were;

- using $dx = -3\cos t \, dt$ or else losing the '3'
- incorrectly finding the value of *a* with $\frac{3}{2}$ or $\frac{1}{2}$ frequently seen

Part (b) could be attempted either by substitution or via trigonometric identities. Integration by substitution was by far the most common with many learners getting the correct form of the solution with the occasional slip in coefficient or sign. It was important that the correct limits to the integral were used with some using the value of t from part (a) rather than the value of u which was $\frac{1}{2}$. Errors made in the value of k in part (a) meant that 4 out of 5 marks were common in part (b).

Question 7

Question 7 was a differential equation set within a given context.

Part (a) involved writing an expression in partial fraction form. This was done accurately by all but a small proportion of learners.

Part (b) required skills in integration, analysis of the model as well as algebraic skills including work with exponentials and natural logs. Due to the negative signs in the partial fractions, errors in signs were common when integrating. Learners who took their ½'s into the fraction also seemed to find this more challenging than those who did not. Whilst most learners achieved the given answer, a significant number arrived there with either incorrect, or limited working. Common issues witnessed in this part included;

- failure to use or find a constant of integration via $t = 0, x = 0$
- using incorrect work when removing the lns. E.g.

  $\ln(4-x) - \ln(2-x) = kt + \ln 2 \Rightarrow \ln\frac{(4-x)}{(2-x)} = kt + \ln 2 \Rightarrow \frac{(4-x)}{(2-x)} = e^{kt} + 2$ instead of

  $\ln(4-x) - \ln(2-x) = kt + \ln 2 \Rightarrow \ln\frac{(4-x)}{(2-x)} = kt + \ln 2 \Rightarrow \frac{(4-x)}{(2-x)} = e^{kt+2} \Rightarrow \frac{(4-x)}{(2-x)} = 2e^{kt}$

- moving directly from $\frac{(4-x)}{(2-x)}=2e^{kt}$ to $x=\frac{4-4e^{2kt}}{1-2e^{2kt}}$ without showing intermediate steps

Correct answers in part (c) were very common, even from those learners who hadn't attempted parts (a) and (b). There were some correct answers however, that appeared without any working. Those learners were not awarded both marks.

Question 8

There were many excellent solutions to this question on parametric equations, tangents and intersections. Very few learners scored full marks however, due to solving the cubic equation in part (c) via a calculator despite the demands of the question.

Part (a) was straightforward with most learners proceeding to find *A* and *B* by setting $y = 0$. The coordinates of *B* were given however and sufficient working needed to be shown to allow all 3 marks to be awarded.

Part (b) was also a good source of marks for many with full marks common. When marks were not attained, this was often a result of either of the following two errors;

- not finding a correct expression for $\frac{dy}{dx}$, usually a result of incorrectly differentiating *y*
- using the *t* value for *A* ($t = -3$) instead of the *t* value for *B* (3)

Many learners made a correct start in part (c) by substituting the parametric equations into their equation for the tangent from part (b). Those who reached a correct quadratic should then have realised that $t=3$ is a (double) root, and so

then divide the resulting cubic equation by $(t-3)$ or t^2-6t+9. This would then lead to the value of *t* at *X*. Once the value of *t* at *X* is known it was a simple task of finding the coordinates. The most common score trait was a special case score of 3 out of the 5 marks for the following solution.

Substitutes $x=t^2+2t, y=t^3-9t,$ into $9x-4y-135=0$

$\Rightarrow 9(t^2+2t)-4(t^3-9t)-135=0$

$\Rightarrow 4t^3-9t^2-54t+135=0 \Rightarrow t=-3.75.$

So, $X=\left(\frac{105}{16},-\frac{1215}{64}\right)$

Learners should heed the warnings given in questions regarding the use of calculators and showing all stages of working.

Question 9

Question 9 tested learner's knowledge of vectors.

Parts (a) and (b) were standard and tested their knowledge of equations of lines in 3 dimensions as well as vector notation. Both of these parts were done extremely well.

In part (c), angle *CAB* was required to be found. This was mainly attempted via scalar product, although other methods were possible. The general idea behind scalar product was well known but there were occasional errors, usually due to one of the following reasons;

- not correctly finding vector *AC*
- attempting to find the wrong angle, usually angle *ACB*
- not paying attention to the direction of lines resulting in an angle of $150°$

If part (c) was correct, learners usually answered part (d) correctly.

Part (e) was a big discriminator. Concise solutions were rare and many required attempts at either lengths of lines, or areas of triangles leading to an equation in λ. The nature of these expressions meant that errors were common especially when attempting to square terms. The best and most concise routes through this problem were from learners who drew diagrams and used the geometry of the situation.

For example, $\overrightarrow{OD_1} = \overrightarrow{OA} + 2 \times \overrightarrow{AB}$ and $\overrightarrow{OD_2} = \overrightarrow{OA} + 2 \times \overrightarrow{BA}$

