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MATHEMATICS **9709/22**

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MARK SCHEME

Maximum Mark: 50

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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Mark Scheme Notes

Marks are of the following three types:

M Method mark, awarded for a valid method applied to the problem. Method marks are not lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. Correct application of a formula without the formula being quoted obviously earns the M mark and in some cases an M mark can be implied from a correct answer.

A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated method mark is earned (or implied).

B Mark for a correct result or statement independent of method marks.

- When a part of a question has two or more "method" steps, the M marks are generally independent unless the scheme specifically says otherwise; and similarly when there are several B marks allocated. The notation DM or DB (or dep*) is used to indicate that a particular M or B mark is dependent on an earlier M or B (asterisked) mark in the scheme. When two or more steps are run together by the candidate, the earlier marks are implied and full credit is given.

- The symbol FT implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A or B marks are given for correct work only. A and B marks are not given for fortuitously "correct" answers or results obtained from incorrect working.

- Note: B2 or A2 means that the candidate can earn 2 or 0.
  B2/1/0 means that the candidate can earn anything from 0 to 2.

- The marks indicated in the scheme may not be subdivided. If there is genuine doubt whether a candidate has earned a mark, allow the candidate the benefit of the doubt. Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored.

- Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise.

- For a numerical answer, allow the A or B mark if a value is obtained which is correct to 3 s.f., or which would be correct to 3 s.f. if rounded (1 d.p. in the case of an angle). As stated above, an A or B mark is not given if a correct numerical answer arises fortuitously from incorrect working. For Mechanics questions, allow A or B marks for correct answers which arise from taking g equal to 9.8 or 9.81 instead of 10.

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The following abbreviations may be used in a mark scheme or used on the scripts:

AEF/OE Any Equivalent Form (of answer is equally acceptable) / Or Equivalent

AG Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid)

CAO Correct Answer Only (emphasising that no "follow through" from a previous error is allowed)

CWO Correct Working Only – often written by a 'fortuitous' answer

ISW Ignore Subsequent Working

SOI Seen or implied

SR Special Ruling (detailing the mark to be given for a specific wrong solution, or a case where some standard marking practice is to be varied in the light of a particular circumstance)

Penalties

MR –1 A penalty of MR –1 is deducted from A or B marks when the data of a question or part question are genuinely misread and the object and difficulty of the question remain unaltered. In this case all A and B marks then become "follow through" marks. MR is not applied when the candidate misreads his own figures – this is regarded as an error in accuracy. An MR –2 penalty may be applied in particular cases if agreed at the coordination meeting.

PA –1 This is deducted from A or B marks in the case of premature approximation. The PA –1 penalty is usually discussed at the meeting.

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Question	Answer	Marks	Guidance
1	Introduce logarithms to both sides and use power law	***M1**	
	Obtain $(3x-1)\log 5 = 4x\log 2$ or equivalent	**A1**	Allow **A1** for poor use of brackets if recovered later
	Solve linear equation for x	**DM1**	dep *M
	Obtain 0.783	**A1**	Allow 3 sf or better
		4	

Question	Answer	Marks	Guidance
2	Solve 3-term quadratic equation or a pair of linear equations	**M1**	For **M1**, must square both sides when attempting a quadratic equation
	Obtain $x = -5$ and $x = 3$	**A1**	
	Substitute (at least) one value of x (less than 4) into $\lvert x+4\rvert - \lvert x-4\rvert$, showing correct evaluation of modulus and producing only one answer in each case	**M1**	
	Obtain –8 and 6 and no others	**A1**	
		4	

Question	Answer	Marks	Guidance
3	Differentiate to obtain form $k_1\sec^2\frac{1}{2}x + k_2\cos\frac{1}{2}x$	**M1**	If a factor of 0.5 is missed, can still get 5/6, penalise at first **A1**
	Obtain $\frac{1}{2}\sec^2\frac{1}{2}x + \frac{3}{2}\cos\frac{1}{2}x$	**A1**	
	Equate first derivative to zero and produce $\cos^3\frac{1}{2}x = k_3$	***M1**	
	Use correct process to find one value of x	**DM1**	Dep on *M, allow for obtaining 1.609….. , 92.2^o or 268^o
	Obtain $x = 4.67$	**A1**	Allow $x = 4.67$ or better for **A1**
	Obtain $y = 1.12$	**A1**	Allow $y = 1.12$ from $x = 4.66$ but nothing else
		6	

Question	Answer	Marks	Guidance
4(i)	Substitute $x = -3$ into either $\mathrm{p}(x)$ or $\mathrm{q}(x)$ and equate to zero (may be implied)	**M1**	Allow long division, but the remainder needs to be independent of x
	Obtain $a = -11$	**A1**	
	Obtain $b = -8$	**A1**	
		3	
4(ii)	Divide $x + 3$ into expression for $\mathrm{q}(x) - \mathrm{p}(x)$ (may be a four term cubic equation), or Obtain a 3 term cubic equation by subtraction	***M1**	Allow *M1 for their $x^3 + 3x + 36$, but must have integer values for a and b
	Obtain $x^2 - 3x + 12$ or $x^2 - 2x - 5$ and $2x^2 - 5x + 7$	**A1**	
	Apply discriminant to quadratic factor of $\mathrm{q}(x) - \mathrm{p}(x)$ or equivalent	**DM1**	dep on *M
	Obtain -39 or equivalent and conclude appropriately	**A1**	
		4	

Question	Answer	Marks	Guidance
5(i)	Obtain derivative of the form ke^{-2x}	***M1**	Condone $k = 4$ for **M1**
	State or imply gradient of curve at P is -8	**A1**	
	Form equation of straight line through $(0, 9)$ with negative gradient	***DM1**	dep on *M
	Obtain $y = -8x + 9$ or equivalent	**A1**	
	Equate equation of curve and equation of straight line	**DM1**	dep on both *M
	Rearrange to confirm $x = \frac{9}{8} - \frac{1}{2}\mathrm{e}^{-2x}$	**A1**	
		6	

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Question	Answer	Marks	Guidance
5(ii)	Use iterative process correctly at least once	**M1**	
	Obtain final answer 1.07	**A1**	
	Show sufficient iterations to 5 sf to justify answer or show sign change in interval $(1.065, 1.075)$	**A1**	
		6	

Question	Answer	Marks	Guidance
6(a)	Obtain $2-2\cos 2x$ as part of integrand	**B1**	
	Obtain $3\sin 2x$ as part of integrand	**B1**	Allow second **B1** for writing
	Integrate to obtain form $k_1x + k_2\sin 2x + k_3\cos 2x$	**M1**	$\int 6\sin x\cos x\,\mathrm{d}x = 6\left(\frac{1}{2}\sin^2 x\right)$, **M1** may then be implied by subsequent work
	Obtain $2x - \sin 2x - \frac{3}{2}\cos 2x$ or $2x - \sin 2x + 3\sin^2 x$	**A1**	
	Apply limits to obtain $\frac{1}{2}\pi + \frac{1}{2}$	**A1**	
		5	
6(b)	Integrate to obtain $2\ln(3x+2)$	**B1**	Allow $\frac{6}{3}\ln(3x+2)$ for **B1**
	Use at least one relevant logarithm property	***M1**	
	Obtain $\frac{3a+2}{2} = 7$ or $\frac{(3a+2)^2}{4} = 49$ or equivalent without ln	**A1**	
	Solve relevant equation to find a	**DM1**	Dep on ***M1**, allow for $49 = (3a+2)^2$ OE or correct working involving $(3a+2)$
	Obtain $a = 4$ only	**A1**	
		5	

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Question	Answer	Marks	Guidance
7(i)	Obtain $4y + 4x\frac{dy}{dx}$ as derivative of $4xy$	**B1**	
	Obtain $4y\frac{dy}{dx}$ as derivative of $2y^2$	**B1**	
	State $2x + 4y + 4x\frac{dy}{dx} + 4y\frac{dy}{dx} = 0$	**B1**	3rd **B1** may be implied by later work
	Substitute $x = -1,\ y = 3$ to find gradient of line	***M1**	dep at least one **B1**
	Form equation of tangent through $(-1, 3)$ with numerical gradient	**DM1**	dep *M
	Obtain $5x + 4y - 7 = 0$ or equivalent of required form	**A1**	Allow any 3 term integer form for **A1**
		6	
7(ii)	Substitute $\frac{dy}{dx} = \frac{1}{2}$ to find relation between x and y	***M1**	dep at least one **B1** in part **(i)**, must be linear
	Obtain $4x + 6y = 0$ or equivalent	**A1**	
	Substitute for x or y in equation of curve	**DM1**	dep on *M
	Obtain $-\frac{7}{4}y^2 = 7$ or $-\frac{7}{9}x^2 = 7$ or equivalent and conclude appropriately	**A1**	
		4	

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