MARK SCHEME for the May/June 2010 question paper

for the guidance of teachers

9709 MATHEMATICS

9709/31

Paper 31, maximum raw mark 75

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 must be read in conjunction with the question papers and the report on the examination.

• CIE will not enter into discussions or correspondence in connection with these mark schemes.

CIE is publishing the mark schemes for the May/June 2010 question papers for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level syllabuses and some Ordinary Level syllabuses.



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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 √ 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 Any Equivalent Form (of answer is equally acceptable)
- AG Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid)
- BOD Benefit of Doubt (allowed when the validity of a solution may not be absolutely clear)
- 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
- MR Misread
- PA Premature Approximation (resulting in basically correct work that is insufficiently accurate)
- SOS See Other Solution (the candidate makes a better attempt at the same question)
- 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 $\sqrt{}$ " 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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1	EITHER:	State or imply non-modular inequality $(x + 3a)^2 > (2(x - 2a))^2$, or corresponding quadratic equation, or pair of linear equations $(x + 3a) = \pm 2(x - 2a)$ Make reasonable solution attempt at a 3-term quadratic, or solve two linear	B1	
		equations	M1	
		Obtain critical values $x = \frac{1}{3}a$ and $x = 7a$	A1	
		State answer $\frac{1}{3}a < x < 7a$	A1	
	OR:	Obtain the critical value $x = 7a$ from a graphical method, or by inspection, or by solving a linear equation or inequality Obtain the critical value $x = \frac{1}{3}a$ similarly	B1 B2	
		State answer $\frac{1}{3}a < x < 7a$	B1	[4]
		[Do not condone \leq for \leq ; accept 0.33 for $\frac{1}{3}$.]		

2	Use correct $\cos 2A$ formula and obtain an equation in $\sin \theta$	M1	
	Obtain $4\sin^2 \theta + \sin \theta - 3 = 0$, or equivalent	A1	
	Make reasonable attempt to solve a 3-term quadratic in sin θ	M1	
	Obtain answer 48.6°	A1	
	Obtain answer 131.4° and no others in the given range	A1 $$	
	Obtain answer 270° and no others in the given range	A1	[6]
	[Treat the giving of answers in radians as a misread. Ignore answers outside the given range.]		

3	(i)	EITHER:	State or imply $n \ln x + \ln y = \ln C$	B1	
			Substitute <i>x</i> - and <i>y</i> -values and solve for <i>n</i>	M1	
			Obtain $n = 1.50$	A1	
			Solve for <i>C</i>	M1	
			Obtain $C = 6.00$	A1	
		OR:	Obtain two correct equations by substituting x- and y-values in $x^n y = C$	B1	
			Solve for <i>n</i>	M1	
			Obtain $n = 1.50$	A1	
			Solve for <i>C</i>	M1	
			Obtain $C = 6.00$	A1	[5]

(ii) State that the graph of $\ln y$ against $\ln x$ has equation $n \ln x + \ln y = \ln C$ which is *linear* in $\ln y$ and $\ln x$, or has equation of the form $nX + Y = \ln C$, where $X = \ln x$ and $Y = \ln y$, and is thus a straight line B1

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- (i) State correct expansion of cos(3x x) or cos(3x + x)
 Substitute expansions in ¹/₂ (cos 2x cos 4x), or equivalent
 Simplify and obtain the given identity correctly
 (ii) Obtain integral ¹/₄ sin 2x ¹/₈ sin 4x
 Substitute limits correctly in an integral of the form asin 2x + bsin 4x
 - Substitute limits correctly in an integral of the form $a \sin 2x + b \sin 4x$ M1Obtain given answer following full, correct and exact workingA1[3]

[1]

	Page 5	5	Mark Scheme: Teachers' version	Syllabus	Paper	
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5	Integrate	Separate variables correctly Integrate and obtain term $\ln x$ Integrate and obtain term $\frac{1}{2}\ln(y^2 + 4)$		B1 B1 P1		
			-	$a = \frac{1}{2} $	B1	
			stant or use limits $y = 0$, $x = 1$ in a solution containing aln x	and $Din(y + 4)$	M1 A1	
			solution in any form, e.g. $\frac{1}{2}\ln(y^2 + 4) = \ln x + \frac{1}{2}\ln 4$			
	Rearrang	Rearrange as $y^2 = 4(x^2 - 1)$, or equivalent			A1	[6]
6	(i)	Using	g the formulae $\frac{1}{2}r^2\theta$ and $\frac{1}{2}r^2\sin\theta$, or equivalent, form an	equation	M1	
			in a correct equation in r and x and/or $x/2$ in any form		A1	
		Obta	in the given equation correctly		A1	[3]
	(ii)	Cons	ider the sign of $x - (\frac{3}{4}\pi - \sin x)$ at $x = 1.3$ and $x = 1.5$, or eq	uivalent	M1	
	(11)		plete the argument with correct calculations		Al	[2]
						r_1
	(iii)		he iterative formula correctly at least once		M1	
			in final answer 1.38 v sufficient iterations to at least 4 d.p. to justify its accurate	ev to 2 d n or shov	A1	
			is a sign change in the interval (1.375, 1.385)	cy to 2 d.p., of shot	A1	[3]
7	(i)	Obto	in modulus $\sqrt{8}$		B1	
/	(1)		in argument $\frac{1}{4}\pi$ or 45°		B1	[2]
		0014	In argument $\frac{1}{4}$ % of 45		DI	[4]
	(ii)	Show	1, i and <i>u</i> in relatively correct positions on an Argand diag	ram	B1	
			the perpendicular bisector of the line joining 1 and i		B1	
			<i>v</i> a circle with centre <i>u</i> and radius 1		B1 B1	۲ <i>4</i> ٦
		Shau	e the correct region		DI	[4]
	(iii)		or imply relevance of the appropriate tangent from O to the	e circle	B1 √	
		•	v out complete strategy for finding $ z $ for the critical point		M1	
		Obta	in answer $\sqrt{7}$		A1	[3]
			A B			
8	(i)	State	or imply the form $\frac{A}{x+1} + \frac{B}{x+3}$ and use a relevant method t	o find A or B	M1	
			$\sin A = 1, B = -1$		A1	[2]
	(ii)	-	re the result of part (i) and substitute the fractions of part (i))	M1	
		Obta	in the given answer correctly		A1	[2]
		т.				
	(iii)	Integ	rate and obtain $-\frac{1}{x+1} - \ln(x+1) + \ln(x+3) - \frac{1}{x+3}$		B3	
			titute limits correctly in an integral containing at least two	terms of the correc		
		form	in given answer following full and exact working		M1	[5]
		Outa	in given answer tonowing full and exact working		A1	[5]

(ii) Use product rule MI Obtain correct derivative in any form AI Equate derivative to zero and solve for x MI Obtain $x = \frac{1}{2}$ AI [4] 10 (i) Express general point of l or m in component form, e.g. $(1 + s, 1 - s, 1 + 2s)$ or (4 + 2t, 6 + 2t, 1 + t) BI Equate at least two corresponding pairs of components and solve for s or t MI Obtain $s = -1$ or $t = -2$ AI Verify that all three component equations are satisfied AI [4] (ii) Carry out correct process for evaluating the scalar product of the direction vectors of l and m MI Using the correct process for the moduli, divide the scalar product by the product of the moduli and evaluate the inverse cosine of the result MI Obtain answer 74.2° (or 1.30 radians) AI [3] (iii) EITHER: Use scalar product to obtain $a - b + 2c = 0$ and $2a + 2b + c = 0$ BI Solve and obtain one ratio, e.g. $a: b$ MI Obtain $a: b: c = 5: -3: -4$, or equivalent AI Obtain answer $5x - 3y - 4z = -2$, or equivalent AI Obtain answer $5x - 3y - 4z = -2$, or equivalent AI Obtain aratio of three of the unknowns, e.g. $a: b: c = -5: 3: 4$ AI Use coordinates of a relevant point and found ratio to find the fourth unknown, e.g. d BI Solve and obtain one ratio, e.g. $a: b$ MI Obtain a ratio of three of the unknowns, e.g. $a: b: c = -5: 3: 4$ AI Use coordinates of a relevant point and found ratio to find the fourth unknown, e.g. d MI Obtain answer $5x + 3y + 4z = 2$, or equivalent AI OR 2: Form a correct 2-parameter equation for the plane, $c.g. r = i + j + k + \lambda(i (- j + k) + \lambda(2i + 2j + k))$ BI State three equations in x, y, z, λ and μ MI State three correct cuputents AI OR 2: Form a correct 2-parameter equation for the plane, $c.g. r = i + j + k + \lambda(i - j + k) + \lambda(2i + 2j + k)$ BI State three equations in x, y, z, λ and μ MI State three correct components of the product AI Obtain norecrect components of the product AI Obtain norecrect components of the product AI Obtain orcect product, e.g. $-5i + 3j + 4k$ AI Form a plane equation and use coordina		Page 6	;	Mark Scheme: Teachers' version	Syllabus	Paper	
Obtain correct derivative in any formA1Use chain rule to find $\frac{dr}{dt}$ M1Obtain a correct expression in any formA1Obtain a correct expression in any formA1Obtain the gradient of the normal in the given form correctlyA1(i)Use product ruleM1Obtain correct derivative to zero and solve for xM1Obtain correct derivative to zero and solve for xM1Obtain x = $\frac{1}{2}$ A1(ii)Express general point of l or m in component form, e.g. $(1 + s, 1 - s, 1 + 2s)$ or $(4 + 2t, 6 + 2t, 1 + t)$ B1Equate at least two corresponding pairs of components and solve for s or tObtain s = -1 or t = -2A1Verify that all three component equations are satisfiedA1(ii)Carry out correct process for evaluating the scalar product of the direction vectors of l and mUsing the correct process for the moduli, divide the scalar product by the product of the moduli and evaluate the inverse cosine of the resultObtain answer 74.2° (or 1.30 radians)A1(iii)EITHER:Use scalar product to obtain a - b + 2c = 0 and 2a + 2b + c = 0Solve and obtain one ratio, e.g. a : bM1Obtain answer 74.2° (or 1.30 radians)A1Obtain answer 5x - 3y - 4z = -2, or equivalentA1Obtain answer 5x - 3y - 4z = -2, or equivalentA1Obtain answer 5x - 3y - 4z = -2, or equivalentA1Obtain answer 5x + 3y + 4z = 2, or equivalentA1Obtain answer 5x + 3y + 4z = 2, or equivalentA1Obtain answer 5x + 3y - 4z = -2, or equivalent<				GCE AS/A LEVEL – May/June 2010	9709	31	
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10 (i) Express general point of <i>l</i> or <i>m</i> in component form, e.g. $(1 + s, 1 - s, 1 + 2s)$ or (4 + 2t, 6 + 2t, 1 + t) B1 Equate at least two corresponding pairs of components and solve for <i>s</i> or <i>t</i> M1 Obtain <i>s</i> = -1 or <i>t</i> = -2 Verify that all three component equations are satisfied A1 [4] (ii) Carry out correct process for the moduli, divide the scalar product of the direction vectors of <i>l</i> and <i>m</i> M1 Using the correct process for the moduli, divide the scalar product by the product of the moduli and evaluate the inverse cosine of the result M1 Obtain answer 74.2° (or 1.30 radians) A1 [3] (iii) <i>EITHER:</i> Use scalar product to obtain $a - b + 2c = 0$ and $2a + 2b + c = 0$ B1 Solve and obtain one ratio, e.g. $a : b$ M1 Obtain answer $74.2°$ (or 1.30 radians) A1 [3] (iii) <i>EITHER:</i> Use scalar product to obtain $a - b + 2c = 0$ and $2a + 2b + c = 0$ B1 Solve and obtain one ratio, e.g. $a : b$ M1 Obtain answer $74.2°$ (or 1.30 radians) A1 [3] (iii) <i>EITHER:</i> Use scalar product to obtain $a - b + 2c = 0$ and $2a + 2b + c = 0$ B1 Solve and obtain one ratio, e.g. $a : b$ M1 Obtain arswer $5x - 3y - 4z = -2$, or equivalent A1 <i>Obtain arswer</i> $5x - 3y - 4z = -2$, or equivalent A1 <i>Obtain aratio of three of the unknowns</i> , e.g. $a : b : c = -5 : 3 : 4$ A1 Use coordinates of a relevant point and found ratio to find the fourth unknown, e.g. d M1 Obtain answer $-5x + 3y + 4z = 2$, or equivalent A1 <i>OR</i> 2: Form a correct 2-parameter equation for the plane, e.g. $\mathbf{r} = \mathbf{i} + \mathbf{j} + \mathbf{k} + \lambda(\mathbf{i} - \mathbf{j} + 2\mathbf{k}) + \mu(2\mathbf{i} + 2\mathbf{j} + \mathbf{k})$ B1 State three correct equations $A = 4$ M1 Obtain answer $5x - 3y - 4z = -2$, or equivalent A1 <i>Obtain answer</i> $5x - 3y - 4z = -2$, or equivalent A1 <i>Obtain in solution correct product of the product</i> A1 Obtain in correct product equations A1 Eliminate λ and μ M1 State three correct opmonents of the product A1 Obtain in correct product, e.g. $-5\mathbf{i} + 3\mathbf{j} + 4\mathbf{k}$ A1 Form a plane equation and use coordinates of a relevant point to calculate			-				[4]
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general equation of plane and evaluate d M1Obtain answer $5x - 3y - 4z = -2$, or equivalentA1OR 1:Using two points on l and one on m , or vice versa, state three equations in a, b, c and d B1Solve and obtain one ratio, e.g. $a:b$ M1Obtain a ratio of three of the unknowns, e.g. $a:b:c = -5:3:4$ A1Use coordinates of a relevant point and found ratio to find the fourth unknown, e.g. d M1Obtain answer $-5x + 3y + 4z = 2$, or equivalentA1OR 2:Form a correct 2-parameter equation for the plane, e.g. $\mathbf{r} = \mathbf{i} + \mathbf{j} + \mathbf{k} + \lambda(\mathbf{i} - \mathbf{j} + 2\mathbf{k}) + \mu(2\mathbf{i} + 2\mathbf{j} + \mathbf{k})$ B1State three equations in x, y, z, λ and μ M1Obtain answer $5x - 3y - 4z = -2$, or equivalentA1OR 3:Attempt to calculate vector product of direction vectors of l and m Obtain correct product, e.g. $-5\mathbf{i} + 3\mathbf{j} + 4\mathbf{k}$ A1Obtain correct product, e.g. $-5\mathbf{i} + 3\mathbf{j} + 4\mathbf{k}$ A1Obtain correct product, e.g. $-5\mathbf{i} + 3\mathbf{j} + 4\mathbf{k}$ A1Otain correct product, e.g. $-5\mathbf{i} + 3\mathbf{j} + 4\mathbf{k}$ A1Obtain correct product, e.g. $-5\mathbf{i} + 3\mathbf{j} + 4\mathbf{k}$ A1Obtain correct product, e.g. $-5\mathbf{i} + 3\mathbf{j} + 4\mathbf{k}$ A1Obtain a plane equation and use coordinates of a relevant point to calculate d M1				· •			
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