OCR
Oxford Cambridge and RSA

Principal Learning

Engineering

Unit **F563:** Mathematical techniques and applications for engineers

OCR Level 3 Principal Learning

Mark Scheme for January 2014

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

Annotations in scoris

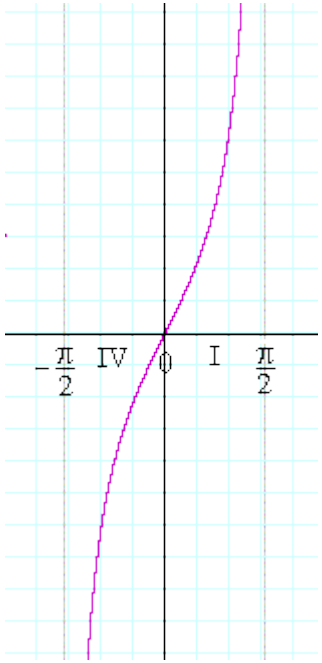
The following annotations are available:

✓ = correct response
✗ = incorrect response
ecf = error carried forward

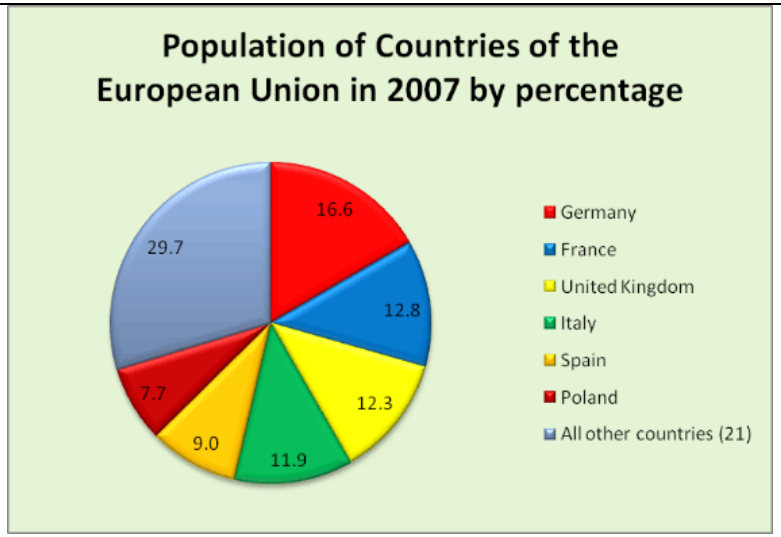
BOD = Benefit of doubt

Highlighting is also available to highlight any particular points on the script.

Question			Expected Answer	Mark	Rationale/Additional Guidance
Section A					
1			$3(2x – 5) – 4x = 6x – 15 – 4x = 2x – 15$ $2x$ $–15$	 **[1]** **[1]**	
2			$x^2 – 64 = (x – 8)(x + 8)$ $(x – 8)$ $(x + 8)$	 **[1]** **[1]**	
3			$(x + 10)/5 – (x + 3)/4 = (4x + 40 – 5x – 15)/20$ $= (–x + 25)/20$ $–x + 25$ 20	 **[1]** **[1]**	 Accept – 0.05x + 1.25 for two marks
4			$(3x+ 4)/3 = (–2x – 6)/6$ $18x + 24 = –6x – 18$ $24x = – 42$ $x = – 42/24$ $x = – 1.75$	 **[1]** **[1]**	
5			An isosceles triangle has two equal sides and two equal angles.	**[2]**	one mark for two equal angles.
6				**[2]**	Award one mark for the shape and one mark for any correct label

Question			Expected Answer	Mark	Rationale/Additional Guidance
Section A					
					
7			Given θ = 45° and the hypotenuse is 1 m then: Sin 45° = length of one side/hypotenuse = length of one side/1 So length of one side = sin 45° = 0.7071 m	**[1]** **[1]**	Award one mark for correct numerical result with or without the unit

Question			Expected Answer	Mark	Rationale/Additional Guidance
Section A					
8			cosec x = 1/sin x and sec x = 1/cos x Substitute into RHS – then sec x/cosec x = (1/cos x)/(1/sin x) = sin x/cos x = tan x QED	**[1]** **[1]**	
9			$y = 4x^4 + 2 \sin x$ $dy/dx = 16x^3 + 2 \cos x$ $16x^3$ $2 \cos x$	 **[1]** **[1]**	
10			$y = 1/x + \cos x = x^{-1} + \cos x$ $dy/dx = -x^{-2} - \sin x$ $= -1/x^2 - \sin x$ $- \sin x$ $-1/x^2$	 **[1]** **[1]**	Accept $-x^{-2}$ for one mark
11			$\int \cos 4x \, dx = (\sin 4x)/4 + C$ $(\sin 4x)/4$ $+C$	 **[1]** **[1]**	
12			$\int_2^3 4x^3 \, dx = [x^4]_2^3 = 3^4 - 2^4$ $= 65$	 **[1]** **[1]**	
13			Pie Charts, drawn as a circle, normally show proportion, which can be measured in percentages or fractions. An example is given:	**[1]** **[1]**	

Question			Expected Answer	Mark	Rationale/Additional Guidance
Section A					
					
14			Mean = (26.25+26.00+26.40+26.60+26.15)/5 = 26.28	**[1]** **[1]**	
15			A dependent event is one in which the probability of an event happening is affected by the probability of another event happening	**[1]** **[1]**	
			Total	**[30]**	

Question			Expected Answer	Mark	Rationale/Additional Guidance
Section B					
1	**(a)**		Given that $Q = mc(t_2 - t_1)$. Calculate the heat transfer Q when Substitute m = 10, c = 480, t_2 = 200 and t_1 = 20. Then Q = (10 x 480)(200 – 20) = 4800 x 180 = 864000	**[1]**	
1	**(b)**		Given that $Q = mc(t_2 - t_1)$ Open the brackets then $Q = mct_2 - mct_1$ Then $mct_1 = mct_2 - Q$ So $t_1 = (mct_2 - Q)/(mc)$	**[1]** **[1]** **[1]**	Accept any other correct method
1	**(c)**		Given A = B/(3C – B) Multiply both sides by (3C – B) then A(3C – B) =B Open the brackets then 3AC – AB = B Add AB to both sides than 3AC = B + AB Simplify B(1 + A) = 3AC So B = 3AC/(1 + A)	**[1]** **[1]** **[1]** **[1]**	Accept any other correct method
1	**(d)**		Given $x = \sqrt{(a^2 - b^2)}$ Square both sides then $x^2 = a^2 - b^2$ Then $b^2 = a^2 - x^2$ So $b = \sqrt{(a^2 - x^2)}$	**[1]** **[1]**	Accept any other correct method
			Total	**[10]**	

Question			Expected Answer	Mark	Rationale/Additional Guidance
2	(a)		Given $x^2 + 2x – 8 = 0$. By inspection $(x – 2)(x + 4) = 0$ So $x = +2$ or $x = – 4$	 [1] [1] [1]	
2	(b)	(i)	Given formula $s = ut – 0.5gt^2$ and $u = 40$, $g = 9.81$ and $s = 20$ So $20 = 40t – (0.5 \times 9.81)t^2$ $20 = 40t – 4.905t^2$ Then $4.905t^2 – 40t + 20 = 0$ Solution of quadratic equation by formulae $t = [–b \pm \sqrt{(b^2 – 4ac)}]/2a$ where $a = 4.905$, $b = –40$ and $c = 20$ so $t = [40 \pm \sqrt{(–40^2 – 4 \times 4.905 \times 20]/(2 \times 4.905)}$ $t = 7.62$ s $t = 0.54$ s Time for ascent is 0.54 s	 [1] [1] [1] [1] [1] [1] [1]	
			Total	**[10]**	

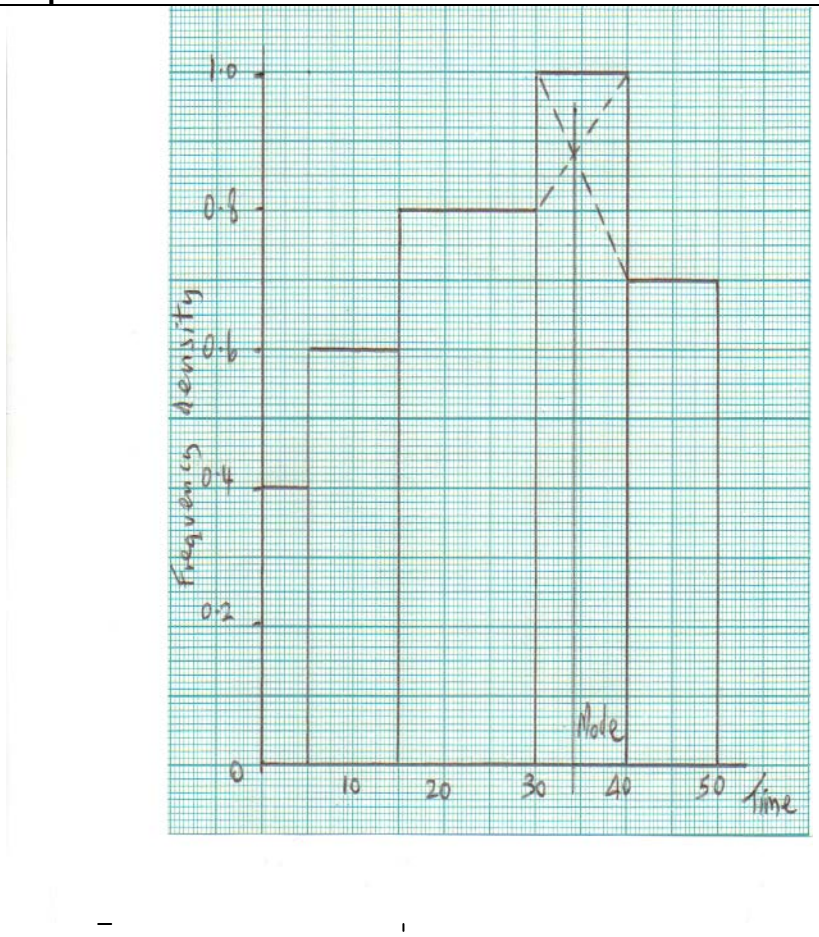
Question			Expected Answer	Mark	Rationale/Additional Guidance
3	(a)	(i)	Given diameter = 300 mm and subtended angle = 75^o. Length of the arc = $\pi x^o r/180$ $= (\pi \times 75 \times 150)/180$ $= 196.35$ mm	[1] [1]	Award one mark for correct numerical result with or without the unit
3	(a)	(ii)	Area of the sector = $\pi x^o r^2/360$ $= (\pi \times 75 \times 150^2)/360$ $= 14726.22$ mm^2	[1] [1]	Award one mark for correct numerical result with or without the unit
3	(b)	(i)	Cosine rule: $a^2 = b^2 + c^2 - 2bc \cos A$ In this case angle A = 60^o, side b = 100 mm and side c = 180 mm. $a^2 = 100^2 + 180^2 - 2(100 \times 180) \cos 60^o$ $a^2 = 10000 + 32400 - 18000$ $a^2 = 24400$ $a = 156.21$ mm	[1] [1] [1] [1]	Award one mark for correct numerical result with or without the unit
3	(b)	(ii)	Area of the triangle = 0.5 bc sin A = $(0.5 \times 180 \times 100) \sin 60^o$ = 7794.23 mm^2	[1] [1]	Award one mark for correct numerical result with or without the unit
			Total	[10]	

Question			Expected Answer	Mark	Rationale/Additional Guidance
4	(a)		Tan 25^o = Height of pylon/75 Height of pylon = 75 tan 25^0 = 34.97 m	[1] [1]	Award one mark for correct numerical result with or without the unit
4	(b)	(i)	Magnitude = $\sqrt{(30^2 + 40^2)}$ = $\sqrt{2500}$ = 50 N tan θ = 30/40 θ = $\tan^{-1}$ (30/40) = 36.87^o Bearing = 36.87^o	[1] [1] [1] [1] [1] [1]	Award one mark for correct numerical result with or without the unit
4	(b)	(ii)	Magnitude = 50 N Bearing = 180^o +36.87^o = 216.87^o	[1] [1]	Award one mark for correct numerical result with or without the unit
			Total	[10]	

Question			Expected Answer	Mark	Rationale/Additional Guidance
5	(a)	(i)	$y = 6 \ln 4x \quad dy/dx = 6/x$	[2]	Award one mark for 6 and one mark for 1/x
5	(a)	(ii)	$y = 5/(e^{3t}) = y = 5 (e^{-3t})$ $dy/dx = -15 (e^{-3t}) = = -15/ (e^{3t})$	[1] [1]	
5	(b)	(i)	$s = 120 e^{-t/4} + 30t - 120$ When t = 3 then $s = 120 e^{-3/4} + (30 \times 3) - 120$ $s = 56.68 + 90 - 120$ $s = 26.68$ m	[1] [1]	Award one mark for correct numerical result with or without the unit
5	(b)	(ii)	$s = 120 e^{-t/4} + 30t - 120$ velocity = ds/dt then $ds/dt = -¼(120 e^{-t/4}) + 30$ $= 30(1 - e^{-t/4})$ When t = 4 then $dx/dt = 30(1- e^{-1})$ $v = 18.96$ ms^{-1}	[1] [1]	Award one mark for correct numerical result with or without the unit
5	(b)	(iii)	v = 15 then $15 = -30 e^{-t/4} + 30$ then $30e^{-t/4} = 15$ So $e^{-t/4} = 0.5$ $-t/4 = \ln 0.5$ t = 2.77 s	[1] [1]	Award one mark for correct numerical result with or without the unit
			Total	[10]	

Question			Expected Answer	Mark	Rationale/Additional Guidance
6	(a)		Given $dy/dx = 4x – 5$ Integrate Then $y = (4x^2)/2 – 5x + C$ $y = 2x^2 – 5x + C$ $2x^2$ $– 5x$	[1] [1]	Do not award any marks for C because this has been dealt with in question A11 OR award one mark for $2x^2 – 5x$ and one mark for a correct value of C
6	(b)		Given $y = x^3 – 5x$ Integrate between the limits Then area = $\int_0^2 x^3 – 5x\,dx = [(x^4/4) – (5x^2/2)]_0^2$ area = $[(2^4/4) – (5)(2^2/2)] – 0$ $= 4 – 10 – 0$ $= – 6$ square units	[1] [1] [1]	Accept the area as 6 square units
6	(c)		$\int 4 \sin 5x + \sqrt{x}\,dx$ $= \int 4 \sin 5x + x^{0.5}\,dx$ $= (– 4/5 \cos 5x) + (x^{1.5}/1.5) + C$ $= (– 4/5 \cos 5x) + ⅔ ({}^2\sqrt{x^3}) + C$	[1] [2] [2]	Do not award any marks for constant C. This has been tested in question A11
			Total	**[10]**	

<table>
<tr><th colspan="3">Question</th><th>Expected Answer</th><th>Mark</th><th>Rationale/Additional Guidance</th></tr>
<tr><td>7</td><td>(a)</td><td></td><td>
<table>
<tr><th>Time in minutes (t)</th><th>Frequency (f)</th><th>Class width</th><th>Frequency density</th></tr>
<tr><td>$0 \leq t < 5$</td><td>2</td><td>5</td><td>0.4</td></tr>
<tr><td>$5 \leq t < 15$</td><td>6</td><td>10</td><td>0.6</td></tr>
<tr><td>$15 \leq t < 30$</td><td>12</td><td>15</td><td>0.8</td></tr>
<tr><td>$30 \leq t < 40$</td><td>10</td><td>10</td><td>1.0</td></tr>
<tr><td>$40 \leq t < 50$</td><td>7</td><td>10</td><td>0.7</td></tr>
</table>
</td><td>[2]</td><td>Award one mark for the class width column and one mark for the frequency density column</td></tr>
</table>

Question			Expected Answer	Mark	Rationale/Additional Guidance
7	(b)			[6]	One mark for correctly labelled vertical axis and for correctly labelled horizontal axis Award five marks for a correctly drawn histogram
7	(c)		Negative skew	[1]	
	(d)		Estimated time mode is 34.5 minutes	[1]	Accept answers between 33 – 36 minutes
			Total	[10]	

Question			Expected Answer	Mark	Rationale/Additional Guidance
8	(a)		The expectation, E, of an event happening is defined as the product of the probability p of an event happening and the number of attempts made, n, i.e. E = pn.	[2]	
	(b)		Each event that can happen in an experiment is called an outcome known as the final result	[2]	
	(c)	(i)	Total number of students = 16 + 14 + 24 + 12 + 13 + 19 + 18 = 116	[1] [1]	
		(ii)	Students who study mathematics = 16 + 14 + 13 + 12 = 55	[1]	
		(iii)	Students who study electronics only = 24	[1]	
		(iv)	Students who study mathematics and electronics = 13 + 14 = 27	[1]	
		(v)	Students who study electronics and science = 19 + 13 = 32	[1]	
		(vi)	Students who study all three subjects = 13		
			Total	**[10]**	

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

Education and Learning
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

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