OCR
RECOGNISING ACHIEVEMENT

Level 3 Certificate

Mathematics for Engineering

OCR Level 3 Certificate

H860/01 Paper 1

Mark Scheme for June 2013

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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.

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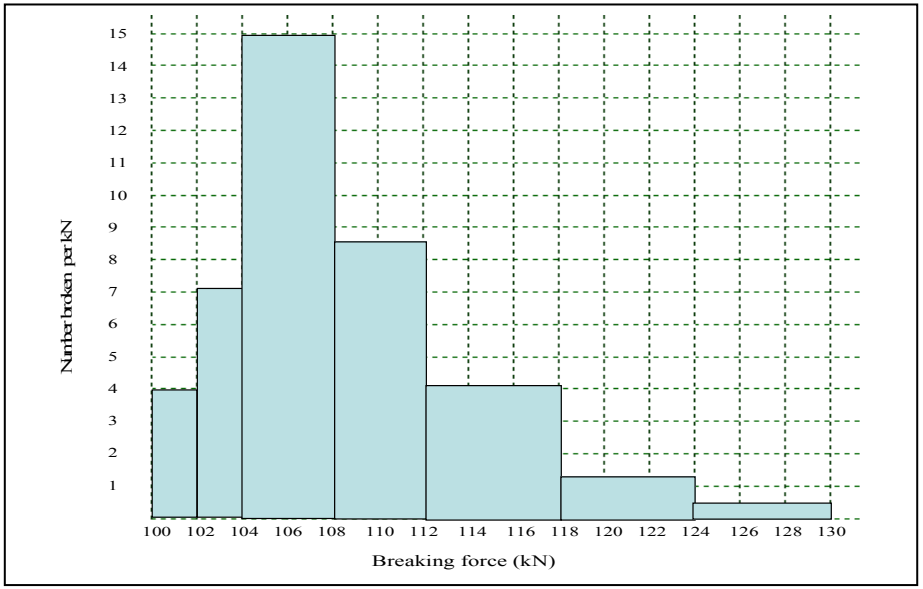
<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>Guidance</th></tr>
<tr><td>1</td><td>(a)</td><td></td><td>
<table>
<tr><th>Breaking force, F kN</th><th>Mid-class value X</th><th>f</th><th>d= X-100</th><th>fd</th><th>fd^2</th></tr>
<tr><td>$0 < F \leq 100$</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>$100 < F \leq 102$</td><td>101</td><td>8</td><td>1</td><td>8</td><td>8</td></tr>
<tr><td>$102 < F \leq 104$</td><td>103</td><td>14</td><td>3</td><td>42</td><td>126</td></tr>
<tr><td>$104 < F \leq 108$</td><td>106</td><td>60</td><td>6</td><td>360</td><td>2160</td></tr>
<tr><td>$108 < F \leq 112$</td><td>110</td><td>34</td><td>10</td><td>340</td><td>3400</td></tr>
<tr><td>$112 < F \leq 118$</td><td>115</td><td>24</td><td>15</td><td>360</td><td>5400</td></tr>
<tr><td>$118 < F \leq 124$</td><td>121</td><td>8</td><td>21</td><td>168</td><td>3528</td></tr>
<tr><td>$124 < F \leq 130$</td><td>127</td><td>2</td><td>27</td><td>54</td><td>1458</td></tr>
<tr><td>Sum</td><td></td><td>150</td><td></td><td>1332</td><td>16080</td></tr>
<tr><td></td><td></td><td></td><td></td><td>8.88</td><td>107.2</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td><td>3

[3]</td><td>Allow 1 mark for mid-class values
Allow 2 marks for frequencies
Allow ± 2 for all values of f

Marks for values other than X and f awarded in parts (c)(ii) and (c)(iii)</td></tr>
<tr><td>1</td><td>(b)</td><td></td><td> 
</td><td>4
[4]</td><td>1 mark for horizontal and vertical axes

1 mark for general shape

1 mark for correct widths

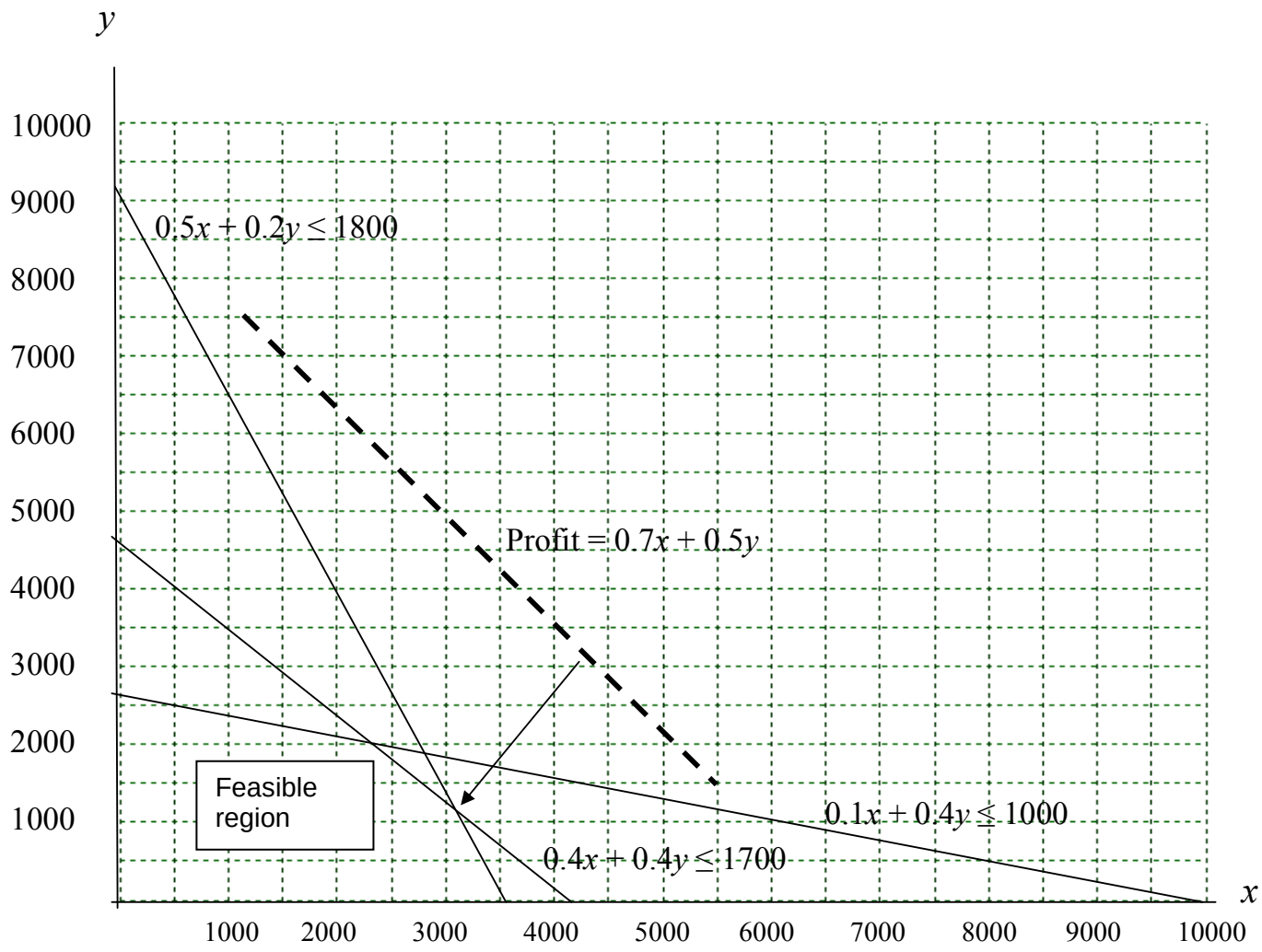
1 mark for correct heights</td></tr>
</table>

Question			Answer	Mark	Guidance
1	(c)	(i)	mean = 100 + 1332/150 = 108.88	2 [2]	1 for value 1332 (OE) from table 1 for answer with ECF Allow 1 mark for $\frac{\sum fd}{\sum f}$ OE seen
1	(c)	(ii)	std = $\sqrt{\frac{16080}{150} - 8.88^2} = 5.3241$	3 [3]	2 for values 16080 and 8.88 (OE) from table 1 for answer with ECF Allow 1 mark for $\sqrt{\frac{\sum fd^2}{\sum f} - \left(\frac{\sum fd}{\sum f}\right)^2}$ OE seen

Question			Answer	Mark	Guidance
2	(a)		Total resistance of circuit **ai** $\frac{1}{1.2}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{3}$		
			Total resistance of circuit **aii** $\frac{1}{2.5}=\frac{1}{R_1+R_2}+\frac{1}{3}$	1	
			From **ai** $\frac{1}{R_1}+\frac{1}{R_2}=\frac{1}{1.2}-\frac{1}{3}=\frac{1}{2}$	1	
			From **aii** $\frac{1}{R_1+R_2}=\frac{1}{2.5}-\frac{1}{3}=\frac{1}{15} \Rightarrow R_1+R_2=15$ and $R_1=15-R_2$	1	or $R_2=15-R_1$
			$\frac{1}{15-R_2}+\frac{1}{R_2}=\frac{1}{2}$		
			$\frac{R_2+(15-R_2)}{(15-R_2)R_2}=\frac{15}{(15R_2-R_2^2)}=\frac{1}{2}$		
			$R_2^2-15R_2+30=0$	1	
			$R_2=\frac{15\pm\sqrt{15^2-120}}{2}$		
			$R_2=12.6235\ \Omega$	1	
			$R_1=2.3765\ \Omega$	1	
				[6]	

Question			Answer	Mark	Guidance
2	(b)	(i)	$R_{AB} = \frac{2}{3}\Omega$	1	
			$R_{BC} = \frac{24}{14} = \frac{12}{7}\Omega$	1	
			Total resistance R, $\frac{2}{3} + \frac{12}{7} = \frac{14+36}{21} = \frac{50}{21}\Omega$		
			Total current $I = \frac{V}{R} = \frac{10}{50/21} = \frac{210}{50} = \frac{21}{5}$ A	1	Allow 1 mark for Ohm's law
				[3]	
2	(b)	(ii)	Voltage drop $V_{AB} = IR_{AB} = \frac{21}{5} \times \frac{2}{3} = \frac{14}{5}$ V	1	
			Voltage drop $V_{BC} = IR_{BC} = \frac{21}{5} \times \frac{12}{7} = \frac{36}{5}$ V	1	
				[2]	
2	(b)	(iii)	$I_1 = \frac{V_{AB}}{R_1} = \frac{14}{5} \times \frac{1}{1} = \frac{14}{5} = 2 \cdot 8\text{A}$	1	
			$I_2 = I - I_1 = \frac{21}{5} - \frac{14}{5} = \frac{7}{5} = 1 \cdot 4\text{A}$	1	
			$I_3 = \frac{36}{5} \times \frac{1}{2} = \frac{18}{5} = 3.6\text{A}$		
			$I_4 = I - I_3 = \frac{21}{5} - \frac{18}{5} = \frac{3}{5} = 0.6\text{A}$	1	
				[3]	

Question			Answer	Mark	Guidance
3	(a)		Profit = $x(1.4 - 0.5(0.5 + 0.4 + 0.1) - 0.2) +$ $y(1.2 - 0.5(0.2 + 0.4 + 0.4) - 0.2) +$ $z(1.3 - 0.5(0.7 + 0.3) - 0.2) =$ $0.7x + 0.5y + 0.6z$	1 1 **[2]**	
3	(b)		$0.5x + 0.2y + 0.7z \leq 2500$ $0.4x + 0.4y + 0.3z \leq 2000$ $0.1x + 0.4y \leq 1000$	1 1 1 **[3]**	
3	(c)	(i)	Maximise $0.7x + 0.5y + 600$ subject to: $0.5x + 0.2y \leq 1800$ $0.4x + 0.4y \leq 1700$ $0.1x + 0.4y \leq 1000$ $x, y \geq 0$	1 1 1 **[3]**	Allow omission of 600 Allow one error or one omission

Question			Answer	Mark	Guidance
3	(c)	(ii)		4 [4]	1 mark for each constraint 1 mark for feasible region identified. (mark for objective function included with part **iii**)

Question			Answer	Mark	Guidance
3	(c)	(iii)	x between 3100 and 3300 y between 1000 and 1200 $x = 3167$ $y = 1083$	2 **[2]**	Accept answers read directly from graph OR solving for: $0.4x + 0.4y = 1700$ $0.5x + 0.2y = 1800$
4	(a)		$\frac{dN}{dt} = -\lambda N$ $\frac{dN}{N} = -\lambda dt$ $\int \frac{1}{N} dN = -\int \lambda dt \quad : \quad \ln(N) = -\lambda t + C$ $N = Ae^{-\lambda t}$ $N = N_0$ when $t = 0 \Rightarrow A = N_0$ $N = N_0 e^{-\lambda t}$	1 1 1 **[3]**	
4	(b)		$e^{-\lambda t} = \frac{N}{N_0}$ $-\lambda t = \ln\left(\frac{N}{N_0}\right)$ $-\lambda t_{1/2} = \ln\left(\frac{1}{2}\right)$ $t_{1/2} = -\frac{1}{\lambda}\ln\left(\frac{1}{2}\right) = \frac{\ln(2)}{\lambda}$	1 1 **[2]**	

Question			Answer	Mark	Guidance
4	(c)		$t = -\frac{\ln\left(\frac{N}{N_0}\right)}{\lambda} = \frac{\ln\left(\frac{N_0}{N}\right)}{\lambda}$	1	
			$N = 35\%\ N_0$		
			$t = \frac{\ln\left(\frac{N_0}{0.35N_0}\right)}{\lambda} = \frac{\ln\left(\frac{1}{0.35}\right)}{\lambda}$	1	
			But $\frac{1}{\lambda} = \frac{t_{1/2}}{\ln(2)} = \frac{5730}{\ln(2)}$	1	
			$t = \frac{\ln\left(\frac{1}{0.35}\right) \times 5730}{\ln(2)} \approx 8700$ years	1	
				[4]	
5	(a)		$a = ge^{-\frac{t}{2}} \sin t$		
			$\frac{da}{dt} = ge^{-\frac{t}{2}}(\cos t - \frac{\sin t}{2})$	1	Allow 1 mark for $(uv)'=uv'+u'v$ OE seen
			For maximum a		
			$\cos t = \frac{\sin t}{2}$	1	
			$\tan t = 2$		
			$t = \tan^{-1} 2 = 1.1071$	1	
			$a \approx 5.04$	1	
				[4]	

Question			Answer	Mark	Guidance
5	(b)	(i)	$I = \int e^{-\frac{t}{2}} \sin t \, dt = -e^{-\frac{t}{2}} \cos t - \frac{1}{2}\int e^{-\frac{t}{2}} \cos t \, dt$	1	Allow 1 mark for $\int uv' = uv - \int vu'$ OE seen
			$\int e^{-\frac{t}{2}} \cos t \, dt = e^{-\frac{t}{2}} \sin t + \frac{1}{2}\int e^{-\frac{t}{2}} \sin t \, dt$	1	
			$I = -e^{-\frac{t}{2}} \cos t - \frac{1}{2}\left(e^{-\frac{t}{2}} \sin t + \frac{1}{2} I \right)$	1	
			$I\left(1 + \frac{1}{4}\right) = -e^{-\frac{t}{2}}(\cos t + \frac{\sin t}{2})$	1	
			$I = -\frac{4}{5} e^{-\frac{t}{2}} \left(\cos t + \frac{\sin t}{2} \right) + C$	1	
				[5]	
5	(b)	(ii)	$v = g(-\frac{4}{5} e^{-\frac{t}{2}} \left(\cos t + \frac{\sin t}{2} \right) + C)$		
			$v_0 = 0 \Rightarrow C = \frac{4}{5}$	1	Solution must solve for C
			$v_1 = 9.8(-\frac{4}{5} e^{-\frac{1}{2}} \left(\cos 1 + \frac{\sin 1}{2} \right) + \frac{4}{5}) = 3.2701 \ \text{m s}^{-1}$	1	
				[2]	

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