OCR
Oxford Cambridge and RSA

GCE

Mathematics (MEI)

Unit **4773**: Decision Mathematics Computation

Advanced GCE

Mark Scheme for June 2016

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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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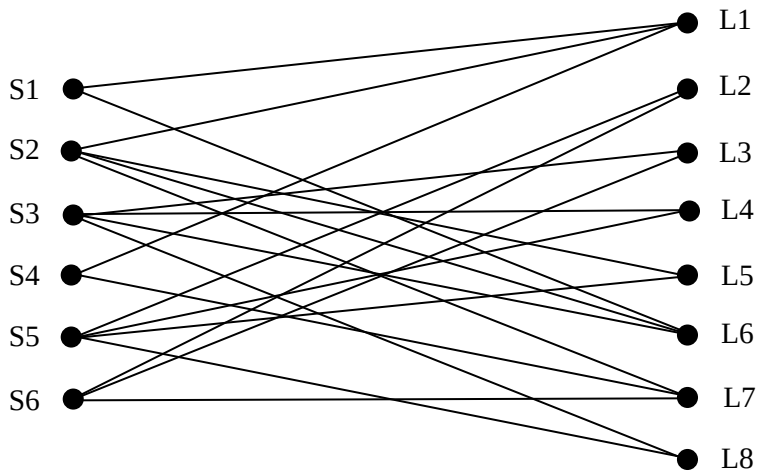
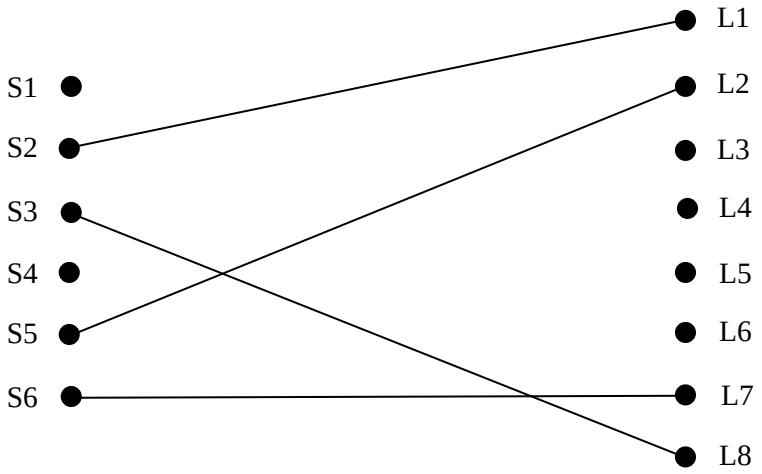
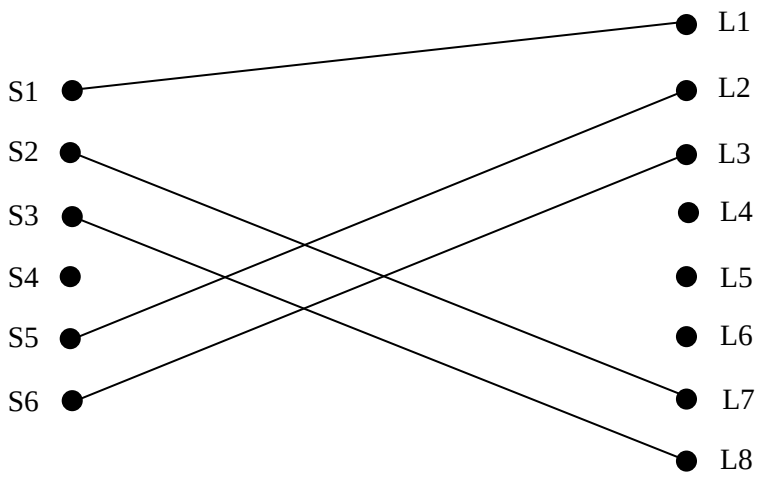
Question			Answer	Marks	Guidance
1	(i)		27 explained	B1	
			0.001	B1	
	(ii)		eg		

gen0	rand#	gen1	rand#s	gen2	rand#s	gen3		
1	0.605065	1	0.343122	1	0.520591	1		
						0		
						0		
				0	0.130456	0	M1	generation 1
						0		
						0	A1	
				0	0.468467	0		
						0		
						0	M1	generation 2
		1	0.202856	1	0.280774	1	A1	
						0		
						0		
				0	0.604996	0	M1	generation 3
						0	A1	
						0		
				0	0.621236	0		
						0		
						0		
		0	0.417294	0	0.183329	0		
						0		
						0		
				0	0.519123	0		
						0		
						0		
				0	0.472353	0		
						0		
						0		

Question			Answer	Marks	Guidance
	(iii)		Repetition and counting 0 or >0 in generation **2**	M1	
			Number of repetitions specified with some justification – e.g. "experimental"	A1	
			Computation of probability	M1	
			Exact answer is 0.2928. (ref ...Galton-Watson branching processes)	A1	between 0.2 and 0.4
	(iv)		Repetition and counting 0, 1, 2, 3 or >3 in generation **3**	M1	
			Number of repetitions specified with some justification – e.g. "experimental"	A1	
			Computation of probabilities	M1	
			From 100000 simulations ... 0.345, 0.129, 0.148, 0.123, 0.255	A1	between 0.7 and 0.8 for first 4 probs
				A1	1^{st} prob 2 to 3 times greater than 2^{nd}, 3^{rd} and 4^{th}
	(v)		Correct subtraction of their probs from (iii) and (iv)	B1	
			Exact answer is 0.34535 – 0.2928 = 0.05255		

Question			Answer	Marks	Guidance
2	(i)			B1	
2	(ii)			B1	

Question			Answer	Marks	Guidance
	(iii)		(S1, L1), (L1, S2), (S2, L7), (L7, S6), (S6, L3)  	M1A1 M1 A1	
	(iv)		(S1, L1), (S2, L5), (S3, L3), (S4, L7), (S5, L4), (S6, L2)	B1	

Question			Answer	Marks	Guidance
	(v)		Max x11+x16+x21+x25+x26+x27+x33+x34+x36+x38+x41+x47+x52+x54+x55 +x58+x62+x63+x67 st x11+x16<1 x21+x25+x26+x27<1 x33+x34+x36+x38<1 x41+x47<1 x52+x54+x55+x58<1 x62+x63+x67<1 x11+x21+x41<1 x52+x62<1 x33+x63<1 x34+x54<1 x25+x55<1 x16+x26+x36<1 x27+x47+x67<1 x38+x58<1 end	M1 M1 M1 A1	objective shrub constraints location constraints

Question	Answer	Marks	Guidance
(vi)	Variable Value Reduced Cost X11 0.000000 0.000000 X16 1.000000 0.000000 X21 0.000000 0.000000 X25 1.000000 0.000000 X26 0.000000 0.000000 X27 0.000000 0.000000 X33 0.000000 0.000000 X34 0.000000 0.000000 X36 0.000000 0.000000 X38 1.000000 0.000000 X41 0.000000 0.000000 X47 1.000000 0.000000 X52 0.000000 0.000000 X54 1.000000 0.000000 X55 0.000000 0.000000 X58 0.000000 0.000000 X62 0.000000 0.000000 X63 1.000000 0.000000 X67 0.000000 0.000000 X24 0.000000 0.000000 Shrub 1 2 3 4 5 6 Location 6 5 8 7 4 3	B1 B1	

Question	Answer	Marks	Guidance
(vii)	Min 10x11+10x16+10x21+20x25+10x26+5x27+10x33+20x34+10x36 +5x38+12x41+7x47+7x52+20x54+20x55+7x58+5x62+10x63+5x67 st x11+x16>1 x21+x25+x26+x27>1 x33+x34+x36+x38>1 x41+x47>1 x52+x54+x55+x58>1 x62+x63+x67>1 x11+x21+x41<1 x52+x62<1 x33+x63<1 x34+x54<1 x25+x55<1 x16+x26+x36<1 x27+x47+x67<1 x38+x58<1 end Solution has objective 49 eg Shrub 1 2 3 4 5 6 Location 6 1 3 7 8 2	B1 B1 B1 B1 B1	objective constraints running LP

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>3</td><td>(i)</td><td></td><td>
Min 22000d1+30000d2+28000d3+25000d4+22000d5+2500x11+3000x13+1600x14
+5200x15+4700x16+3750x17+3450x21+6700x22+3000x23+2250x24+5450x26
+2100x27+2400x33+1500x34+4300x35+3800x36+1750x37+2100x41+5700x42
+4800x43+2390x44+2560x47+5200x51+5600x52+3430x54+6300x56+3400x57
st x11+x21+x41+x51=1
x22+x42+x52=1
x13+x23+x33+x43=1
x14+x24+x34+x44+x54=1
x15+x35=1
x16+x26+x36+x56=1
x17+x27+x37+x47+x57=1
6d1-x11-x13-x14-x15-x16-x17>0
6d2-x21-x22-x23-x24-x26-x27>0
5d3-x33-x34-x35-x36-x37>0
5d4-x41-x42-x43-x44-x47>0
5d5-x51-x52-x54-x56-x57>0
end
int 6

Objective value = 70000

<table>
<tr><td></td><td>C1</td><td>C2</td><td>C3</td><td>C4</td><td>C5</td><td>C6</td><td>C7</td></tr>
<tr><td>D1</td><td>x</td><td></td><td>x</td><td>x</td><td>x</td><td>x</td><td></td></tr>
<tr><td>D5</td><td></td><td>x</td><td></td><td></td><td></td><td></td><td>x</td></tr>
</table>
</td><td>
B1

M1
A1

M1
A1

B1

B1

B1cao

M1
A1cao
</td><td>
objective

customer indicator
constraints

switching on depot
indicators

integer variables

running

objective value

depots
customers
</td></tr>
</table>

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td></td><td>(ii)</td><td></td><td>Indifferent at 22200.

Objective value = 70000 ... showing that the cost reduction is critical, since otherwise the objective would have been reduced

<table><tr><td></td><td>C1</td><td>C2</td><td>C3</td><td>C4</td><td>C5</td><td>C6</td><td>C7</td></tr><tr><td>D1</td><td>x</td><td></td><td></td><td>x</td><td>x</td><td>x</td><td></td></tr><tr><td>D2</td><td></td><td>x</td><td>x</td><td></td><td></td><td></td><td>x</td></tr></table></td><td>B1

B1

E1

B1</td><td>22200

ob value still 70000 or other valid justification

explanation

customers</td></tr>
<tr><td></td><td>(iii)</td><td></td><td>Indifferent at 4360/4361

Objective value = 71860 in both cases ... demonstrating the criticality

<table><tr><td></td><td>C1</td><td>C2</td><td>C3</td><td>C4</td><td>C5</td><td>C6</td><td>C7</td></tr><tr><td>D1</td><td></td><td></td><td>x</td><td>x</td><td>x</td><td>x</td><td></td></tr><tr><td>D4</td><td>x</td><td>x</td><td></td><td></td><td></td><td></td><td>x</td></tr></table></td><td>B1

B1

E1

B1</td><td>4361

4360

explanation

customers</td></tr>
</table>

Question			Answer	Marks	Guidance
4	(i)		$u_{n+2} = 0.99u_{n+1} + 1.01(u_{n+1} - u_n) = 2u_{n+1} - 1.01u_n$ $2\times2100 - 1.01\times2000 = 4200 - 2020 = 2180$	M1A1 B1	
	(ii)		$u_{n+2} - 2u_{n+1} + 1.01u_n = 0$ $\lambda^2 - 2\lambda + 1.01 = 0$ $(-2)^2 - 4\times1\times1.01 < 0$	B1 B1 B1	
	(iii)		oscillatory	B1	
	(iv)		2000 1904.666353 2100 1765.002907 2180 1606.292797 2239 1429.932658 2276.2 1237.509592 2291.01 1030.787198 2283.058 811.6897092 2252.1959 582.2843481 2198.50322 344.7620898 2122.288581 101.4169881 2024.08891 -145.3757345 Customer numbers increase up to u_5, then start to decrease. Negative values seen (so not realistic). Ignore any comments about fractional values.	M1 A1 A1 B1 B1	

Question			Answer	Marks	Guidance
4	(v)		2000 2171 2100 2149 2180 2128 2239 2107 2276 2086 2291 2065 2283 2044 2260 2024 2237 2004 2215 1984 2193 1964	B1 B1	correctly rounding removing the "negative gains"
	(vi)		With $\alpha = 0.99$ Ulrike would need β to exceed 1.26 ... which seems unreasonable. With $\alpha = 0.995$ β would need to exceed 1.15. With $\alpha = 0.999$ β needs to be around 1.01. With $\alpha=1$ β can slip below 1 and still be OK	B1 B1	considering some appropriate αs considering corresponding βs
	(vii)		$(0.99 + \beta)^2 - 4\beta = 0.9801 - 2.02\beta + \beta^2 = (\beta - 1.01)^2 - 0.04$ For this to be positive we need $\beta > 1.21$	M1 A1	

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