OCR
RECOGNISING ACHIEVEMENT

GCE

Mathematics

Advanced Subsidiary GCE

Unit **4736:** Decision Mathematics 1

Mark Scheme for January 2013

Oxford Cambridge and RSA Examinations

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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.

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Annotations and abbreviations

Annotation in scoris	Meaning
✓and ✗	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
SC	Special case
^	Omission sign
MR	Misread
Highlighting	

Other abbreviations in mark scheme	Meaning
M1 dep*	Method mark dependent on a previous mark, indicated by *
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working

Subject-specific Marking Instructions for GCE Mathematics (OCR) Decision strand

a. Annotations should be used whenever appropriate during your marking.

The A, M and B annotations must be used on your standardisation scripts for responses that are not awarded either 0 or full marks. It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

For subsequent marking you must make it clear how you have arrived at the mark you have awarded.

b. An element of professional judgement is required in the marking of any written paper. Remember that the mark scheme is designed to assist in marking incorrect solutions. Correct *solutions* leading to correct answers are awarded full marks but work must not be judged on the answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the working must always be looked at and anything unfamiliar must be investigated thoroughly.

Correct but unfamiliar or unexpected methods are often signalled by a correct result following an *apparently* incorrect method. Such work must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, award marks according to the spirit of the basic scheme; if you are in any doubt whatsoever (especially if several marks or candidates are involved) you should contact your Team Leader.

c. The following types of marks are available.

M
A suitable method has been selected and *applied* in a manner which shows that the method is essentially understood. Method marks are not usually 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, eg by substituting the relevant quantities into the formula. In some cases the nature of the errors allowed for the award of an M mark may be specified.

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). Therefore M0 A1 cannot ever be awarded.

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

d. When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. (The notation 'dep *' is used to indicate that a particular mark is dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate has once gone wrong in a part of a question, the work from there on is worthless so that no more marks can sensibly be given. On the other hand, when two or more steps are successfully run together by the candidate, the earlier marks are implied and full credit must be given.

e. The abbreviation ft implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A and B marks are given for correct work only – differences in notation are of course permitted. A (accuracy) marks are not given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a solution, there may be various alternatives that are equally acceptable. In such cases, exactly what is acceptable will be detailed in the mark scheme rationale. If this is not the case please consult your Team Leader.

Sometimes the answer to one part of a question is used in a later part of the same question. In this case, A marks will often be 'follow through'. In such cases you must ensure that you refer back to the answer of the previous part question even if this is not shown within the image zone. You may find it easier to mark follow through questions candidate-by-candidate rather than question-by-question.

f. Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise. Candidates are expected to give numerical answers to an appropriate degree of accuracy, with 3 significant figures often being the norm. Small variations in the degree of accuracy to which an answer is given (eg 2 or 4 significant figures where 3 is expected) should not normally be penalised, while answers which are grossly over- or under-specified should normally result in the loss of a mark. The situation regarding any particular cases where the accuracy of the answer may be a marking issue should be detailed in the mark scheme rationale. If in doubt, contact your Team Leader.

g. Rules for replaced work. NB Follow these maths-specific instructions rather than those in the assessor handbook.

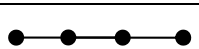
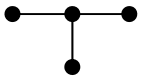
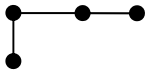
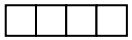
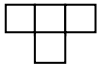
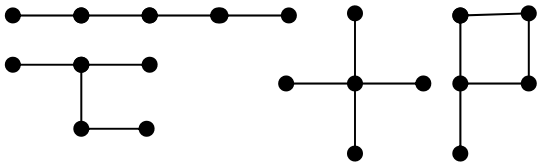
If a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests.

If there are two or more attempts at a question which have not been crossed out, examiners should mark what appears to be the last (complete) attempt and ignore the others.

h. For a *genuine* misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some units. This is achieved by withholding one A mark in the question.

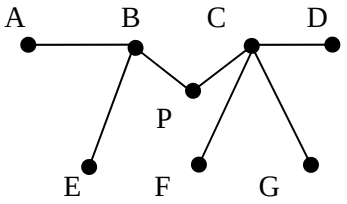
Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

Question			Answer	Marks	Guidance
1	(i)		C S 1st pass: 18 7 9 20 15 21 6 10 22 1 0 2nd pass: 18 9 7 20 15 21 6 10 22 2 1 3rd pass: 20 18 9 7 15 21 6 10 22 3 3 4th pass: 20 18 15 9 7 21 6 10 22 3 2 5th pass: 21 20 18 15 9 7 6 10 22 5 5 6th pass: 21 20 18 15 9 7 6 10 22 1 0 7th pass: 21 20 18 15 10 9 7 6 22 4 3 8th pass: 22 21 20 18 15 10 9 7 6 8 8	 M1 M1 A1 M1 A1 **[5]**	Condone values not involved in passes omitted (values after the gap) List correct at end of 2nd pass(even if labelled as 1st or 3rd) List correct at end of 4th pass (follow through earlier errors if possible) Sorting into increasing order or from RHS could earn this mark (only) All passes correct Condone omission of passes where no swaps occur Values given for number of swaps for each pass, S values are either C-1 or C (need not be correct, could be tallies) Correct numbers of comparisons and swaps written down (not tallies) for each pass (cao, not ft)
1	(ii)		Box 1: 22 7 Box 2: 21 9 Box 3: 20 10 Box 4: 18 6 Box 5: 15	 M1 A1 **[2]**	 Exactly five boxes used with 22, 21, 20, 18, 15 in separate boxes All correct and in correct order
1	(iii)		33 kg eg Box 1: 22+10 = 32 Box 2: 21+ 9 = 30 Box 3: 20+7+6 = 33 Box 4: 18+15 = 33	 M1 A1 **[2]**	33 (may be implied from packing, ignore 128÷4 = 32 if seen) A valid packing of the nine sacks using four boxes, with $W = 33$

Question			Answer	Marks	Guidance
2	(i)		(A)  (B)  (C) (D) 	M1 A1 **[2]**	Or topologically equivalent graphs Any two correct graphs All four correct
2	(ii)		(1)  (2)  (3) - Not possible, square corresponding to node of order 3 must be adjacent to each of the other three squares AND two of the others must be adjacent to each other. Cannot have three squares each adjacent to the other two. (4) (5) and (6) - Not possible, as in (3). Or contain graph from (3) as a subgraph, or contain K_3 (a triangle) as a subgraph, or equivalent.	M1 A1 B1 **[3]**	Or or or rotations or reflections Correct diagrams for any two of (1), (2), (4) (Allow "A" or "D" for (1), "B" for (2), "C" for (4)) (1), (2), (4) identified as possible and (3), (5), (6) as not possible Explaining what the problem is with any one of those that are not possible Need only give evidence of having understood the issue. Could say that there cannot be more than one square joined to three others (cannot have 2 vertices of order 3) for (5) or (6) Allow recognition that there cannot have a triangle of arcs Do not allow claims about the graphs being non-planar (which is not true)
2	(iii)		(a) Shape C (b) Shapes A and D	B1 B1 **[2]**	C, or this tetromino drawn Both A and D, or these two drawn, but not just the tree (1)
2	(iv)			M1 A1 A1 **[3]**	Any two correct graphs A third correct graph All four correct, and no extras. Allow graphs drawn over pentominoes (but not just pentominoes without graphs) [If score 0, then SC1 available for identifying orders correctly for at least three]

Question			Answer	Marks	Guidance
3	(i)		*A* 1 | 0 *C* 3 | 13 13 *E* 5 | 27 27 *G* 41 *B* 2 | 11 11 *D* 4 | 18 18 *F* 6 | 28 31 28 *H* 7 | 40 40 Route *A-C -F-H* Weight 40	M1 A1 M1 A1 B1 B1 **[6]**	Updating from 31 to 28 at *F* All temporary labels correct, with no extra values seen. All permanent labels correct. May be consistently interchanged with order of labelling boxes. Condone blank at *A*. ISW *G* if given permanent label All order of labelling values correct, condone blank at *A* and others reduced by 1. *G* may be blank or have labels 8 41 *ACFH* (cao) 40 (cao)
3	(ii)		Without *AD*, the only odd nodes are *A* and *G* Repeat shortest path from *A* to *G* Weight = 41 Weight of all arcs minus *AD* = 212 212 + 41 = 253	M1 A1 ft M1 A1 **[4]**	*A*, *G* 41, or follow through from part (i) 212 seen or implied from final weight (230 – 18) Calculation of 212 + (their) 41
3	(iii)		*A* and *G* are still the only odd nodes Without *AC* and *CD*, shortest paths are: *A* to *D* = 18 and *D* to *G* = 31 ⇒ 49 *A* to *F* = 31 and *F* to *G* = 16 ⇒ 47 Repeat *AFG* = 47 Weight of all arcs minus *AC* and *CD* = 205 205 + 47 = 252	 M1 A1 M1 A1 **[4]**	Shortest path from A to G previously used arc AC, so need to recalculate this. Considering a valid route from A to G, with weight correct, or implied from AFG (or AG) = 47 47 205 (230 – 13 – 12) or (their) 212 – 7 Calculation of (their) 205 + 47 with working shown

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>4</td><td>(i)</td><td></td><td>Pam – Bob – Alan – Gita – Caz –
– Fred – Ella – Dan – Pam</td><td>M1</td><td>P – B – A – G – C (allow 1, 3, 2, ... on table) [A – B – P – C – G ⇒ SC1]</td></tr>
<tr><td></td><td></td><td></td><td></td><td>A1</td><td>Correct nearest neighbour from P and going as far as D</td></tr>
<tr><td></td><td></td><td></td><td></td><td>B1</td><td>A closed cycle, written out in letters, that includes all seven employees and Pam (whether from a correct application of nearest neighbour or not)</td></tr>
<tr><td></td><td></td><td></td><td>4+6+9+7+10+13+16+18
=83</td><td>M1
A1
[5]</td><td>sca summing weights for their cycle, or their P to D (their 65)
83 (cao) (65 + 18 = 83)</td></tr>
<tr><td>4</td><td>(ii)</td><td></td><td>
<table>
<tr><th></th><th>P</th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th><th>G</th></tr>
<tr><td>P</td><td>–</td><td>10</td><td>4</td><td>8</td><td>18</td><td>12</td><td>12</td><td>9</td></tr>
<tr><td>A</td><td>10</td><td>-</td><td>6</td><td>10</td><td>18</td><td>12</td><td>11</td><td>9</td></tr>
<tr><td>B</td><td>4</td><td>6</td><td>-</td><td>9</td><td>17</td><td>10</td><td>11</td><td>10</td></tr>
<tr><td>C</td><td>8</td><td>10</td><td>9</td><td>-</td><td>15</td><td>13</td><td>10</td><td>7</td></tr>
<tr><td>D</td><td>18</td><td>18</td><td>17</td><td>15</td><td>-</td><td>16</td><td>19</td><td>20</td></tr>
<tr><td>E</td><td>12</td><td>12</td><td>10</td><td>13</td><td>16</td><td>-</td><td>13</td><td>14</td></tr>
<tr><td>F</td><td>12</td><td>11</td><td>11</td><td>10</td><td>19</td><td>13</td><td>-</td><td>18</td></tr>
<tr><td>G</td><td>9</td><td>9</td><td>10</td><td>7</td><td>20</td><td>14</td><td>18</td><td>-</td></tr>
</table>
PB = 4
BA = 6
PC = 8
CG = 7
BE = 10
CF = 10
CD = 15

Total weight = 60 (minutes)


</td><td>M1

A1

M1

A1

B1

B1
[6]</td><td>Entries PB and PC (only) identified in P column of table

All entries chosen correctly, and no extras

Written list begins with PB, BA, PC (order of letters for any arc may be reversed, eg BP, AB, CP, ...)

Correct list
(order of letters for any arc may be reversed, eg BP, AB, CP, ...)
Need not write down weights. BE and CF may be interchanged.

Correct tree (cao)

60, or 1 hour (cao)</td></tr>
</table>

Question			Answer	Marks	Guidance
4	(iii)		Two least weight arcs from G = 7+9 = 16 Weight of MST without G = 60 – 7 = 53 Lower bound = 53 + 16 = 69	B1 M1 A1 **[3]**	7 and 9 or 7+9 or 16 (must see some evidence of this) 53, follow through their tree if possible (may be implied from answer) 69 (cao)
4	(iv)		Team 1: Alan, Bob and Ella Team 2: Caz, Dan, Fred and Gita PC + CD + CG + CF = 40 PC + PB + BA + BE = 28 So it takes 40 minutes	B1 M1 A1 **[3]**	{A, B, E}, {C, D, F, G} in any order (cao) Evidence that candidate knows that P must contact C first (may be implied from answer 40) 40 (cao)

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>5</td><td>(i)</td><td></td><td>$P = x + y + z$</td><td>B1
[1]</td><td>$x + y + z$ or $kx + ky + kz$ for any $k > 0$</td></tr>
<tr><td>5</td><td>(ii)</td><td></td><td>Each box of miniature cupcakes uses $24\times3 = 72$ units of topping,
each box of small cupcakes uses $20\times5 = 100$ units
and each box of standard cupcakes uses $12\times7 = 84$ units.

So the total $72x + 100y + 84z$ units.

Hence, $72x + 100y + 84z \leq 5000$
$\Rightarrow 18x + 25y + 21z \leq 1250$ (as given)</td><td>M1

A1

[2]</td><td>Any one of 24×3 or 20×5 or 12×7 (or 72 or 100 or 84) seen

$72x + 100y + 84z \leq 5000$</td></tr>
<tr><td>5</td><td>(iii)</td><td></td><td>$24\times2 = 48$, $20\times3 = 60$, $12\times4 = 48$

$\Rightarrow 48x + 60y + 48z \leq 3000$

$\Rightarrow 4x + 5y + 4z \leq 250$</td><td>
M1

A1
[2]</td><td>
$48x + 60y + 48z \leq 3000$ (or any positive multiple of $4x + 5y + 4z \leq 250$)

$4x + 5y + 4z \leq 250$</td></tr>
<tr><td>5</td><td>(iv)</td><td></td><td><table><tr><td>P</td><td>x</td><td>y</td><td>z</td><td>s</td><td>t</td><td>RHS</td></tr><tr><td>1</td><td>-1</td><td>-1</td><td>-1</td><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>18</td><td>25</td><td>21</td><td>1</td><td>0</td><td>1250</td></tr><tr><td>0</td><td>4</td><td>5</td><td>4</td><td>0</td><td>1</td><td>250</td></tr></table></td><td>B1

M1

A1
[3]</td><td>A 3×7 table of numbers with three basis columns (P and slack variables)

Constraint rows correct for the x, y, z and RHS columns, follow through their constraints, or given and their (iii)

Objective row has -1 -1 -1 in columns for x, y and z (or equal negative numbers)</td></tr>
</table>

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>5</td><td>(v)</td><td></td><td>1250÷18 = 69.4, 250÷4 = 62.5
250÷4 is the least positive ratio
new R3 = R3 ÷ 4
new R1 = R1 + new pivot row
new R2 = R2 – 18×new pivot row
<table><tr><td>P</td><td>x</td><td>y</td><td>z</td><td>s</td><td>t</td><td>RHS</td></tr><tr><td>1</td><td>0</td><td>0.25</td><td>0</td><td>0</td><td>0.25</td><td>62.5</td></tr><tr><td>0</td><td>0</td><td>2.5</td><td>3</td><td>1</td><td>-4.5</td><td>125</td></tr><tr><td>0</td><td>1</td><td>1.25</td><td>1</td><td>0</td><td>0.25</td><td>62.5</td></tr></table></td><td>B1

B1

B1

M1

A1

[5]</td><td>Follow through their tableau if possible, except for final A mark (*)
250÷4 or 62.5 seen and chosen (showing their least positive ratio with x as pivot column). May find working in (iv)
Correct calculation shown for pivot row (provided pivot value is positive)
May find working in (iv)
Correct calculations for other rows (accept reasonable abbreviated forms)
(Their) pivot row correct
A correct tableau (cao) rows and columns may be interchanged, condone omission of P column
(*) Watch out for correct but scaled second constraint leading to t column scaled. If correct, this gets all the marks</td></tr>
<tr><td>5</td><td>(vi)</td><td></td><td>x = 62.5 y = 0, z = 0

No decimals, so optimal profit is £62

72×62=4464 ⇒ 536 units of topping

48×62 = 2976 ⇒ 24 decorations left over</td><td>
M1

A1

M1

A1
[4]</td><td>May be answered in (v)
Reading off their values for all three variables, from first iteration
£62 (cao), condone 62
72×their 62 or 48×their 62 (or equivalent)
Both 536 and 24 (cao)</td></tr>
<tr><td>5</td><td>(vii)</td><td></td><td>4P + y ≤ 250
No decorations left over so no slack in this constraint ⇒ 4P + y = 250
250÷4 = 62.5, so maximum P = 62
and y = 2 boxes of small cupcakes

No topping left over, 18P+7y+3z = 1250
⇒ z = 40
x+y+z = 62 ⇒ x = 20</td><td>B1
M1

A1

M1

A1
[5]</td><td>4P + y ≤ 250 in any form
Using (their) 4P + y = 250
P = 62 and deducing that y = 2 (cao)
Using their P and y in 18P+7y+3z = 1250 to give an integer value for z
x = 20 and z = 40 (cao)</td></tr>
</table>

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