Mark Scheme (Results)

Summer 2013

GCE Decision Maths D1 (6689/01R)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.

- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.

- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.

- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.

- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.

- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.

- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
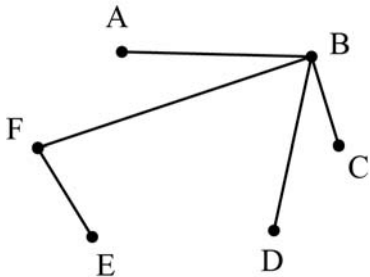
EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

   - **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
   - **A** marks: accuracy marks can only be awarded if the relevant method (M) marks have been earned.
   - **B** marks are unconditional accuracy marks (independent of M marks)
   - Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes:

   - bod – benefit of doubt
   - ft – follow through
   - the symbol $\sqrt{}$ will be used for correct ft
   - cao – correct answer only
   - cso - correct solution only. There must be no errors in this part of the question to obtain this mark
   - isw – ignore subsequent working
   - awrt – answers which round to
   - SC: special case
   - oe – or equivalent (and appropriate)
   - dep – dependent
   - indep – independent
   - dp decimal places
   - sf significant figures
   - ✳ The answer is printed on the paper
   - ⌐ The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
   - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

8. In some instances, the mark distributions (e.g. M1, B1 and A1) printed on the candidate's response may differ from the final mark scheme.

Question Number	Scheme	Marks
1. (a)	$C - 5 = F - 2 = D - 6$ change status to give $C = 5 - F = 2 - D = 6$ Improved matching is (A unmatched) $B = 4$, $C = 5$, $D = 6$, $E = 1$, $F = 2$	M1 A1 A1 (3)
(b)	E.g. activities 3 and 4 can only be done by B E.g. both A and E can only do activity 1	B1 (1)
(c)	$A - 1 = E - 6 = D - 2 = F - 4 = B - 3$ Change status to give $A = 1 - E = 6 - D = 2 - F = 4 - B = 3$ Complete matching is $A = 1$, $B = 3$, $C = 5$, $D = 2$, $E = 6$, $F = 4$	M1 A1 A1 (3)
		(7 marks)

Notes for Question 1

a1M1: An alternating path (e.g. letter – number – letter – ...) from C to 6 or vice versa

a1A1: CAO – a correct path including change status **either** stated (only accept 'change (of) status' **or** 'c.s.') **or** shown (**all** symbols e.g. (...–... = ...) **interchanged** (... = ... – ...)). Chosen path clear.

a2A1: CAO must follow from the correct stated path. Accept on a **clear** diagram (with five arcs **only**).

b1B1: A good, clear, complete, correct answer (all relevant nodes must be referred to and must be correct)

c1M1: An alternating path from A to 3 or vice versa.

c1A1: CAO including change status (stated or shown), chosen path clear.

c2A1: CAO must follow from **two correct** stated paths (so **both** previous M marks must have been awarded). Accept on a **clear** diagram (with six arcs only).

Question Number	Scheme	Marks
2. (a)	AB(85), BC(100), BD(135); BF(150), EF(140).	M1 A1; A1 **(3)**
(b)		B1 **(1)**
(c)	610 (minutes)	B1 **(1)**
(d)	E.g. (any three) • Kruskal starts with the shortest arc, Prim starts with any node. • It is necessary to check for cycles when using Kruskal, not with Prim. • When using Prim the 'growing' tree is always connected. • When using Kruskal arcs are considered in ascending order of weight. • Prim can be used when the network is given in matrix form. • Prim adds nodes to the growing tree, Kruskal adds arcs. Other correct statements also get credit	B1 B1 B1 **(3)**
		(8 marks)

Notes for Question 2

a1M1: Prim's – first three arcs correctly chosen **or** first four nodes correctly chosen, in order.{A, B, C, D,….}. Any rejections seen during selection is **M0**. Order of nodes may be seen across the top of the matrix {1, 2, 3, 4, –, –}

a1A1: First four arcs correctly chosen **or** all six nodes correctly chosen {A, B, C, D, F, E}. Order of nodes may be seen across the top of the matrix {1, 2, 3, 4, 6, 5}

a2A1: CSO (must be considering arcs for this final mark).

Misread: Starting at a node other than A scores **M1 only – must** have the first three arcs (or four nodes or numbers) correct.

Starting at	Minimum arcs required for M1	Nodes	order
A	AB BC BD	ABCD(FE)	1234(65)
B	AB BC BD	BACD(FE)	2134(65)
C	BC AB BD	CBAD(FE)	3214(65)
D	BD AB BC	DBAC(FE)	3241(65)
E	EF BF AB	EFBA(CD)	43(56)12
F	EF BF AB	FEBA(CD)	43(56)21

b1B1: CAO (weights on arcs not required)

c1B1: CAO (condone lack of/incorrect units)

d1B1: One correct statement.

d2B1: A second correct statement.

d3B1: A third correct statement.

In part (d) all technical language must be correct (so do not condone point for vertex/node etc.)

Question Number	Scheme	Marks
3. (a)		M1 A1
		M1 A1 (4)
(b)	Total float on H = 20 − 9 − 5 = 6	M1 A1 (2)
(c)	93/37 = 2.5135 so 3 (workers)	M1 A1 (2)
(d)		M1 A1
		M1 A1 (4)
		(12 marks)

The activity network (a):

Activity	Duration		Activity	Duration
A	(8)		H	(5)
B	(7)		I	(9)
C	(9)		J	(11)
D	(9)		K	(5)
E	(5)		L	(4)
F	(8)		M	(6)
G	(7)			

Event times (early / late):

- Start: 0 / 0
- After A: 8 / 12
- After B/C: 9 / 9 ; 9 / 9
- After E/F: 17 / 17
- After D: 26 / 26
- J node: 31 / 31
- After H/G (J start): 16 / 20
- Finish: 37 / 37

Gantt chart (d):

```
         0  2  4  6  8  10 12 14 16 18 20 22 24 26 28 30 32 34 36
Worker 1 |    C     |    F     |     I      |   K   |    M    |
Worker 2 |   A   | E  |  H  |       J        |   L   |
Worker 3 |  B  |  G  |   D   |
```

Notes for Question 3

a1M1: **All** top boxes complete, values generally increasing left to right, condone one rogue.

a1A1: CAO.

a2M1: Bottom boxes complete, values generally decreasing right to left, condone one rogue. Condone missing 0 or 37 for the M mark only.

a2A1: CAO

b1M1: Correct calculation seen. All three numbers correct (ft).

b1A1: Float correct (no follow through on this mark)

c1M1: Attempt to find lower bound. [82 – 104 / their finish time] accept awrt 2.5

c1A1: CAO – correct calculation seen or awrt 2.5, then 3. (Beware 37/13 gives 3 also, so 3 with no working gets M0A0.)

d1M1: Not a cascade chart. 4 workers used at most. At least 8 new (10 in total) activities placed.

d1A1: The critical activities (F I K M) and B correct. F – 8; I – 9; K – 5; M – 6; B – 7. B completed by 9 (its late finish time).

Now check the last 6 activities – the last two marks are for D, E, G, H, J and L only

First check that there are only three workers and that all 11 new (13 in total) activities are present (just once).

Then check precedences (see table below) – each row of the table could give rise to 1 error only in precedences

Finally check the length of each activity (see number in brackets in the activity column in the table below)

Activity	I.P.A	Activity	I.P.A
A (8)	-	H (5)	C
B (7)	-	I (9)	E F
C (9)	-	J (11)	G H
D (9)	A	K (5)	D I
E (5)	A	L (4)	D I
F (8)	B C	M (6)	E F J K
G (7)	B C		

d2M1: 3 workers. All 11 new (13 in total) activities present (just once). Condone one error either precedence, or activity length, on activities D, E, G, H, J and L.

d2A1: 3 workers. All 11 new (13 in total) activities present (just once). No errors on activities D, E, G, H, J and L.

Question Number	Scheme	Marks
4.(a)	E.g. a quick sort S J H A C K̲ P D T L pivot K J H A̲ C D K̲ S P T̲ L pivots A T A̲ J H C̲ D K̲ S P̲ L T̲ pivots C P A̲ C̲ J H̲ D K̲ L P̲ S T̲ pivot H (L) (S) A̲ C̲ D H̲ J K̲ L P̲ S T̲ sort completed + named correctly	M1 A1 A1 A1 **(4)**
(b)	Pivot 1 = $\left[\frac{1+10}{2}\right]$ = 6 Komal, L is after K so reject 1 - 6 Pivot 2 = $\left[\frac{7+10}{2}\right]$ = 9 Sam, L is before S so reject 9 - 10 Pivot 3 = $\left[\frac{7+8}{2}\right]$ = 8 Polly, L is before P so reject 8 Pivot 4 = 7 Lydia – name found	M1 A1 A1 A1 cso **(4)**
		(8 marks)

Notes for Question 4

a1M1: Quick sort – pivots, p, selected and first pass gives <p, p, >p.

a1A1: First two passes correct, pivots chosen consistently for third pass.

a2A1: CAO sort completed correctly

a3A1: 'Stop' + correct name for their sort – phonetically close

b1M1: Using their 'sorted list' + choosing middle right pivots+ discarding/retaining half the list. If their list   contains one error (one error is either a missing letter, an extra letter or one letter incorrectly placed) then M1 only in part (b).

b1A1: First pass correct i.e. 6th item from a correct list and retaining L – T (no sticky pivots)

b2A1: Second and third passes correct i.e. 9th (S) and 8th (P) items from a correct list (no sticky pivots).

b3A1: CSO search complete + 'found'

Notes for Question 4 Continued

Additional solutions

Quick sort middle left

| | | | | | | | | | | | |
|S|J|H|A|C̲|K|P|D|T|L|Pivot C|M1|

A̲ C̲ S J H K̲ P D T L   Pivots (A) and K
A̲ C̲ J H̲ D K̲ S P̲ T L   Pivots H and P   A1
A̲ C̲ D̲ H̲ J̲ K̲ L̲ P̲ S̲ T   Pivots (D, J, L) and S
A̲ C̲ D̲ H̲ J̲ K̲ L̲ P̲ S̲ T   A1
        Quick sort complete   A1

Bubble sort left to right

S J H A C K P D T L
J H A C K P D S L T   T in place, consistent direction   M1
H A C J K D P L S T   Passes 1 and 2 correct   A1
A C H J D K L P S T
A C H D J K L P S T
A C D H J K L P S T   Sort correct   A1
        Bubble Sort complete   Sort named correctly + 'stop'   A1

Bubble sort right to left:

S J H A C K P D T L
A S J H C D K P L T   A in place, consistent direction   M1
A C S J H D K L P T   Passes 1 and 2 correct   A1
A C D S J H K L P T
A C D H S J K L P T
A C D H J S K L P T
A C D H J K S L P T
A C D H J K L S P T
A C D H J K L P S T   Sort correct   A1
        Bubble Sort complete   Sort named correctly + 'stop'   A1

Sorting into reverse alphabetical order is acceptable for full marks

Question Number	Scheme	Marks
5. (a)	AF + GH = 15 + 31 = 46* AG + FH = 32 + 15 = 47 AH + FG = 30 + 17 = 47 so repeat arcs AB, BF and GH	M1 A3,2,1.0 A1 **(5)**
(b)	E.g. ABCDBFDEHGFHGAFBA (17 nodes) length = 181 + 46 = 227	B1 B1 ft **(2)**
(c)	One path will have to be repeated. The shortest is 15 So repeat AF, use G and H as the start and finish. **or** repeat FH, use A and G as the start and finish.	M1 A1A1 **(3)**
		(10 marks)

Notes for Question 5

a1M1: Three distinct pairings **of their** four odd nodes

a1A1: Any one row correct including pairing **and** total

a2A1: Any two rows correct including pairing **and** total

a3A1: All three rows correct including pairing **and** total

a4A1: CAO correct **arcs** identified AB, BF and GH. Accept ABF or AF via B (check to see if via B appears in working) but **do not** accept AF for this mark

b1B1: Any correct route (checks: 17 nodes, the route starts and ends at A, pairings AB, BF and GH appear twice in the route and every letter from A to H (inclusive) appears at least once).

b2B1ft: correct answer of 227 **or** 181 + their least out of a choice of at least **two** totals given in part (a)

c1M1: Identifies need to repeat one pairing (maybe implicit) and 15 (or either AF or FH) specifically identified as the **least**

c1A1: Repeat (either AF **or** FH) identified clearly

c2A1: G and either A **or** H identified as start and finish.

Question Number	Scheme	Marks
6. (a)		M1 A1 (One start A – E) A1 (F – J + dummy 1) A1 (K + dummy 2) A1 (all arrows + finish) **(5)**
(b)	1st dummy – G depends on D only, F depends on C and D. 2nd dummy – I and J must be expressed uniquely in terms of their end events.	B1 B1 **(2)**
		(7 marks)

Notes for Question 6

a1M1: 7 activities and one dummy placed. Must be considering activity on arc (activity on node is M0).
a1A1: One start + A, B, C, D and E dealt with correctly.
a2A1: F, G, H, I and J and 1st dummy dealt with correctly.
a3A1: K and 2nd dummy dealt with correctly.
a4A1: CSO - all arrows present and correctly placed with one finish.
b1B1: First dummy correctly described (C, D, F and G referred to)
b2B1: Second dummy correctly described (mention of 'uniqueness' alone is not sufficient for this mark).

Question Number	Scheme	Marks
7. (a)	E.g. We would be able to find the shortest distance from J to every other vertex. E.g. We would only need to apply Dijkstra's algorithm once.	B1 **(1)**
(b)

Shortest route is C_2EFGIJ
length 48 (miles) | M1

A1 (G, H, I J)
A1(D, E, F)
A1ft (C_1, C_2)

A1
A1ft **(6)**
(7 marks) |

Notes for Question 7

a1B1: CAO

b1M1: A larger value replaced by a smaller value at least once in the working values at either G, E, D, C_1 or C_2.

b1A1: All values in G, H, I and J correct. The working values at G must be in the correct order. Condone lack of 0 in the working value at J.

b2A1: All values in D, E and F correct and the working values in the correct order. Penalise order of labelling only once per question. (F, E and D labelled in that order with G, H, I and J labelled before F).

b3A1ft: All values in C_1 and C_2 ft correct and the working values in the correct order. Penalise order of labelling only once per question. (C_2 labelled after all other nodes (D to J) – condone lack of final value or order of labelling for C_1)

b4A1: Route CAO

b5A1ft: Their final value ft (if answer is not 48 ft their final value at either C_1 or C_2 dependent on their route)

If the candidate uses either C_1 or C_2 as the starting vertex then this is **not** a misread. They can score a maximum of M1A0A0A0A1A1ft. If starting at:

C_1 – M1 for a larger value replaced by a smaller value at either C_2, F, G, H, I or J , then A0 A0 A0 then A1 for the route (C_1DFGIJ) and then A1 for 49 (or ft their final value at J).

C_2 – M1 for a larger value replaced by a smaller value at either C_1, F, G, H, I or J, then A0 A0 A0 then A1 for the route (C_2 EFGIJ) and then A1 for 48 (or ft their final value at J).

If the candidate uses both C_1 and C_2 as the starting vertices then award M1 for a larger value replaced by a smaller value at either F, G, H, I or J, then A0 A0 A0 then A1 for the correct route only (C_2 EFGIJ) and A1 for 48 (no ft).

Question Number	Scheme	Marks
8. (a)	$y \leq 16$; and $y \leq 2x$	B1; M1 A1 **(3)**
(b)	$4x + 3y \leq 120$	M1 A1 **(2)**
(c)	$x \leq \frac{3}{4}(x + y)$ so $4x \leq 3x + 3y$ so $x \leq 3y$	M1 A1 **(2)**
(d)	The correct two lines (4x + 3y = 120, x = 3y) R labelled correctly	B1 B1 B1 **(3)**
(e)	(P =) $45x + 30y$	B1 **(1)**
(f)	At (0,0) P = 0 At (8, 16) P = 840 At (18, 16) P = 1 290 At (24, 8) P = 1 320	M1 A1 (any 2) A1 (any 3) A1 (all 4)
(g)	So optimal point is (24, 8) giving (£)1 320	B1 **(5)**
		(16 marks)

Notes for Question 8

a1B1: CAO for $y \leq 16$

a1M1: Coefficients correct, accept =, <, >, ≤,≥ here

a1A1: CAO

b1M1: Coefficients correct and 120 accept =, <, >, ≤,≥ here

b1A1: CAO

c1M1: Accept non-integer coefficients here, accept =, <, >, ≤,≥ here, coefficients correct.

c1A1: CAO must be integer coefficients.

d1B1: 4x + 3y = 120 correctly drawn. The line must pass within one small square of the point (18, 16) and if line extended must go from axis to axis through the points of intersection with the axes within one small square. The line must be long enough to form the feasible region. Check using measurement tool if required. Ignore shading.

d2B1: x = 3y correctly drawn. The line must pass within one small square of the origin and the point (24, 8). The line must be long enough to form the feasible region. Ignore shading.

d3B1: R labelled (not just implied by shading) – **must** have scored the first two marks in this part.

e1B1: CAO (isw if (P =) 45x + 30y is simplified to k(45x + 30y) but if 45x + 30y not stated then B0)

f1M1: At least two of **their**, **or** the correct R vertices found (either by reading off their graph or using simultaneous equations) **and** tested using their **P.** Objective line method (only) is M0.

f1A1: Two vertices found and tested correctly CAO (must be using two of the **correct** vertices and the values for P must be correct).

f2A1: Three vertices found and tested correctly CAO (must be using three of the **correct** vertices and the values for P must be correct).

f3A1: All four vertices found and tested correctly CAO (**all** values of P must be correct).

g1B1: CAO for profit (condone lack of £)

Ofqual

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