

Mark Scheme (Pre-standardisation)

January 2016

Pearson Edexcel International A Level
in Decision Mathematics 1 (WDM01)
Paper 01

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications are awarded by Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk. Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus.

Pearson: helping people progress, everywhere

Pearson aspires to be the world's leading learning company. Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk

January 2016

Publications Code IA043151

All the material in this publication is copyright

© Pearson Education Ltd 2016

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.

PEARSON EDEXCEL IAL 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.

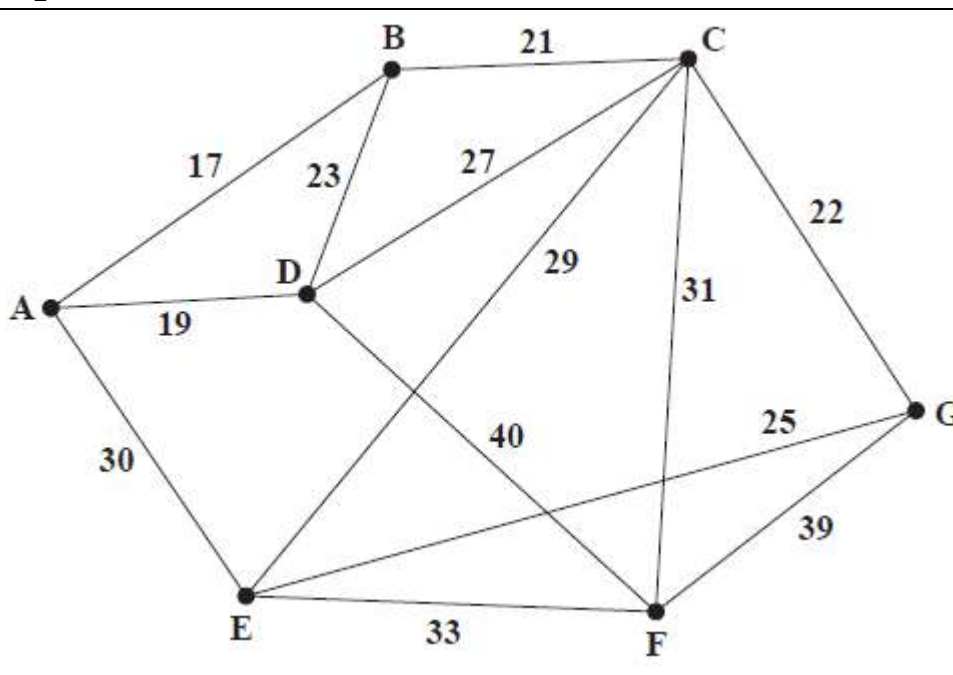
3. Abbreviations

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

- bod – benefit of doubt
 - ft – follow through
 - the symbol \surd 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)
 - d... or dep – dependent
 - indep – independent
 - dp decimal places
 - sf significant figures
 - * The answer is printed on the paper or ag- answer given
 - \square or d... 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.

| Question Number | Scheme | Marks |
|-----------------|---|------------------------|
| 1. | | |
| (a) | Alternating path $D - 1 = C - 6$ Change status $D = 1 - C = 6$ Improved matching $A=4, (B \text{ unmatched}), C = 6, D = 1, E = 3, F = 2$ | M1 A1 (2) |
| (b) | e.g. Tasks 4 and 5 can only be done by A e.g. B can only do 2, E can only do 3, and F can only do 2 or 3. So there are three workers to match to just two tasks. | B1 (1) |
| (c) | E to 4 should be chosen e.g. E to 4 would release A to 5 e.g. if A is retrained then tasks 4 and 5 can still only be done by A | M1 A1 (2) |
| (d) | Alternating path $B - 2 = F - 3 = E - 4 = A - 5$ Change status $B = 2 - F = 3 - E = 4 - A = 5$ Complete matching $A = 5, B = 2, C = 6, D = 1, E = 4, F = 3$ | M1 A1 A1 (3) |
| | | 8 marks |
| | Notes: | |
| a1M1 | An alternating path from D to 6 (or vice versa) including change status (either stated or shown) | |
| a1A1 | Cao – correct improved matching (from correct stated path). Accept on a clear diagram (with five arcs only). | |
| b1B1 | Cao | |
| c1M1 | E to 4 selected with a reason given. One of A, 4 or 5 must be mentioned. | |
| c1A1 | A correct reason given – must explicitly explain why E to 4 allows a complete matching to occur. | |
| d1M1 | An alternating path from B to 5 (or vice versa) | |
| d1A1 | Cao – a correct path including change status either stated or shown. Chosen path clear. | |
| d2A1 | Cao – must follow from the correct stated path. Accept on a clear diagram (with six arcs only). | |
| | | |

| Question Number | Scheme | Marks |
|-----------------|--|--------------------|
| 2. | | |
| (a) | e.g. accept (i) Every pair of vertices connected by a path (ii) Connected graph with no cycles (iii) All nodes connected | B1 B1 B1 (3) |
| (b) | $n - 1$ | B1 (1) |
| (c) |  | M1 A1 (2) |
| (d) | Kruskal: AB, AD, BC, CG, reject BD, EG, reject CD, reject CE, reject AE, CF | M1 A1 A1 (3) |
| (e) | 135 (km) | B1 (1) |
| | | 10 marks |
| | Notes: | |
| a1B1 | Must see 'all pairs' and 'path' but not describing complete graph | |
| a2B1 | Cao | |
| a3B1 | Cao (accept definition of minimum spanning tree) | |
| b1B1 | Cao | |
| c1M1 | Either all arcs correct (ignore weights) or all but two arcs correct (including correct weight) | |
| c1A1 | Cao | |
| d1M1 | Kruskal's – first three arcs correctly chosen and at least one rejection seen at some point | |
| d1A1 | All six arcs selected correctly AB, AD, BC, CG, EG, CF | |
| d2A1 | Cso – all selections and rejections correct (in correct order and at the correct time) | |
| e1B1 | Cao (ignore lack of units) | |
| | | |

| Question Number | Scheme | Marks |
|-----------------|---|-------------------------------|
| 3. | | |
| (a) | Bin 1: $\underline{12.1}$ $\underline{9.3}$ $\underline{10.9}$ Bin 2: $\underline{15.7}$ $\underline{6.4}$ $\underline{7.9}$ Bin 3: $\underline{17.4}$ 8.1 Bin 4: $\underline{20.1}$ Bin 5: 14.0 | M1 A1 A1 (3) |
| (b)(i) | 12.1 15.7 10.9 17.4 9.3 20.1 7.9 8.1 14.0 6.4 15.7 12.1 17.4 10.9 20.1 9.3 8.1 14.0 7.9 6.4 | M1 A1 |
| (ii) | Comparisons = 9 + 8 = 17 Swaps = 7 + 5 = 12 | B1 B1 (4) |
| (c) | 12.1 9.3 15.7 10.9 17.4 $\underline{6.4}$ 20.1 7.9 8.1 14.0 Pivot 6.4 12.1 9.3 15.7 10.9 $\underline{17.4}$ 20.1 7.9 8.1 14.0 $\underline{6.4}$ Pivot 17.4 20.1 $\underline{17.4}$ 12.1 9.3 15.7 $\underline{10.9}$ 7.9 8.1 14.0 $\underline{6.4}$ Pivot (20.1) 10.9 20.1 $\underline{17.4}$ 12.1 $\underline{15.7}$ 14.0 $\underline{10.9}$ 9.3 $\underline{7.9}$ 8.1 $\underline{6.4}$ Pivots 15.7 7.9 20.1 $\underline{17.4}$ $\underline{15.7}$ 12.1 $\underline{14.0}$ $\underline{10.9}$ 9.3 $\underline{8.1}$ $\underline{7.9}$ $\underline{6.4}$ Pivots 14.0 8.1 20.1 $\underline{17.4}$ $\underline{15.7}$ $\underline{14.0}$ 12.1 $\underline{10.9}$ 9.3 $\underline{8.1}$ $\underline{7.9}$ $\underline{6.4}$ Sort complete | M1 A1 A1ft A1 (4) |
| (d) | Bin 1: $\underline{20.1}$ $\underline{12.1}$ Bin 2: $\underline{17.4}$ 14.0 Bin 3: $\underline{15.7}$ $\underline{10.9}$ 6.4 Bin 4: $\underline{9.3}$ $\underline{8.1}$ 7.9 | M1 A1 A1 (3) |
| (e) | e.g. $\frac{121.9}{33} \approx 3.694$ so yes 4 bins is optimal | B1 (1) |
| | | 15 marks |
| | Notes: | |
| a1M1 | First four items placed correctly | |
| a1A1 | First eight items placed correctly | |
| a2A1 | Cso | |
| b1M1 | Bubble sort – 6.4 at the end of the list after the first pass | |
| b1A1 | Cao | |
| b1B1 | Cao on total number of comparisons (allow 9 and 8 seen and referred to correctly) | |
| b2B1 | Cao on total number of swaps (allow 7 and 5 seen and referred to correctly) | |
| c1M1 | Quick sort – pivots, p, selected and first pass given >p, p, <p. If only choosing one pivot per iteration then M1. | |
| c1A1 | First pass correct, next pivot chosen correctly for second pass. | |
| c2A1ft | Second and third passes correct (follow through from their first pass and choice of pivots) – and next pivot(s) chosen consistently for fourth pass. | |
| c3A1 | Cso including choice of pivots for the fifth pass and ‘sort complete’ | |
| d1M1 | First four items placed correctly | |
| d1A1 | First eight items placed correctly | |
| d2A1 | Cso | |
| e1B1 | Cao | |

| Question Number | Scheme | Marks |
|-----------------|--|--|
| 4. | | |
| (a) | <p>Quickestest route: A – G – H – K Shortest time: 32 (mins)</p> | <p>M1 A1 (JEFD) A1 (BG) A1ft (HK)</p> <p>A1 A1ft (6)</p> |
| (b) | Route from B to K via A: B – D – E – A – G – H – K Length: 51 (mins) | B1 B1ft (2) |
| (c) | $A(ED)B + F(G)H = 19 + 15 = 34$ $AF + B(K)H = 16 + 18 = 34$ $A(G)H + B(DE)F = 29 + 11 = 40$ Arcs AF, BK, KH or AE, ED, DB, FG, GH will be traversed twice Route length = $196 + 34 = 230$ (mins) | <p>M1 A1 A1 A1 A1A1 A1ft (7)</p> |
| | | 15 marks |
| Notes: | | |
| a1M1: | A larger value replaced by a smaller value at least once at B or H or K. | |
| a1A1: | All values in J, F, E and D correct. | |
| a2A1: | All values in B and G correct. | |
| a3A1ft: | All values in H and K correct on the follow through. | |
| a4A1: | Cao (shortest path) | |
| a5A1ft: | Shortest length correct on the follow through | |
| b1B1: | Cao (route) | |
| b2B1ft: | Their final value at B + their final value at K | |
| c1M1: | Three distinct pairings of their four odd nodes | |
| c1A1: | Any one row correct including pairing and total | |
| c2A1: | Any two rows correct including pairing and total | |
| c3A1: | All three rows correct including pairing and total | |
| c4A1: | Cao – one combination of arcs that need traversing twice | |
| c5A1: | Cao – both combination of arcs that need traversing twice | |
| c6A1ft: | $196 +$ their smallest repeat out of a choice of at least two totals seen | |

| Question Number | Scheme | Marks |
|-----------------|--|---|
| 5. | | |
| (a), (b) | | <p>B1</p> <p>B1</p> <p>B1</p> <p>B1 (R) (4)</p> <p>B1</p> <p>B1 (2)</p> |
| (c) | $V\left(\frac{775}{76}, -\frac{91}{76}\right)$ $P = \frac{1801}{38}$ | <p>M1 A1</p> <p>A1 (3)</p> |
| (d) | $x = 3, y = -4$ minimum value is 3 | <p>B1 B1 (2)</p> |
| | | 11 marks |
| Notes: | | |
| a1B1: | Any two lines correctly drawn | |
| a2B1: | Any three lines correctly drawn | |
| a3B1: | All four lines correctly drawn | |

| Question Number | Scheme | Marks |
|-----------------|--|-------|
| a4B1: | Region, R, correctly labelled – not just implied by shading – dependent on scoring the first three marks in this part. | |
| b1B1: | Correct objective line | |
| b2B1: | V labelled clearly on their graph. This mark is dependent on the correct five line segments that define the boundary of the feasible region. | |
| c1M1: | Simultaneous equations being used to find their V. Must get to $x = \dots$ and $y = \dots$ | |
| c1A1: | Correct coordinates of V stated exactly | |
| c2A1: | Correct value for P | |
| d1B1: | Cao – for x and y | |
| d2B1: | Cao (value of $5x + 3y$) | |
| | | |

| Question Number | Scheme | Marks |
|-----------------|--|-----------------------------|
| 6. | | |
| (a) (i) | The dummy from event 5 to event 6 is needed to show that J depends on F but I depends on D, E and F | B1 |
| (ii) | The dummy from event 7 to event 9 is because activities G and H must be able to be described uniquely in terms of the events at each end | B1 (2) |
| (b) | | M1 A1 M1 A1 (4) |
| (c) | 21 (hours) | B1 (1) |
| (d) | $\frac{64}{21} \approx 3.048$ so at least 4 workers required | M1 A1 (2) |
| (e) | | M1 A1 M1 A1 (4) |
| (f) | <p>e.g.</p> | M1 A1 A1 (3) |
| 16 marks | | |

| Question Number | Scheme | Marks |
|-----------------|--|-------|
| | Notes: | |
| a1B1 | Cao – all relevant activities must be referred to - so activities I, J, F and either D or E must be mentioned. | |
| a2B1 | Cao – mention of describing activities uniquely in terms of the events at each end. | |
| b1M1 | All top boxes complete, values generally increasing from left to right, condone one 'rogue' | |
| b1A1 | Cao on top boxes | |
| b2M1 | All bottom boxes complete, values generally decreasing right to left, condone one 'rogue' | |
| b2A1 | Cao on bottom boxes | |
| c1B1 | Cao | |
| d1M1 | Attempt to find lower bound: $[55 - 73 / \text{their finish time}]$ or $[\text{sum of the activities} / \text{their finish time}]$ | |
| d1A1 | Cao – correct calculation seen then 4. | |
| e1M1 | At least 8 activities added including 5 floats. Scheduling diagram scores M0. | |
| e1A1 | Critical activities dealt with correctly and four other non-critical activities dealt with correctly. | |
| e2M1 | All 11 activities including all 8 floats | |
| e2A1 | Cao | |
| f1M1 | Not a cascade chart. 3 workers used and at least 9 activities placed. | |
| f1A1 | 3 workers, All 11 activities present (just once). Condone one error either precedence or activity length. | |
| f2A1 | 3 workers. All 11 activities present (just once). No errors. | |

Pearson Education Limited. Registered company number 872828
with its registered office at 80 Strand, London WC2R 0RL