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Mark Scheme (Results)

Summer 2014

Pearson Edexcel GCE in Decision Mathematics 1 (6689/01)

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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.

PEARSON 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.

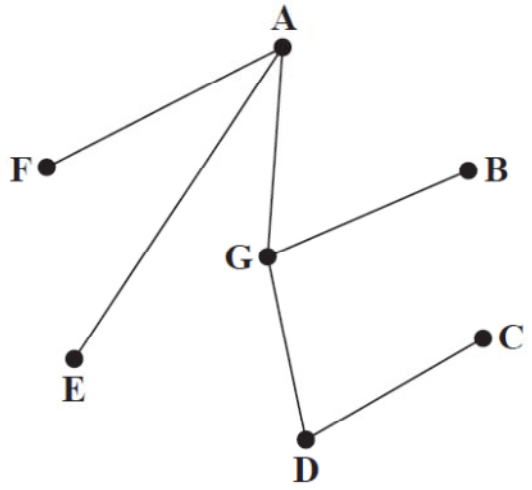
   - bod – benefit of doubt
   - ft – follow through
   - the symbol $\surd$ will be used for correct ft
   - cao – correct answer only
   - cso - correct solution only. There must be no errors in this part of the question to obtain this mark
   - isw – ignore subsequent working
   - awrt – answers which 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
   - $\sqsubset$ 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)	AG, DG, AF; AE BG; CD	M1 A1 A1 **(3)**
(b)		B1 **(1)**
(c)	Weight of tree = 298 (s)	B1 **(1)** **5 marks**

Notes for Question 1

a1M1: First three arcs correctly chosen in order (AG, DG, AF, … or weights 42, 41, 48, …) **or** first four nodes correctly chosen in order. {A.G,D,F,…} **If any rejections seen at any point then M1 (max) only.** Order of nodes may be seen at the top of the matrix {1, -, -, 3, -, 4, 2} so please check the top of the matrix carefully.

a1A1: First five arcs correctly chosen in order (AG, DG, AF, AE, BG or weights 42, 41, 48, 50, 58,…) **or** all seven nodes correctly chosen in order. {A,G,D,F,E,B,C}. Order of nodes may be seen at the top of the matrix so for the first two marks accept {1, 6, 7, 3, 5, 4, 2} (**do not** condone any missing numbers e.g. the number 7 must be above C).

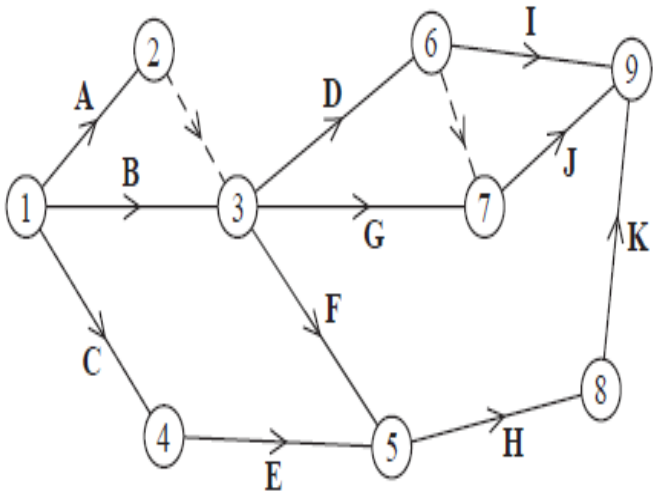
a2A1: CSO - all **arcs** correct **stated** and chosen in the correct order. They must be considering arcs for this final mark (do not accept a list of the weights of each arc, nodes or numbers across the top of the matrix unless the correct list of arcs (in the correct order) is also seen).

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

Starting at	Minimum arcs required for M1	Nodes	Order
A	AG DG AF	AGDF(EBC)	1(6)(7)3(5)42
B	BG DG AG	BGDA(FEC)	41(7)3(6)(5)2
C	CD DG AG	CDGA(FEB)	4(7)12(6)(5)3
D	DG AG AF	DGAF(EBC)	3(6)(7)1(5)42
E	EA AG DG	EAGD(FBC)	2(6)(7)41(5)3
F	FA AG DG	FAGD(EBC)	2(6)(7)4(5)13
G	GD AG AF	GDAF(EBC)	3(6)(7)2(5)41

b1B1: CAO (condone lack of weights on arcs).

c1B1: CAO (condone lack of units).

Question Number	Scheme	Marks
2. (a)		M1 (7 activities + 1 dummy) A1 (start + ABCE) A1 (DFGHK + 1st dummy) A1 (IJ + 2nd dummy) A1cso **(5)**
(b)	1st dummy – (A and B both) must be able to be described uniquely in terms of the events at each end. 2nd dummy – I depends on D only but J depends on D and G.	B1 B1 **(2)** **7 marks**

Notes for Question 2

In (a) condone lack of, or incorrect, numbered events throughout – also 'dealt with correctly' means that the activity starts from the correct event (but not necessarily finishes at the correct event) e.g. 'H dealt with correctly' requires the correct precedence for this activity i.e. F and E labelled correctly and leading into the same event and H starting from that event (but not necessarily H leading into K). **Activity on node is M0**.

Ignore incorrect or lack of arrows for the first four marks in (a) only
a1M1: 7 activities (labelled on arc) and one dummy placed.
a1A1: One start + activities A, B, C and E dealt with correctly.
a2A1: Activities D, F, G, H and K and our 1st dummy dealt with correctly.
a3A1: Activities I and J and our 2nd dummy dealt with correctly.
a4A1: CSO (all four previous marks must have been awarded) - **all** arrows present and correctly placed with one finish.
Note that another valid solution would be the dummy going from event 3 to event 2 and D, G and F coming out of event 2. Or the candidate could start with a dummy from event 1 to ensure the uniqueness of activities A and B.

b1B1: CAO – with no incorrect terminology (e.g. event for activity) - please note that e.g. 'so that activities can be defined uniquely' is **not** sufficient to earn this mark. There must be a mention of describing activities uniquely **in terms of the events at each end**. However give bod on statements that imply that an activity begins and ends at the same event e.g. 'so that activites do not have the same start and finish' is sufficient for B1.
b2B1: CAO – all relevant activities (do not allow the word 'event' for 'activities') must be referred to – so activities D, G, I **and** J must all be mentioned for this mark.

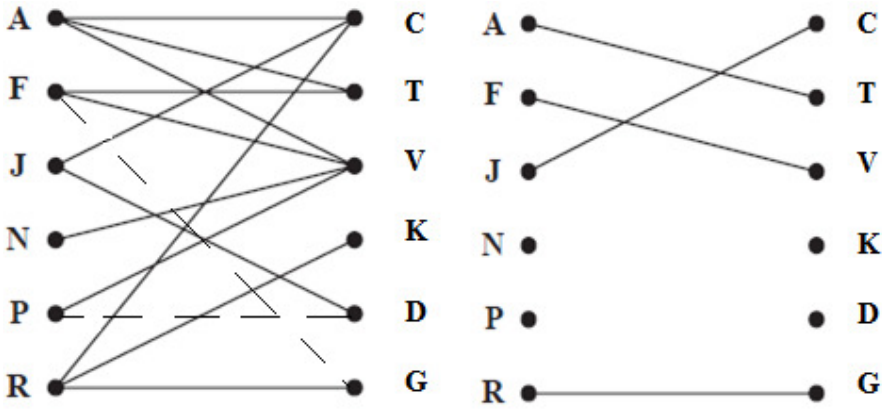
Question Number	Scheme	Marks
3. (a)	D(A)E + F(J)K = 35 + 15 = 50* D(HJ)F + E(FJ)K = 24 + 40 = 64 D(HJ)K + EF = 33 + 25 = 58 Arcs DA, AE, FJ, JK will be traversed twice Route length = 451 + 50 = 501 (km)	M1 A1 (2 correct) A1 (3 correct) A1 A1ft **(5)**
(b)	Vertex J would appear 3 times in the shortest inspection route	B1 **(1)**
(c)	We only have to repeat one pair of odd vertices which does not include vertex K (DE = 35, DF = 24, EF = 25) DF is the smallest of the three so repeat DF (DH, HJ, JF) and therefore the other hut should be built at E Route e.g. EADEHDHJFBEFCGFJHLGKJLMK The length of the route is 475 (km)	DM1 A1 A1 A1ft **(4)** **10 marks**

Notes for Question 3

a1M1: Three distinct pairings of the **correct** four odd nodes.
a1A1: **Any** two rows correct including pairings **and** totals.
a2A1: **All** three rows correct including pairings **and** totals.
a3A1: CAO correct **arcs** clearly (**not** just in their working) stated: DA, AE, FJ, JK. Accept DAE, FJK **or** DE via A, FK via J. Do not accept DE, FK.
a4A1ft: The correct answer of 501 **or** 451 + their smallest repeat out of a choice of at least **two** totals seen.

b1B1: CAO (3)

c1DM1: Identifies the need to repeat one path of the three (DE, DF, EF) which does not include K (maybe implicit) or listing of possible repeats – this mark is dependent on scoring the M mark in (a). **Stating any path (DE, DF, EF) that does not include K is sufficient for this mark.**
c1A1: Identifies DF **as the least of those paths not including K and E** as the position of the other hut. They have to explicitly state that DF is the **least** path that does **not include K or** they can list all three paths (DE, DF, EF) and then say DF is the smallest as this implicitly implies that they are considering only paths that do not include K.
c2A1: Any correct route - checks: starts at E and finishes at K (or vice-versa), 24 vertices (D, G, K, L appear twice and E, F, H, J appear three times and every other letter appears once).
c3A1ft: Correct answer of 475 **or** 451+ their DF (i.e. the least path that does not include K – so their smallest of DE, DF or EF – must be **their** smallest value (usually from (a)) not what they state/think is their smallest value).

Question Number	Scheme	Marks
4. (a) (b)		B1 B1 **(2)**
(c)	Alternating path either N – V = F – T = A – C = J – D or P – V = F – T = A – C = J – D Change status N = V – F = T – A = C – J = D or P = V – F = T – A = C – J = D Improved matching A = C, F = T, J = D, N = V, (P unmatched), R = G or A = C, F = T, J = D, (N unmatched), P = V, R = G	M1 A1 A1 **(3)**
(d)	e.g. both K and G can only be allocated to R e.g. N and P can only be allocated to V	B1 **(1)**
(e)	Alternating path P – D = J – C = A – T = F – G = R – K or N – V = P – D = J – C = A – T = F – G = R – K Change status P = D – J = C – A = T – F = G – R = K or N = V – P = D – J = C – A = T – F = G – R = K Complete matching A = T, F = G, J = C, N = V, P = D, R = K	M1 A1 A1 **(3)**
		9 marks

Notes for Question 4

a1B1: CAO – condone the addition of an arc from F to G and/or one from P to D only.

b1B1: CAO – these four arcs and no additional ones.

c1M1: An alternating path (e.g. letter 1st set – letter 2nd set – letter 1st set - …) from **either** N **or** P **to** D – or vice versa.
c1A1: 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.

e.g.

- N * V = F * T = A * C = J * D
  N = V * F = T * A = C * J = D — Scores M1A1 (change status shown)

- change status N – V = F – T = A – C = J – D — Scores M1A1 (change status stated)

- c.s. N – V = F – T = A – C = J – D — Scores M1A1 (change status stated)

- N – V = F – T = A – C = J – D
  c.s. N = V – F = T – A = C – J = D — Scores M1A1 (change status stated and shown)

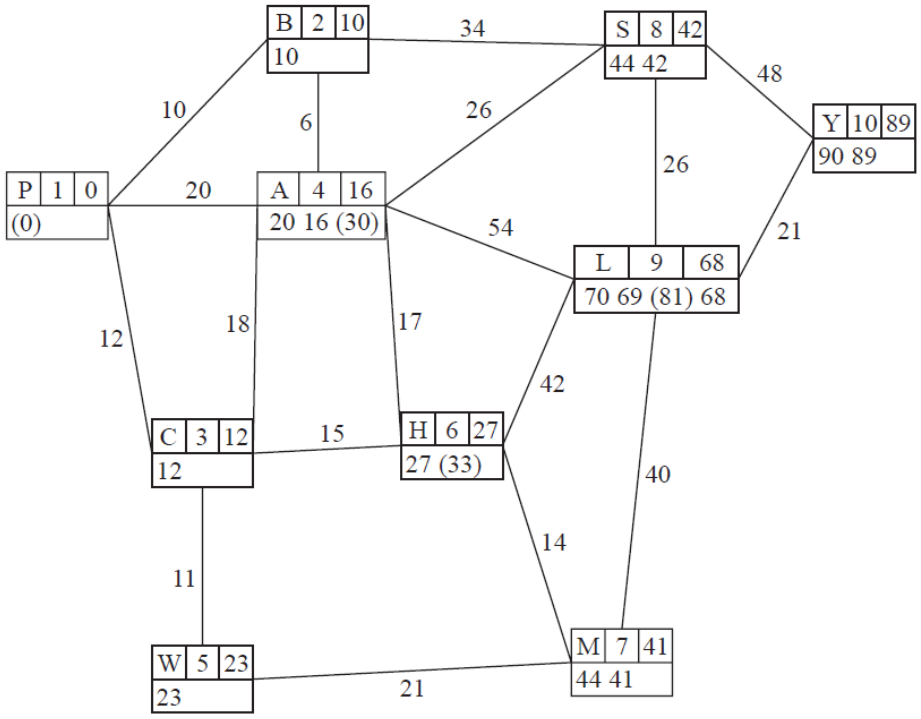
- N – V = F – T = A – C = J – D
  N = V, F = T, A = C, J = D, … — Scores M1A0 (no change status stated or shown)

c2A1: CAO must follow from the correct stated path. Accept on a **clear** diagram (with five arcs **only**). Condone lack of P or N being stated as unmatched.

d1B1: CAO – **one** completely correct statement – do not accept a general statement (specific nodes must be referred to). Note that these need to be checked carefully e.g. V can only be allocated to N and P **or** only N and P can be allocated to V are both B0. For B1 it would need to be e.g.'N and P can only be allocated to V'.

e1M1: A second alternating path from either N (if P used in (c)) or P (if N used in (c)) to K (or vice-versa)
e1A1: CAO including change status (stated **or** shown), chosen path clear.
e2A1: 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).

Please remember to check the diagrams on the top of the second page – many candidates will draw their improved matching and/or their complete matching there.

Question Number	Scheme	Marks
5. (a)		M1 A1 (PBCAW) A1 (HMS) A1ft (LY)
	Shortest route: P – B – A – S – L – Y Length: 89 (miles)	B1 B1ft **(6)**
(b)	Shortest route: P – C – H – M – L – Y Difference in routes: (41 + 40 + 21) – 89 = 13 (miles)	B1 M1 A1 **(3)** **9 marks**

Notes for Question 5

In (a) it is important that all values at each node are checked very carefully – the order of the working values must be correct for the corresponding A mark to be awarded e.g. at L the working values must be 70 69 68 – in that order (70 68 69 is incorrect).
The values in brackets in the working values at P, A, H and L can be ignored but if a candidate does have additional values at these nodes then they must be these ones only. Penalise any other/incorrect working values with the corresponding A mark. It is also important that the order of labelling is checked carefully – some candidates start with a label of 0 at P (rather than 1) – this is fine. Also the order of labelling must be a strictly increasing sequence – so 1, 2, 3, 3, 4, … will be penalised once (see notes below) but 1, 2, 3, 5, 6, … is fine.

a1M1: A larger value replaced by smaller value at least once in the working values at either A or M or L or S or Y.
a1A1: All values in P, B, C, A and W correct. The working values at A must be in the correct order. Condone lack of 0 in P's working value. Ignore additional working value of 30 at the end of A (may read 20 16 30 – rather than 20 16 - at A).
a2A1: All values in H, M and S correct and the working values in the correct order. Penalise order of labelling only once per question (H, M and S labelled in that order and H must be labelled after P, B, C, A and W). Ignore additional working value of 33 at the end of H (may read 27 33).
a3A1ft: All values in L and Y correct on the follow through and the working values in the correct order. Penalise order of labelling only once per question (L and Y labelled in that order and L labelled after all other nodes (excluding Y)). Ignore additional working value of 81 at L - may read 70 69 81 68 – rather than 70 69 68 – which is fine – however, 70 69 68 81 is incorrect and loses this mark.

To follow through L check that all the working values at L follow from the candidate's final values from nodes A, H, M and S (in whatever order the candidate has labelled these four nodes) and that the final value, and order of labelling, follows through correctly. Repeat for Y (which will have working values from S and L).

a1B1: CAO for the route (or starting at Y to P).
a2B1ft: Follow through on their final value at Y – if their answer is not 89 follow through their final value at Y (condone lack of units).

b1B1: CAO for the route (or starting at Y to P).
b1M1: Their final value at M + 40 + 21 - accept a value of 102 (with no other working) for this mark.
b1A1: CAO (condone lack of units) – accept, as a minimum,102 followed by 13 for both marks. If 13 with no working then award the previous M mark but withhold the final A mark.

Question Number	Scheme	Marks
6. (a)	Bin 1: 24 14 8 Bin 2: x 19 6 Bin 3: 25 17 Bin 4: 9	M1 A1 A1 **(3)**
(b)	e.g. using middle right 24 14 8 x 19 25 6 17 9 pivot 19 24 x 25 19 14 8 6 17 9 pivots x 6 24 25 x 19 14 8 17 9 6 pivots 25 17 25 24 x 19 17 14 8 9 6 pivots (24) 8 25 24 x 19 17 14 9 8 6 pivot 9 25 24 x 19 17 14 9 8 6 (sort complete)	M1 (quick sort) A1 (1st pass/pivots for 2nd) A1ft (2nd /3rd pass/pivot for 4th) A1cso **(4)**
(c)	(i) Bin 1: 25 24 Bin 2: x 19 9 Bin 3: 17 14 8 6 (ii) Bin 1: 25 24 Bin 2: x 19 8 Bin 3: 17 14 9 6	M1 A1 A1 A1 **(4)**
(d)	$x + 19 + 9 = 50 \Rightarrow x = 22$ $x + 19 + 8 = 50 \Rightarrow x = 23$	B2,1,0 **(2)** **13 marks**

Notes for Question 6

a1M1: First four items placed correctly (so by this we mean the values must be in the correct order so for bin 1: 24 8 14 is M0) and at least six values put in bins (so bin 1 correct, the x in bin 2 and two other values placed). If a candidate gives x a value in the given interval then allow this for the M mark in (a) only.
a1A1: First seven items placed correctly (so bins 1 and 2 correct and 25 in bin 3).
a2A1: CSO – all correct.

b1M1: Quick sort, pivot, p, chosen (must be choosing middle left or right – **choosing first/last item as pivot is M0**) and first pass gives >p, p, <p. So after the first pass the list should read (values greater than the pivot), pivot, (values less than the pivot). **If only choosing one pivot per iteration M1 only**.
b1A1: First pass correct, next two pivots chosen correctly for second pass. If a candidate gives x a value in the given interval then allow this for the M mark and first A mark only in (b).
b2A1ft: Second and third passes correct (follow through from their first pass and choice of pivots) – **and** next pivot(s) chosen correctly for the fourth pass.
b3A1: CSO (correct solution only – all previous marks in this part **must** have been awarded) including choice of pivots for the fifth pass and 'sort complete' – this could be shown **either** by a 'stop' statement **or** final list being re-written **or** using each item as a pivot.

c1M1: **Must be using list** in decreasing order (independent of (b)). First four items placed correctly and at least six values put in bins (so bin 1 correct and the x and 19 in bin 2). If a candidate has given x a value in (c) then M0.
c1A1: First six values correct (bin 1 correct, the x and 19 in bin 2, the 17 and 14 in bin 3).
c2A1: One allocation correct.
c3A1: Both allocations correct – both allocations must be clear.

d1B1: A correct value of x stated (working not necessary) – dependent on one correct allocation in (c).
d2B1: Both values correctly calculated (with relevant working) – dependent on both correct allocations seen in (c). **If more than two values for x stated (e.g. all possible integer values) then no marks in (d).**

SC for (c): if the 'sorted' list they use in (c) has one 'error' from (b) (e.g. a missing number, an extra number or one number incorrectly placed) then M1A1 can be awarded in (c) (for their first four items (M1) and their first six items (A1) correctly placed). However no marks in (d). If there is more than one 'error' then M0. Allow full marks in (c) if a correct list is used in (c) even if the list is incorrect at the end of (b).

Part (b) **Using middle left as pivot**

24	14	8	x	19	25	6	17	9	pivot 19	
24	x	25	19	14	8	6	17	9	pivots x 6	M1 A1
24	25	x	19	14	8	17	9	6	pivots 24 8	
25	24	x	19	14	17	9	8	6	pivots (25) 17	A1ft
25	24	x	19	17	14	9	8	6	pivot 14	
25	24	x	19	17	14	9	8	6	(sort complete)	A1cso

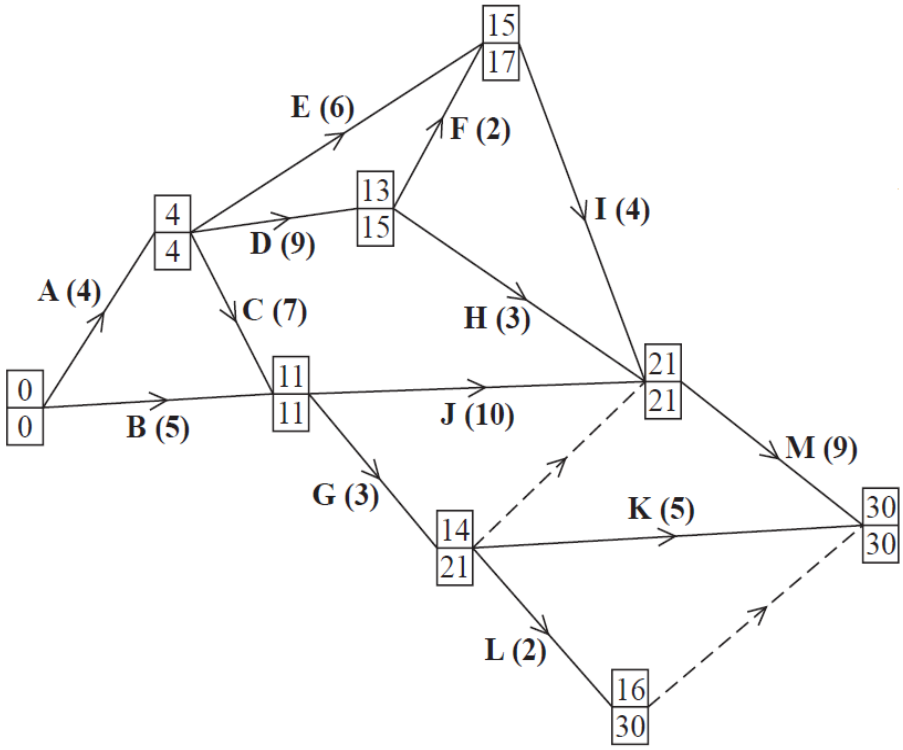
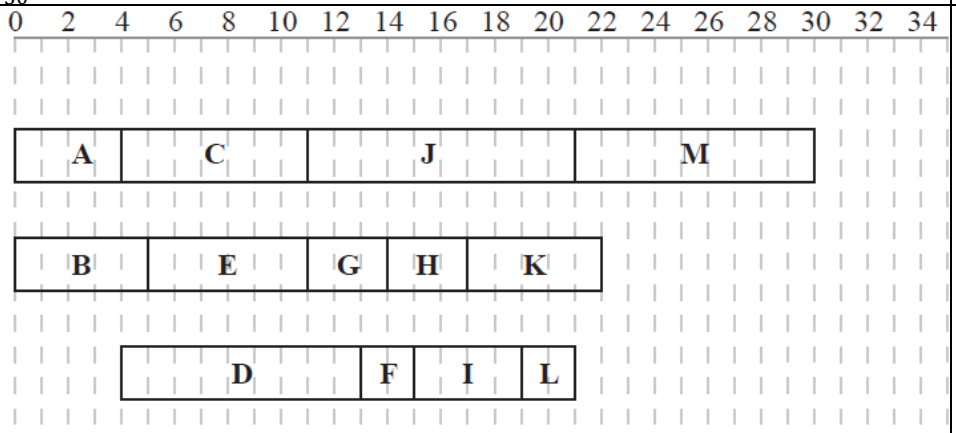
Misreads

- If they have used the correct numbers at any point in (a) and then use an incorrect number in (b) (say 71 instead of 17) from the beginning of the sort or misread one of their own numbers **during (b)** then count it as one '**error' in (b)** (so they will lose at least the final A mark but should be able to gain at least the M mark and ft A mark) – then mark (c) according to the SC above. More than one 'error' in (b) loses all subsequent A marks in (b). Allow recovery in (c) if they use the correct list.

Sorting list into ascending order in (b)

- If the candidate sorts the list into ascending order and reverse the list **in (b)** then they can score full marks in (b).
- If the list is not reversed in (b) then mark as a misread (so remove the last two A marks earned in (b)). If the list is reversed at the start of (c) but not in (b) then still treat this as a misread. If the list is still in ascending order in (c) award no marks for first fit increasing. If the candidate says that the list needs reversing in (b) but doesn't actually show the reversed list in (b) then remove the final A mark in (b).

Ascending (middle left)										Ascending (middle right)									
24	14	8	*x*	19	25	6	17	9	M1	24	14	8	*x*	19	25	6	17	9
14	8	6	17	9	19	24	*x*	25	A1	14	8	6	17	9	19	24	*x*	25
6	14	8	17	9	19	*x*	24	25		6	14	8	17	9	19	*x*	24	25
6	8	14	17	9	19	*x*	24	25	A1ft	6	14	8	9	17	19	*x*	24	25
6	8	14	9	17	19	*x*	24	25		6	8	14	9	17	19	*x*	24	25
6	8	9	14	17	19	*x*	24	25	A1cso	6	8	9	14	17	19	*x*	24	25

Question Number	Scheme	Marks
7. (a)	The total float $F(i,j)$ of activity (i,j) is defined to be $F(i,j) = l_j - e_i -$ duration (i,j), where e_i is the earliest time for event i and l_j is the latest time for event j **(see note below)**	B2,1,0 **(2)**
(b)		M1 A1 A1 **(3)**
(c)	Critical activities: A C J M	B1 **(1)**
(d)	G can be delayed by 21 – 11 – 3 = 7 (days)	M1 A1 **(2)**
(e)	$\frac{69}{30} = 2.3$ so lower bound is 3 workers	M1 A1 **(2)**
(f) e.g.		M1 A1 A1 A1 **(4)** **14 marks**

Notes for Question 7

a1B1: For the first mark: the idea that total float is 'how long an activity can be delayed for'. Give bod.
a2B1: For both marks: **either** a clear correct statement e.g. the **total/maximum** (oe) amount of time that an activity may be delayed from its **early** start without delaying the project/activity **finish** time **or** (total float =) **latest** finish – **earliest** start – **duration** (of activity). Ignore comments that infer that total refers to the sum of the floats for all activities in an activity network. Note that B1B0 should be awarded for an answer that has the pertinent idea of 'float' (see a1B1 above) and B1B1 for a clear correct statement (see a2B1 above) – B0B1 cannot be awarded in this part.
b1M1: All top boxes and all bottom boxes completed. Values generally increasing from left to right (for top boxes) and values generally decreasing from right to left (for bottom boxes) . Condone missing 0 or 30 for M only (for bottom boxes). Condone one rogue value in top boxes **and** one rogue value in bottom boxes (if values do not increase from left to right (or decrease right to left) then if **one** value is ignored and then the values do increase from left to right (or decrease right to left) then this is considered to be one rogue value).
b1A1: CAO for top boxes.
b2A1: CAO for bottom boxes.

c1B1: CAO

d1M1: Correct calculation for their activity G seen - their three numbers correct. Final value must be non-negative.
d1A1: CAO (**no follow through** on this A mark). Answer of 7 with no working scores no marks in this part.

e1M1: Attempt to find lower bound: [59 – 79 / their finish time] or [sum of the activities / their finish time]
e1A1: CAO – correct calculation seen then 3. [As 30/13 also gives 3, an answer of 3 with no working scores M0A0.]

f1M1: Not a cascade chart. 4 'workers' used at most and at least 8 activities placed.
f1A1: The critical (A, C, J, M) activities and B and D correct A – 4, C – 7, J – 10, M – 9, B – 5, D – 9. B must be completed by its late finish time (11) and D must start after A and finishing before its late finish time (15).

Now check the last 7 activities – the last two marks are for E, F, G, H, I, K and L **only.**

First check that there are only three workers and that all 13 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 and the time interval in which the activity must take place (interval is inclusive).

Activity	Duration	Time interval	IPA
E	6	4 – 17	A
F	2	13 – 17	D
G	3	11 – 21	B, C
H	3	13 – 21	D
I	4	15 – 21	E, F
K	5	14 – 30	G
L	2	14 – 30	G

f2A1: 3 workers. All 13 activities present (just once). Condone **one** error either precedence or time interval or activity length, on activities E, F, G, H, I, K and L only.
f3A1: 3 workers. All 13 activities present (just once). No errors on activities E, F, G, H, I, K and L.

Question Number	Scheme	Marks
8. (a)	$y \leq 2x, \quad 5y \geq 2x, \quad 2x + y \leq 36, \quad 4x + y \geq 36$	B2,1,0 **(2)**
(b)	B(6,12), C(9,18), D(15,6)	B1
	$A\left(\frac{90}{11}, \frac{36}{11}\right)$	B1
	P at A: $P = \frac{90}{11} + \frac{36}{11}k$, or P at B: $P = 6 + 12k$, or P at C: $P = 9 + 18k$, or P at D: $P = 15 + 6k$	B1
	$\frac{90}{11} + \frac{36}{11}k < 6 + 12k$ or $9 + 18k < 15 + 6k$	M1
	either $k > \frac{1}{4}$ or $k < \frac{1}{2}$ stated	A1
	$\frac{1}{4} < k < \frac{1}{2}$	A1 **(6)**
		8 marks

Notes for Question 8

a1B1: **Any** two correct inequalities (condone strict inequalities).
a2B1: CAO (inequalities cannot be strict for this mark).

As there are a number of different methods that the candidates can adopt – consider the candidate's full response and mark each attempt according to the notes below – award the candidate the marks for their best response/attempt. However, do not mix the approaches together e.g. if they find the exact coordinates of all four vertices and then state that the maximum gradient of P is -2 then this would score the first two marks only (method 1).

Method 1 (point testing)
b1B1: The coordinates of B, C and D stated **exactly** (or implied by later working).
b2B1: The coordinates of A stated **exactly** (or implied by later working).
b3B1: The objective function calculated in terms of k at their A or their B or their C or their D.
b1M1: Either (their objective function at A) $<$ (their objective function at B) **or** (their objective function at C) $<$ (their objective function at D) (condone equals sign or any inequality).
b1A1: Either $k > \frac{1}{4}$ **or** $k < \frac{1}{2}$ **or** $k \geq \frac{1}{4}$ **or** $k \leq \frac{1}{2}$ - with no incorrect working.
b2A1: CAO $\frac{1}{4} < k < \frac{1}{2}$ **or** $\frac{1}{4} \leq k \leq \frac{1}{2}$ (or as separate inequalities) – with no incorrect working.

Method 2 (objective line method I)
Comparing the gradient of the objective function to the gradient of the two lines with negative gradient.
b1B1: The **minimum** gradient (of P) stated as -4 – **must** see mention of minimum – either in words or mathematically e.g. allow $m_P > -4$ or $-\frac{1}{k} > -4$ (this second inequality would score B1B0B1M1).
b2B1: The **maximum** gradient (of P) stated as -2 – **must** see mention of maximum either in words or mathematically e.g. allow $m_P < -2$ or $-\frac{1}{k} < -2$. (this second inequality would score B0B1B1M1).
b3B1: Gradient of objective function stated as $-\frac{1}{k}$.
b1M1: Comparing gradient of objective function to either -2 or -4.
Final two marks as in method 1.
Method 3 (objective line method II)

b1B1: **Minimum** P parallel to $4x + y\ (= \cdots)$ (limiting case) – **must** see explicit mention of minimum.
b2B1: **Maximum** P parallel to $2x + y\ (= \cdots)$ (limiting case) – **must** see explicit mention of maximum.
b3B1: Re-arranging equations (either seen or implied) to give $x + \frac{y}{4}(= \cdots), x + \frac{y}{2}(= \cdots)$
b1M1: Compare coefficients of y in the objective function & lines.
Final two marks as in method 1.

SC: If **no** working seen or **no incorrect** working seen – so none of the marks are awarded by any of three methods – candidates can score a max of 3/6 for the 'correct' answers

k ■ $\frac{1}{2}$ **or** k ■ $\frac{1}{4}$ (where ■ is any inequality or equals) award first B mark.
$k > \frac{1}{4}$ **or** $k < \frac{1}{2}$ **or** $k \geq \frac{1}{4}$ **or** $k \leq \frac{1}{2}$ award the first two B marks.
$\frac{1}{4} < k < \frac{1}{2}$ **or** $\frac{1}{4} \leq k \leq \frac{1}{2}$ award the first three B marks.

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