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INTERNATIONAL A LEVEL MATHEMATICS • DECISION 1 (WDM11)

Decision 1 Practice Paper 3

Mark Scheme

AIMING FOR A/A*

Written in the style of the Pearson Edexcel International Advanced Level paper (WDM11/01) • 75 marks

Every question marked line by line the way an examiner marks it, with notes on the common errors

Mark every line, not just the answer. Method marks are given for a correct method even when the final answer is wrong. If you lost marks, find the *first* line where your working differs from the scheme. That is the thing to fix.

Code	Meaning
M1	Method mark: for knowing a correct method and attempting to apply it. Small slips in the working do not lose this mark.
dM1	Dependent method mark: can only be given if the method mark before it has been given.
A1	Accuracy mark: for a correct answer or line of working. It depends on the method mark before it.
B1	Independent mark: for a correct result or statement, whatever method was used.
*	The answer is given in the question. Every step must be shown, and the answer must follow from correct working (cso).
cao / cso	Correct answer only / correct solution only, with no errors anywhere in the working.
ft / oe	Follow through from your own earlier answer / or any correct equivalent form.
awrt	Answers which round to the value given, so 21.52… earns “awrt 21.5”.

How decision marks work. Decision Mathematics is a methods paper. Method marks need the algorithm to be applied in the right way and the working to be seen: the order arcs are chosen, the working values, the pivots, the bins. An answer with no working rarely earns more than one mark. Accuracy marks then need the values to be right, and a correct answer reached by the wrong algorithm earns nothing.

Rough grade guide (out of 75): A **47** • B **40** • C **33**

Based on recent WDM11 grade boundaries. Real boundaries change every series, so treat this as a guide, not a grade.

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What to revise next

Write in your score for each question. Where you dropped marks, tap the chapter to practise ten more exam questions on it.

Q	What it tested	Marks	Practise it	Score
1	Bubble sort and binary search run backwards to find unknowns	10	Ch 1 Algorithms	
2	Lower bound, first-fit decreasing and an optimal packing by full bins	11	Ch 1 Algorithms	
3	Degrees and arcs; Prim's algorithm with a required arc	11	Ch 2 Graphs and Networks Ch 3 Algorithms on Graphs	
4	Route inspection when an arc has an unknown length	11	Ch 4 Route Inspection Ch 3 Algorithms on Graphs	
5	A table of least distances, bounds and the real route	10	Ch 5 Travelling Salesman Ch 3 Algorithms on Graphs	
6	Event times, a cascade chart and why the worker bound fails	11	Ch 6 Critical Path Analysis	
7	Reducing three variables to two; the best whole-number point	11	Ch 7 Linear Programming	
	Total	**75**		

Where did the marks go? Every question on Paper 3 has a trap, and most lost marks come from it, not from the algorithm: an equal value treated as a swap, a lower bound taken as the answer, the direct arc used where a path is shorter, or a rounded vertex that breaks a constraint. For each question, find the line where the trap caught you and write down the check that would have spotted it. That list is your revision plan for the hardest marks on a real paper.

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Question 1

10 marks

Part	Scheme	Marks
(a)	After pass 2, 21 is last, so 21 reached the end on pass 1: $k < 21$ (if $k > 21$, k would have moved to the end instead)	**M1**
	After pass 1 the list is 8 14 k 17 11 21. In pass 2, k moves past 17, so $k > 17$ (for $14 < k < 17$ it would stay third)	**M1**
	$17 < k < 21$	**A1**
	$\boxed{k = 18, 19 \text{ or } 20}$	**A1**
	k is different from 17 and 21, so both inequalities are strict. Including 17 or 21 loses the final A1.	**(4)**
(b)	Pass 3: 8 14 11 17 19 21	**B1**
	Pass 4: 8 11 14 17 19 21; pass 5: no swaps, so sorted	**B1**
		(2)
(c)	First comparison with the middle item, $\left\lceil \frac{1+11}{2} \right\rceil = 6$, which is n	**M1**
	If $n < 44$: items 9 (58), 8 (52), 7 (47) follow, giving four comparisons, so $n > 44$ ($n = 44$ would be found)	**M1**
	If $n > 44$: list 1 to 5, item 3 (23), then list 4 to 5, item 5 (38), then the list is empty: three comparisons	**A1**
	$44 < n < 47$ with different integers: $\boxed{n = 45 \text{ or } 46}$	**A1**
		(4)
		Total for Question 1: 10 marks

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Question 2

11 marks

Part	Scheme	Marks
(a)	$155 \div 40 = 3.875$ 4 sections	**M1** **A1** **(2)**
(b)	Sorted: 22, 21, 20, 19, 17, 15, 12, 11, 10, 8, and applied Section 1: 22, 17 Section 2: 21, 19 Section 3: 20, 15 Section 4: 12, 11, 10 Section 5: 8	**M1** **A1** **A1** **(3)**
(c)	Look for full sections: $22+10+8$, $21+19$, $17+12+11$ Fourth section: $20+15$, so 4 sections 4 equals the lower bound in (a), so no allocation can use fewer: it is optimal *First-fit decreasing is not guaranteed to be optimal. Stating that (b) is optimal scores M0 A0 B0.*	**M1** **A1** **B1** **(3)**
(d)	Four sections hold 160 cm in total: $155+y \leqslant 160$, so $y \leqslant 5$ $y = 5$ fits: the section with 20 and 15 has 5 cm spare, the other three are full $y = 5$	**M1** **M1** **A1** **(3)**
		Total for Question 2: 11 marks

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Question 3

11 marks

Part	Scheme	Marks
(a)	The sum of the degrees is twice the number of arcs, so it is even; $1+2+2+3+3=11$ is odd, so d is odd	B1 (1)
(b)	$11+d=2\times 7$ $\boxed{d=3}$	M1 A1 (2)
(c)	Degrees 1, 3, 3, 3 are odd: four odd vertices, so $\boxed{\text{neither}}$	B1 (1)
(d)	AC 18, BC 14, BF 17 CD 21, DE 16 Weight $\boxed{86\text{ km}}$	M1 A1 A1 (3)
(e)	Start with BE (or B and E both in the tree), then apply Prim's algorithm BE 39, BC 14, DE 16, BF 17, AC 18 $\boxed{104\text{ km}}$ *Adding BE to the tree in (d) without removing an arc gives 125, and is not a tree.*	M1 A1 A1 (3)
(f)	Adding BE to the tree makes the cycle $BCDE$; remove its longest arc, CD (21): $86+39-21=104$	B1 (1)
		Total for Question 3: 11 marks

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Question 4

11 marks

Part	Scheme	Marks
(a)	A, B, D and F have odd degree (3), so the network is not Eulerian	**B1** **(1)**
(b)	Odd vertices A, B, D, F: three pairings considered $AD = 17$ by ACD, not the road AD (20) $AD + BF = 17 + 10 = 27$, $AB + DF = 15 + 17 = 32$, $AF + BD = 22 + 9 = 31$ Repeat AC, CD and BF: $89 + 20 + 27 =$ $\boxed{136\,\text{km}}$	**M1** **A1** **A1** **A1** **(4)**
(c)	The shortest A to D distance is the smaller of x and 17 (by ACD) So $AD + BF \leqslant 27 < 31$ and < 32: this pairing is always the best The road AD is on the repeated path only if $x < 17$; otherwise ACD is repeated $\boxed{0 < x < 17}$ *Using the road AD as the distance for every x gives $x + 10 < 31$, so $x < 21$: M1 M0 A0 A0.*	**M1** **M1** **A1** **A1** **(4)**
(d)	Finish at an odd vertex and repeat the remaining pair: finish B, $DF = 17$; finish D, $BF = 10$; finish F, $BD = 9$ Finish at $\boxed{F}$: $109 + 9 =$ $\boxed{118\,\text{km}}$	**M1** **A1** **(2)**
		Total for Question 4: 11 marks

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Question 5

10 marks

Part	Scheme	Marks
(a)	$AD = DA = 30$ (by ABD) $CE = EC = 21$ (by CFE)	**B1** **B1** **(2)**
(b)	From A: $ACBDEFA$ $11+9+14+10+8+23 =$ 75 km From D: $DEFCBAD$, $10+8+13+9+16+30 =$ 86 km	**M1** **A1** **A1** **(3)**
(c)	$DEFCBABD$ *The table entry $AD = 30$ is the path ABD, so B is passed through twice in the real network.*	**B1** **(1)**
(d)	Delete A: tree BC 9, CF 13, DE 10, EF 8 = 40; $40+11+16 = 67$ Delete C: tree AB 16, BD 14, DE 10, EF 8 = 48; $48+9+11 = 68$ The better lower bound is the larger: 68 km	**M1** **M1** **A1** **(3)**
(e)	$68 \leqslant$ length $\leqslant 75$	**B1** **(1)**
		Total for Question 5: 10 marks

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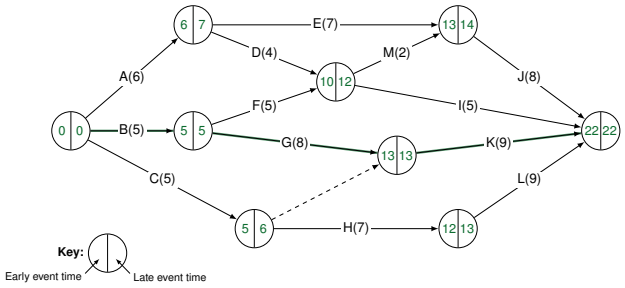
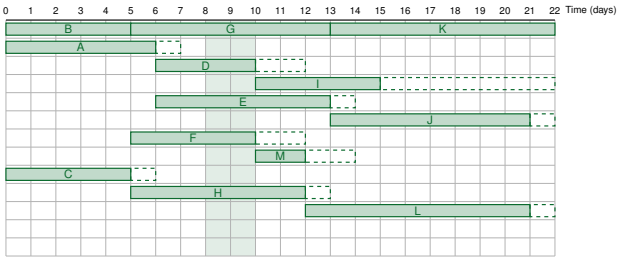
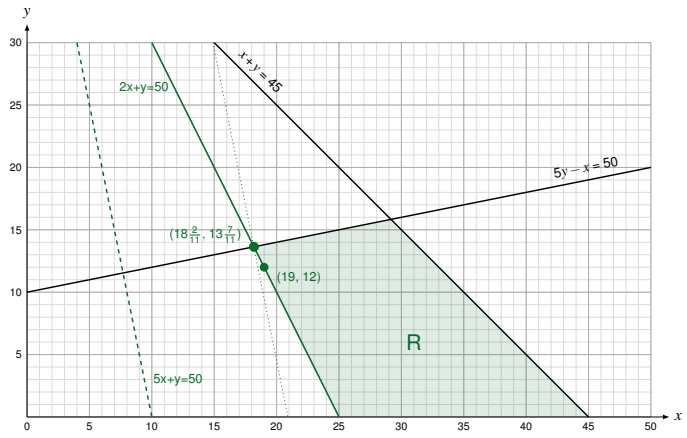
Question 6

11 marks

Part	Scheme	Marks
(a)	Early event times 0, 6, 5, 5, 10, 13, 13, 12, 22 Late event times 0, 7, 5, 6, 12, 14, 13, 13, 22	M1 A1
		A1
	The late time at event 3 is 6: the smaller of $13-0$ *(the dummy, then* K *from event 6) and* $13-7$ *(from* H*).*	(3)
(b)	B, G, K; 22 days	B1
		(1)
(c)	$\frac{6+5+5+4+7+5+8+7+5+8+9+9+2}{22} = \frac{80}{22} = 3.6\ldots$	M1
	4 workers	A1
		(2)
(d)	Critical activities in one row; at least eight others with correct start times	M1
	Floats correct on six non-critical activities	A1
	All correct	A1
		
		(3)
(e)	D (latest start 8, finish 10), E (6 to 13 at the latest 7 to 14), F (latest start 7), G (critical) and H (latest start 6) must all be in progress	M1
	From day 8 to day 10 five activities run at once, so 4 workers cannot finish in 22 days	A1
		(2)
	Total for Question 6: 11 marks	

Question 7

11 marks

Part	Scheme	Marks
(a)	$z = 50 - x - y \geqslant 5$, so $x + y \leqslant 45$	**B1** **(1)**
(b)	$2x + 8y + 3(50 - x - y) \leqslant 200$ $-x + 5y + 150 \leqslant 200$, so $5y - x \leqslant 50$	**M1** **A1*** **(2)**
(c)	$x \geqslant 50 - x - y$ $\boxed{2x + y \geqslant 50}$	**M1** **A1** **(2)**
(d)	$P = 5x + 9y + 10(50 - x - y)$ $\boxed{P = 500 - 5x - y}$	**M1** **A1** **(2)**
(e)	Line $2x + y = 50$ drawn and R shaded correctly  Maximising P means minimising $5x + y$: the objective line $5x + y = k$ leaves R at $\left(18\frac{2}{11}, 13\frac{7}{11}\right)$ Whole-number points near it: (18, 13), (18, 14), (19, 14) are not feasible; (19, 13) gives 392; (19, 12) gives 393 $\boxed{\text{19 croissants, 12 muffins, 19 bread: £393}}$ *(19, 12) lies on $2x + y = 50$, which is why it beats the nearer point (19, 13). Giving (19, 13) scores M1 M1 M1 A0.*	**M1** **M1** **M1** **A1** **(4)**
		Total for Question 7: 11 marks

TOTAL FOR PAPER: 75 MARKS