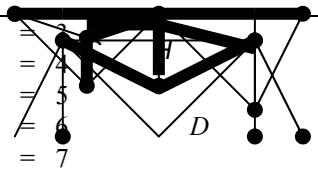
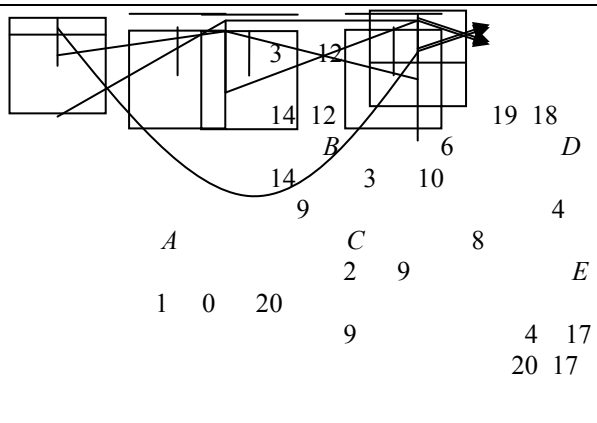
1



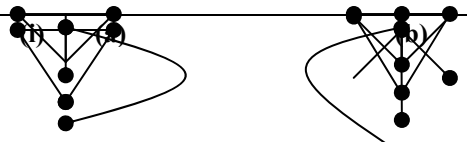
BC = 3			
FG = 4		M1	For selecting all arcs up to *AB* and deleting *AB* in list
JL = 5			
EG = 6		A1	For deleting *AC*, *DE* in list and selecting arcs for tree correctly, indicated in any way
AE = 7			
BG = 7			
~~*AB* = 8~~			
CH = 8		M1	For a spanning tree drawn
DF = 8		A1	For correct (minimum) spanning tree drawn
GJ = 8			
HK = 8			
~~*AC* = 9~~			
~~*DE* = 9~~			
FI = 9			
~~*GH* = 9~~			
~~*IJ* = 9~~			
~~*JK* = 9~~			
~~*AD* = 10~~			
~~*DG* = 10~~			
~~*GK* = 10~~			
~~*IL* = 10~~			
~~*KL* = 10~~			
~~*GI* = 11~~			
~~*CG* = 12~~			
~~*DI* = 12~~	Total weight = 73	B1 **5**	For total = 73

2



	M1	For temporary labels at *B* correct, no extras
	M1	For temporary labels at *E* correct, no extras
	A1	For permanent labels correct at *B*, *C* and *E* (dependent on both M marks)
	B1	For order of labelling correct at *C*, *B* and *E*
	M1	For temporary labels at *D* correct
	A1	For no permanent label at *D*
6		

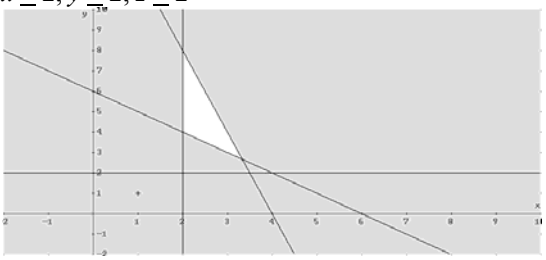
3 **(i)** **(a)** **(b)**

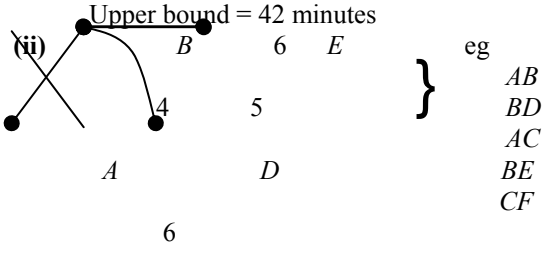


(c) **(d)**

	B1	For a correct graph for (a)
	B1	For a correct graph for (b)
	B1	For a clearly correct graph for (c)
	B1	For a clearly correct graph for (d)
(4)		
(ii) $2n$ if n is even $2n + 1$ if n is odd	M1 (2) A1 **6**	For treating the cases n odd and n even separately For both rules correct

4	**(i)**	P x y z s t 1 -5 4 3 0 0 0 0 2 -3 4 1 0 10 0 6 5 4 0 1 60	M1 A1 (2)	For overall structure correct, including two slack variable columns For a correct initial tableau, with no extra constraints added
	(ii)	Pivot on 2 in x column r1 = r1 + 5npr r2 = r2 ÷ 2 r3 = r3 - 6npr 1 0 -3.5 13 2.5 0 25 0 1 -1.5 2 0.5 0 5 0 0 14 -8 -3 1 30 $x = 5$, $y = 0$, $z = 0$ $P = 25$	M1 A1 M1 A1 B1 (6) B1 **8**	For the correct pivot choice for their tableau For dealing with the pivot row correctly (formula or numerical) For dealing with the other rows correctly (formulae or numerical) For a correct tableau (not ft) For reading off x, y and z from their tableau For reading off P from their tableau

5	**(i)**	x = number of lengths swum using breaststroke y = number of lengths swum using backstroke z = number of lengths swum using butterfly Maximise $2x + y + 5z$	B1 B1 (2)	For defining variables as 'number of lengths swum' using each stroke, or equivalent For a correct expression using their variables
	(ii)	$x + y + z \geq 8$ $2x + 0.5y + z \leq 10$ $x \geq 2$, $y \geq 2$, $z \geq 2$	B1 B1 B1 (3)	For a correct expression using their variables For a correct expression using their variables For correct expressions using their variables
	(iii)	 (2, 4), (2, 8), (3.3, 2.7) $2\times2 + 8 = 12$ $2\times3.33 + 2.67 = 9.33$ So maximum is when $x = 2$ and $y = 8$	M1 A1 M1 A1 (6)	For plotting the sloping lines correctly For completely correct shading For two correct vertices from their graph For all three vertices correct to at least 1 dp For calculating P at vertices or using a valid line of constant profit or writing down their max point For the correct values
	(iv)	Swim 2 lengths using breaststroke, 8 lengths using backstroke and 2 lengths using butterfly Total = 22 style marks	B1 B1 (2) **13**	For interpreting their solution in the context of the original problem (at least for x and y) For calculating the number of marks for their solution

6	**(i)**	*A-B-D-E-G-F-C-A* 42 minutes *A-B-D-C-F-G-E-A* 46 minutes Upper bound = 42 minutes	M1 A1 B1 B1 B1ft(5)	For *A-B-D-E-G-F-C*, with or without closing tour For 42 For *A-B-D-C-F-G-E*, with or without closing tour For 46 For the smaller of their two times
	(ii)	 eg *AB* *BD* *AC* *BE* *CF* *A B D C E F* or A B D E C F Total weight of tree = 31 minutes Two least weight arcs from *G* have weight 5+5 =10 minutes Lower bound = 31 + 10 = 41 minutes	M1 A1 B1 A1 ft M1 A1 (6)	For a diagram or listing showing a tree connecting the vertices *A*, *B*, *C*, *D*, *E* and *F*, but not *G* For a diagram showing this tree (vertices need to be labelled, but arc weights are not needed) For a valid vertex or arc order For the total weight of their tree stated For stating or using *GE*, *GF* or 5+5 or 10 For 41 or 10 + their 31 calculated
	(iii)	Odd nodes: *B D E F* *BD* = 5 *BE* = 6 *BF* = 16 *EF* = 10 *DF* = 14 *DE* = 7 15 20 23 120 minutes Travel *BD*, *EG* and *FG* twice (accept *BD*, *EGF*) 3 times	B1 M1 A1 B1 (5) B1 **16**	For identifying or using *B D E F* For calculating 5+10 or 6+14 or 16+7 (may be implied from correct pair chosen) For 120 (unsupported 120 scores 0 marks) For correct arcs listed and no others For 3

7	**(i)**	Original list: 34 42 27 31 12 48 24 37 1st pass: 34 27 31 12 42 24 37 48 2nd pass: 27 31 12 34 24 37 42 48 3rd pass: 27 12 31 24 34 37 42 48 4th pass: 12 27 24 31 34 37 42 48 5th pass: 12 24 27 31 34 37 42 48 6th pass: 12 24 27 31 34 37 42 48 Swaps = 5+5+2+2+1 =15 Comparisons = 7+6+5+4+3+2 = 27	M1 M1 M1 A1 B1 B1 (6)	nb decreasing or numbers misread ⇒ M only For result of first pass correct (underlined entries may be omitted) For second and third passes correct, must be using bubble sort For fourth and fifth passes correct, must be using bubble sort For sixth pass correct, from correct method For 15, from correct method For 27, from correct method
	(ii)	Original list: 95 74 61 87 71 82 53 57 1st pass: 74 95 61 87 71 82 53 57 2nd pass: 61 74 95 87 71 82 53 57 3rd pass: 61 74 87 95 71 82 53 57 4th pass: 61 71 74 87 95 82 53 57 5th pass: 61 71 74 82 87 95 53 57 6th pass: 53 61 71 74 82 87 95 57 7th pass: 53 57 61 71 74 82 87 95 Swaps = 1+2+1+3+2+6+6 = 21 Comparisons = 1+2+2+4+3+6+7 = 25	M1 M1 M1 A1 B1 B1 (6)	nb decreasing or numbers misread ⇒ M only For result of first pass correct (underlined entries may be omitted) For second and third passes correct, must be using shuttle sort For fourth and fifth passes correct, must be using shuttle sort For seventh pass correct, from correct method For 21, from correct method For 25, from correct method
	(iii)	Each script is looked at once so the time taken is roughly proportional to the number of scripts	B1 B1 (2)	For 'each script is looked at once', or equivalent For 'proportional', or equivalent
	(iv)	Splitting 100 scripts takes 50 seconds so splitting 500 scripts takes about 250 seconds Sorting 50 scripts takes 250 seconds = 0.1×50^2 Sorting 250 scripts takes about 0.1×250^2 = 6250 seconds Total = 6500 seconds or 108 minutes 20 seconds	M1 M1 A1 (4) A1 **18**	250 (but not for 250 + 50) $(500\div2)^2$, $(250)^2$, $(100\div2)^2$ or equivalent For 6250, dependent on previous M only For 6500 or equivalent