Question Number	Scheme	Marks
Q1 **(a)**		

H	V	L	A	N	J	S	T	P	(N)
H	L	A	J	N	V	S	T	P	(A, T)
A	H	L	J	N	S	P	T	V	(L, P)
A	H	J	L	N	P	S	T	V	(J)
A	H	J	L	N	P	S	T	V	

M1
A1
A1ft

A1cso **4**

(b)

1st choice $\left[\frac{1+9}{2}\right]=5$ Nicky, reject 1 - 5

2nd choice $\left[\frac{6+9}{2}\right]=[7.5]=8$ Tom, reject 8 - 9

3rd choice $\left[\frac{6+7}{2}\right]=[6.5]=7$ Sharon, reject 7

4th choice 6 Paul name found

M1A1

A1

A1cso **4**

Total 8

Notes:

(a) 1M1: quick sort, pivots, p, chosen and two sublists one <p one >p.
1A1: first pass correct and next pivots chosen correctly/consistently.
2A1ft: second pass correct, next pivots correctly/consistently chosen.
3A1: all correct, cso.

(b) 1M1: binary search on what they think is a alphabetical list, choosing pivot, rejecting half list.
1A1: first pass correct, condone 'sticky' pivot here, bod generous
2A1: second pass correct, pivot rejected.
3A1: cso.

Note: If incorrect list in (a) mark (b) as a misread.

Q1 Alternative solutions

Middle right

H	V	L	A	N	J	S	T	P	(N)	M1
H	L	A	J	N	V	S	T	P	(A T)	A1
A	H	L	J	N	S	P	T	V	(L P)	A1ft
A	H	J	L	N	P	S	T	V	(J)	
A	H	J	L	N	P	S	T	V		A1 cso
							list sorted			

Middle left

H	V	L	A	N	J	S	T	P	(N)	M1
H	L	A	J	N	V	S	T	P	(L S)	A1
H	A	J	L	N	P	S	V	T	(A V)	A1ft
A	H	J	L	N	P	S	T	V	(H)	
A	H	J	L	N	P	S	T	V		A1 cso

First

H	V	L	A	N	J	S	T	P	(H)	M1
A	H	V	L	N	J	S	T	P	(V)	A1
A	H	L	N	J	S	T	P	V	(L)	
A	H	J	L	N	S	T	P	V	(N)	A1ft
A	H	J	L	N	S	T	P	V	(S)	
A	H	J	L	N	P	S	T	V		A1 cso

Q2

(a) DE GF DC $\left\{\begin{matrix}\text{not CE}\\ \text{BD}\end{matrix}\right\}$ EG (not EF not CF) AC (not AB) GH — M1 A1 A1 — **3**

(b)

	A	B	C	D	E	F	G	H
A	-	31	30	-	-	-	-	-
B	31	-	-	**24**	-	-	-	38
C	30	-	-	**22**	24	**29**	-	-
D	-	**24**	**22**	-	18	-	-	**34**
E	-	-	24	18	-	28	**26**	-
F	-	-	**29**	-	28	-	21	-
G	-	-	-	-	**26**	21	-	**33**
H	-	38	-	**34**	-	-	**33**	-

B2, 1, 0 — **2**

(c) AC CD DE BD GE GF GH — M1 A1 A1 — **3**

(d) Weight: 174 — B1 — **1**

Total 9

Notes:

(a) 1M1: Kruskal's algorithm – first 4 arcs selected chosen correctly.
1A1: All seven non-rejected arcs chosen correctly.
2A1: All rejections correct and in correct order and at correct time.

(b) 1B1: condone two (double) errors
2B1: cao

(c) 1M1: Prim's algorithm – first four arcs chosen correctly, in order, **or** first five nodes chosen correctly, in order.{A,C,D,E,B….}
1A1: First six arcs chosen correctly **or** all 8 nodes chosen correctly, in order. {A,C,D,E,B,G,F,H}
2A1: All correct and arcs chosen in correct order.

(d) 1B1: cao

Starting at	Minimum arcs required for M1	Nodes	order
A	AC CD DE DB	ACDEB(GFH)	15234(768)
B	BD DE DC	BDEC(GFAH)	(7)1423(658)
C	CD DE DB	CDEB(GFAH)	(7)4123(658)
D	DE DC DB	DECB(GFAH)	(7)4312(658)
E	ED DC DB	EDCB(GFAH)	(7)4321(658)
F	FG GE ED DC DB	FGEDCB(AH)	(7)654312(8)
G	GF GE ED DC DB	GFEDCB(AH)	(7)654321(8)
H	HG GF GE	HGFE(DCBA)	(8765)4321

Question Number	Scheme	Marks
Q3		
(a)	e.g. total weight is 239, lower bound is $\frac{239}{60} = 3.98$ so 4 bins.	M1 A1 **2**
(b)	Bin 1 : 41 Bin 4 : 36 Bin 2 : 28 + 31 Bin 5 : 32 Bin 3 : 42 Bin 6: 29	M1 A1 A1 **3**
(c)	Full Bins : 28 + 32 31 + 29 The other 3 items (42, 41, 36) require 3 separate bins	M1 A1 **2**
(d)	There are 5 items over 30. No two of these 5 can be paired in a bin, so at least 5 bins will be required.	B2, 1, 0 **2**
		Total 9

Notes:

(a) 1M1: Any correct statement, must involve calculation
1A1: cao (accept 4 for both marks)

(b) 1M1: Bins 1 and 2 correct and at least 6 values put in bins
1A1: Bins 1,2,3 and 4 correct.
2A1: All correct

(c) 1M1: Attempt to find two full bins and allocate at least 6 values
1A1: cao

(d) 1B1: Correct argument may be imprecise or muddled (bod gets B1)
2B1: A good, clear, correct argument. (They have answered the question 'why?')

Misread in (b) First Fit Decreasing

Bin 1: 42 Bin 2: 41 Bin 3: 36 Bin 4: 32 28 Bin 5: 31 29
(Remove up to two A marks if earned – so M1 max in (b) if first 4 bins correct.)

Question Number	Scheme	Marks
Q4		
(a)	BC + EG = 10.4 + 10.1 = 20.5 smallest	M1 A1
	BE + CG = 8.3 + 16.1 = 24.4	A1
	BG + CE = 14.9 + 11.9 = 26.8	A1
	So repeat tunnels BA, AC and EG	A1
		5
(b)	Any route e.g. ACFGDCABDEGEBA	B1
	Length = 73.3 + their 20.5 = 93.8km	M1 A1
		3
(c)	The new tunnel would make C and G even.	
	So only BE would need to be repeated.	B1
	Extra distance would be 10 + 8.3 = 18.3 < 20.5 [91.6 < 93.8]	
	So it would decrease the total distance.	DB1
		2
		Total 10

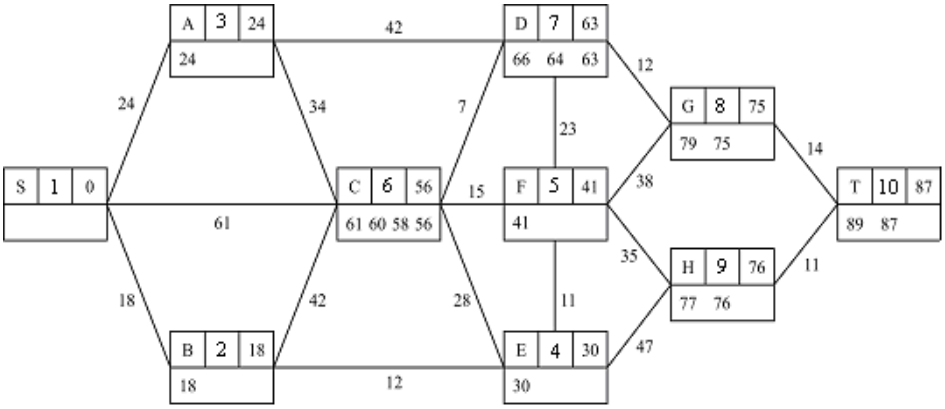
Notes:

(a) 1M1: Three pairings of their four odd nodes
1A1: one row correct
2A1: two rows correct
3A1: all correct
4A1: correct **arcs** identified

(b) 1B1: Any correct route (14 nodes)
1M1: 73.3 + ft their least, from a choice of at least two.
1A1: cao

(c) 1B1: A correct explanation, referring to BE and relevant numbers (8.3, 12.2, 2.2, 18.3,81.3, 91.6) maybe confused, incomplete or lack conclusion –bod gets B1
2B1D: A correct, clear explanation all there + conclusion (ft on their numbers.)

Question Number	Scheme	Marks
Q5	e.g.	
(a)	G – 3 = E – 2 = A – 4 = S – 6	M1
	Change status G = 3 – E = 2 – A = 4 – S = 6	A1
	Improved matching	A1
	A = 4 (C unmatched) E = 2 G = 3 J = 5 S = 6	**3**
(b)	e.g. Both C and J can only be matched to 5 Both 1 and 6 can only be done by S	B2, 1, 0 **2**
(c)	C – 5 = J – 4 = A – 2 = E – 6 = S – 1	M1
	Change status C = 5 – J = 4 – A = 2 – E = 6 – S = 1	A1
	Complete matching	
	A = 2 C = 5 E = 6 G = 3 J = 4 S = 1	A1
		3
		Total 8
	Notes: (a) 1M1: Path from G to 6 or 1 1A1: CAO including change status (stated or shown), chosen path clear. 2A1: CAO must ft from stated path, diagram ok (b) 1B1: Correct answer, may be imprecise or muddled (bod gets B1) all relevant nodes should be referred to and must be correct, but condone one (genuine) slip. 2B1: Good, clear, correct answer. (c) 1M1: Path from C to 1 or 6 [whichever they didn't use before.] 1A1: CAO including change status (stated or shown), chosen path clear. (Don't penalise change status twice.) 2A1: CAO must ft from stated path, diagram ok	
	Alt (a) G – 3 = E – 2 = A – 4 = S – 1 c.s. G = 3 – E = 2 – A = 4 – S = 1 A = 4, (C unmatched), E = 2, G = 3, J = 5, S = 1 (c) C – 5 = J – 4 = A – 2 = E – 6 c.s. C = 5 – J = 4 – A = 2 – E = 6 A = 2, C = 5, E = 6, G = 3, J = 4, S = 1	

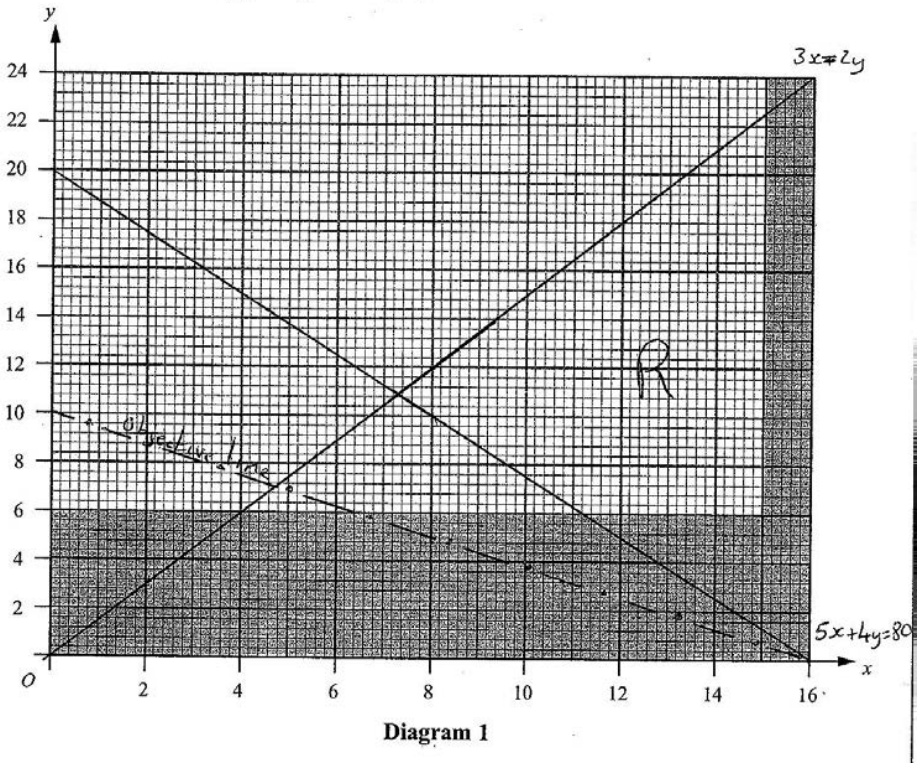
Question Number	Scheme	Marks
Q6		
(a)		M1 A1 A1ft A1
	Route: SBEFHT Time: 87 minutes	B1 B1ft **6**
(b)	Accept demonstration of relevant subtractions, or general explanation.	B2ft,1ft, 0 **2**
(c)	Route: EFHT	B1 **1**
		Total 9

Notes:

(a) 1M1: Smaller number replacing larger number in the working values at C or D or G or H or T. (generous – give bod)
1A1: All values in boxes S, A, B, E and F correct
2A1ft: All values in boxes C and D (ft) correct. Penalise order of labelling errors just once.
3A1: All values in boxes G, H and T correct
1B1: CAO (not ft)
2B1ft: Follow through from their T value, condone lack of units here.

(b) 1B1ft: Partially complete account, maybe muddled, bod gets B1
2B1ft: Complete, clear account.

(c) 1B1: CAO

Question Number	Scheme	Marks
Q7		
(a)	To indicate the strict inequality	B1 **1**
(b)	$3x = 2y$ and $5x + 4y = 80$ added to the diagram. R correctly labelled.  **Diagram 1**	B1, B1 B1 **3**
(c)	[Minimise C =] $500x + 800y$	B1, B1 **2**
(d)	Point testing or Profit line Seeking integer solutions (11, 7) at a cost of £ 11 100.	M1 A1 M1 B1, B1 **5**
		Total 11

Notes:

(a) 1B1: CAO

(b) 1B1: $3x = 2y$ passing through 1 small square of (0,0) and (12, 18), but must reach x = 15

2B1: $5x + 4y = 80$ passing through 1 small square of (0, 20) and (16, 0) (extended if necessary) but must reach y = 6

3B1: R CAO (condoning slight line inaccuracy as above.)

(c) 1B1: Accept expression and swapped coefficients. Accept 5x + 8y for 1 mark

2B1: CAO (expression still ok here)

(d) 1M1: Profit line [gradient accept reciprocal, minimum length line passes through (0, 2.5) (4, 0)] **OR** testing 2 points in their FR near two different vertices.

1A1: Correct profit line **OR** 2 points correctly tested in correct FR (my points)

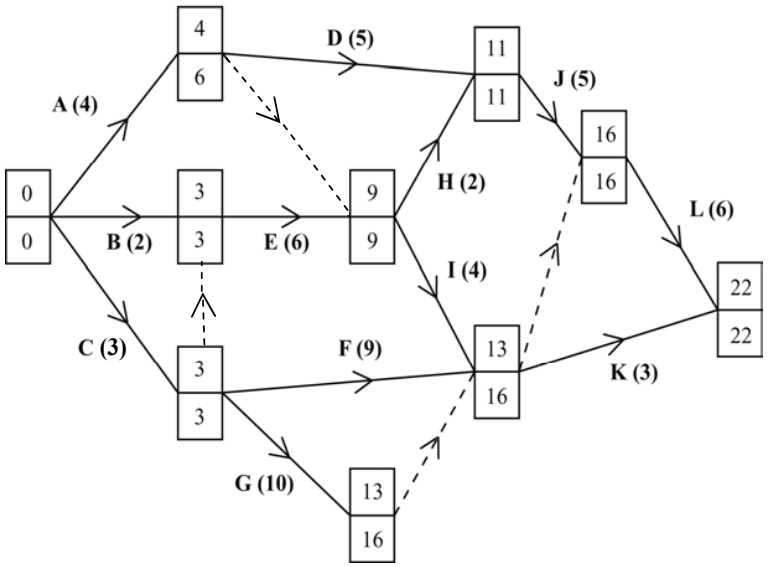
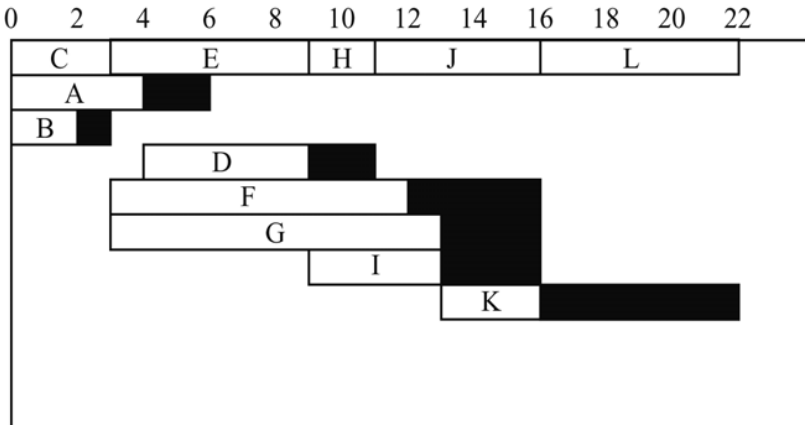
e.g

$(7\frac{3}{11}, 10\frac{10}{11}) = 12\,363\frac{7}{11}$	or	$(7,11) = 12\,300$
		$(8,10) = 12\,000$
		$(8,11) = 12\,800$
$(11\frac{1}{5}, 6) = 10\,400$	or	$(11,6) = 10\,300$
$(15,6) = 12\,300$	or	$(15,7) = 13\,100$
$(15, 22\frac{1}{2}) = 25\,500$	or	$(15,22) = 25\,100$
$(11,7) = 11\,100$		

2M1: Seeking integer solution in correct FR (so therefore no y = 6 points)

1B1: (11,7) CAO

2B1: £11 100 CAO

Question Number	Scheme	Marks
Q8 **(a)**		M1 A1 M1 A1 **4**
(b)	Critical activities: C E H J L	B1 **1**
(c)		M1 A1 A1 A1 **4**
(d)	4 workers needed e.g. at time 8 ½ (noon on day 9) activities E, D, F and G must be happening.	B2, 1, 0 **2**
		Total 11

Notes for Q8

(a) 1M1: Top boxes completed generally increasing left to right.
1A1: CAO.
2M1: Bottom boxes completed generally decreasing right to left.
2A1: CAO.

(b) 1B1: Critical activities cao.

(c) 1M1: At least 10 activities placed, at least five floats. Scheduling diagram gets M0.
1A1: my critical activities correct.
2A1: condone one error on my non-critical activities.
3A1: my non-critical activities correct.

(d) 1B1: A correct statement, details of either time (7<time<9, 8<day<10), or activities, bod gets B1. Allow 1 B mark (only) on ft from their 12 activity, 7 float diagram.
2B1: A correct, complete full statement details of time and activities.