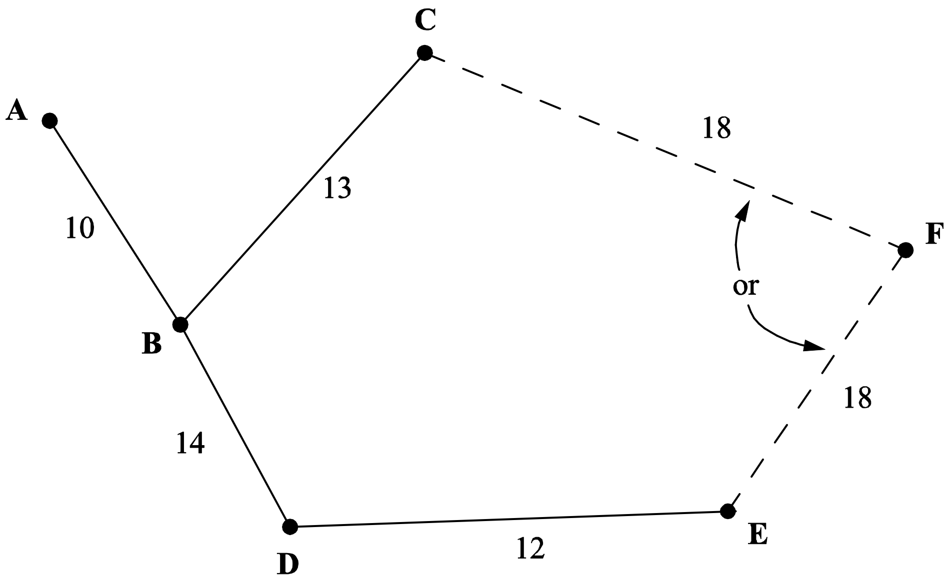
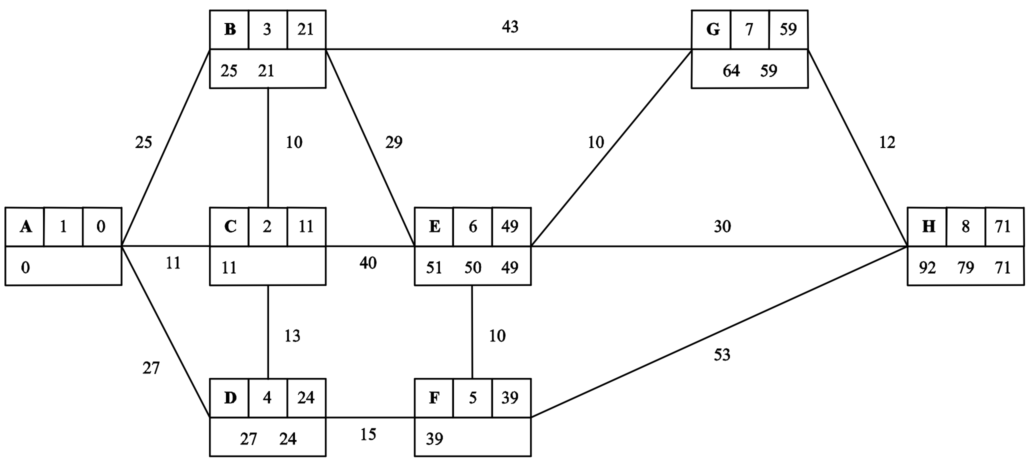
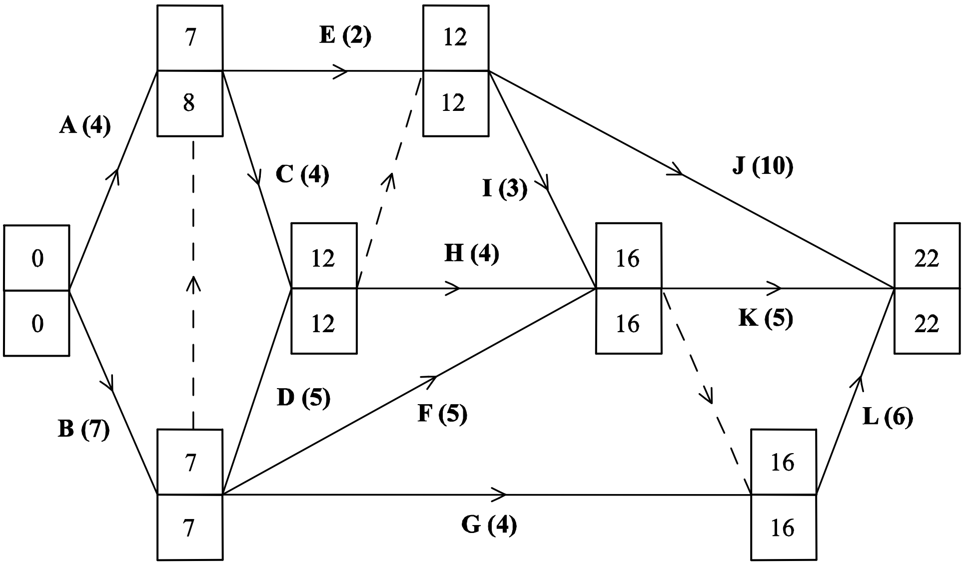
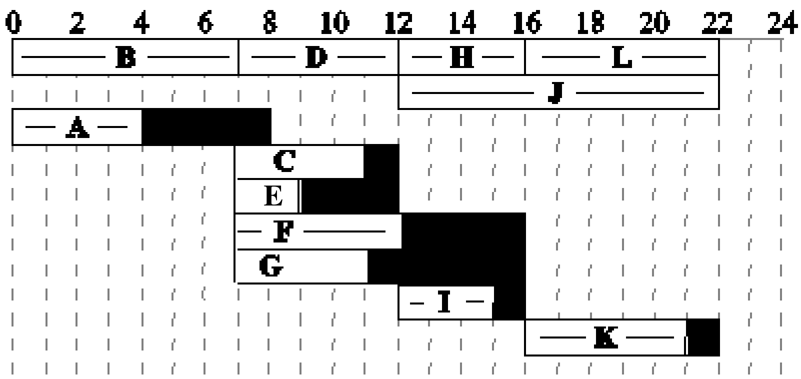
Question Number	Scheme	Marks
1. **(a)**	The list is not in alphabetical order.	B1 (1)
(b)	E.g. A Quick sort J M C B T $\boxed{H}$ K R G F H C B $\boxed{G}$ F $\boxed{H}$ J M $\boxed{T}$ K R G T C $\boxed{B}$ F $\boxed{G}$ $\boxed{H}$ J M $\boxed{K}$ R $\boxed{T}$ B K $\boxed{B}$ C $\boxed{F}$ $\boxed{G}$ $\boxed{H}$ J $\boxed{K}$ M $\boxed{R}$ $\boxed{T}$ F R $\boxed{B}$ C $\boxed{F}$ $\boxed{G}$ $\boxed{H}$ J $\boxed{K}$ M $\boxed{R}$ $\boxed{T}$ Sort complete + named correctly	M1 A1 A1 A1= B1 (4)
(c)	Pivot 1 = $\left[\frac{1+10}{2}\right]=6$ Jenny reject 1 - 6 Pivot 2 = $\left[\frac{7+10}{2}\right]=9$ Richard reject 9 - 10 Pivot 3 = $\left[\frac{7+8}{2}\right]=8$ Merry reject 8 Pivot 4 = 7 Kim - name found	M1 A1 A1ft A1 (4) **9**

Question Number	Scheme	Marks
2. **(a)(i)**	A tree is a connected graph with no cycles/circuit	B1
(a)(ii)	A minimum spanning tree is a tree that contains all vertices and the total length of its arcs (weight of tree) is as small as possible.	B1 B1 (3)
(b)	AB, DE, BC; $\left\{\begin{matrix}\text{reject AC}\\ \text{BD}\end{matrix}\right\}$ reject BE, reject CE, use either EF or CF	M1; A1 A1 (3)
(c)		B1 (1)
(d)	No, there are two solutions since either EF or CF should be used.	B1 (1) **8**

Question Number	Scheme	Marks
3. **(a)**	$6x+5y\le 60$ $2x+3y\ge 12$ $3x\ge 2y$ $x\le 2y$	B2,1,0 (2)
(b)	Drawing objective line{ (0,3) (1,0)} Testing at least 2 points Calculating optimal point Testing at least 3 points $\left(7\frac{1}{17},3\frac{9}{17}\right)=\left(\frac{120}{17},\frac{60}{17}\right)\approx(7.06,3.53)$	M1 A1 DM1 A1 awrt (4)
(c)	$24\frac{12}{17}=\frac{240}{17}\approx 24.7$ (awrt)	B1 (1)
(d)	(6,4)	B1 (1) **8**
4. **(a)**	[Given A – 3 = R – 4 = C – 5] $\text{A}-1=\text{H}-2$ $\text{A}-1=\text{H}-3=\text{R}-4=\text{C}-5$	M1 A1 A1 (3)
(b)	$\text{A}=3, \text{C}=5,\ \text{H}=1,\ (\text{J unmatched}),\ \text{R}=4$	B1 (1)
(c)	Alternating path : $\text{J}-4=\text{R}-3=\text{A}-1=\text{H}-2$ Change status : $\text{J}=4-\text{R}=3-\text{A}=1-\text{H}=2$ $\text{A}=1,\ \text{C}=5,\ \text{H}=2,\ \text{J}=4,\ \text{R}=3$	M1 A1 A1 (3) **7**

Question Number	Scheme	Marks
5. (a)	$AC + DF = 9 + 13 = 22 \leftarrow$ $AD + CF = 16 + 8 = 24$ $AF + CD = 17 + 7 = 24$ Repeat **arcs** AC, DG and GF	M1 A1 A1 A1 A1ft (5)
(b)	E.g. ADCACGDGFGECBEFBA Length of route $= 98 + 22 = 120\,(\text{km})$	B1 B1ft (2)
(c)	CF (8) is the shortest link between 2 odd nodes excluding D Repeat CF (8) since this is the shortest path excluding D. We finish at A Length of route = 98 + 8 = 106 (km)	 M1 A1ft A1ft (3) **10**
6. (a)	 ACDFEGH Length 71 (km)	M1 A1 (ABCD) A1ft (EF) A1ft (GH) A1 A1ft (6)
(b)	E.g. 71 – 12 = 59 GH 49 – 10 = 39 FE 24 – 13 = 11 CD 59 – 10 = 49 EG 39 – 15 = 24 DF 11 – 11 = 0 AC Or Trace back from H including arc XY if (Y already lies on the path and) the difference of the final values of X and Y equals weight of arc XY.	B2,1,0 (2)
(c)	ACBEGH Length 72 (km)	B1 B1 (2) **10**

Question Number	Scheme	Marks
7.		
(a)	see table below	B3,2,1,0 (3)
(b)		M1 A1 M1 A1 (4)
(c)	Critical activities are B D J H L	M1 A1 (2)
(d)		M1 A1 M1 A1 (4)

(a)

Activity	Proceeded by	Activity	Proceeded by	Activity	Proceeded by
(A)	(-)	E	A B	I	C D E
(B)	(-)	(F)	(B)	J	C D E
C	A B	(G)	(B)	K	F H I
(D)	(B)	H	C D	L	F G H I

Question Number	Scheme	Marks
7. (e)	E.g. Between time 7 and 16, 3 workers could do 3 x 9 = 27 days work. Activities C, D, E, F, G, H, I and 4 days of J need to be done This totals 31 days work. So it is not possible to complete the project with three workers. OR If three workers are used three activities H, J and I need to happen at time 13.5, this reduces the float on F and G, meaning that at 10.5 D, C, F and G need to be happening. Our initial assumption is incorrect hence four workers are needed.	 B3,2,1,0 (3) **16**
8.	Let x be the number of type A radios and y be the number of type B radios. $(\text{Maximise P} =) 15x + 12y$ Subject to $x \geq 50$ $\frac{1}{5}(x+y) < x$ (accept $\leq$) $[y < 4x]$ $\frac{2}{5}(x+y) > x$ (accept $\geq$) $[2y > 3x]$ $3x + 2y \leq 200$ $y \geq 0$	B1 B1 B1 B1 B1 B1 B1 **7**