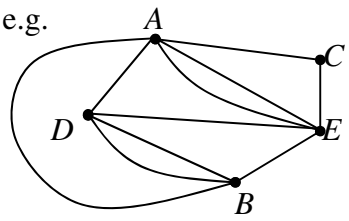
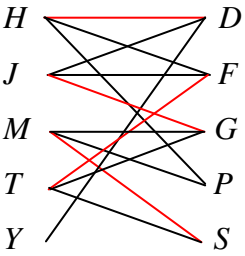
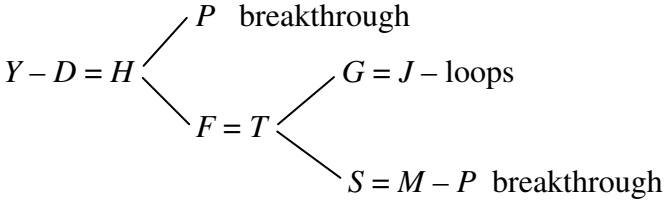
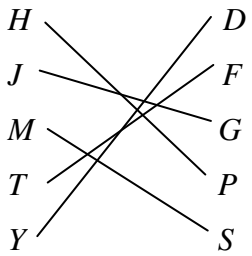
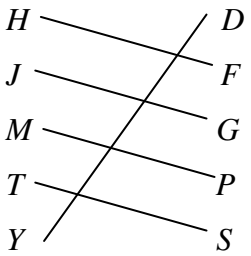
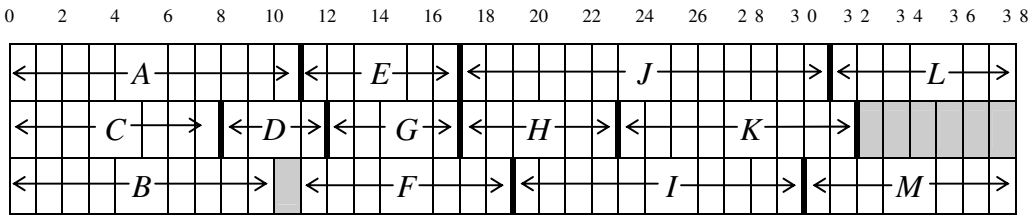
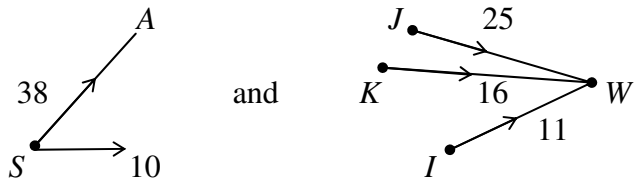
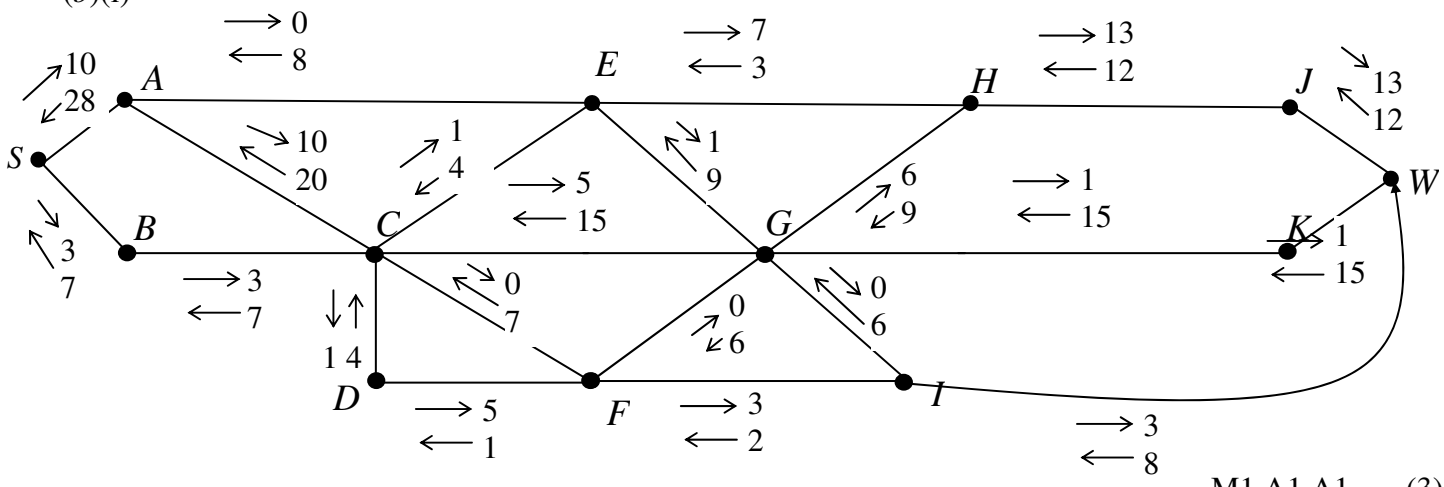
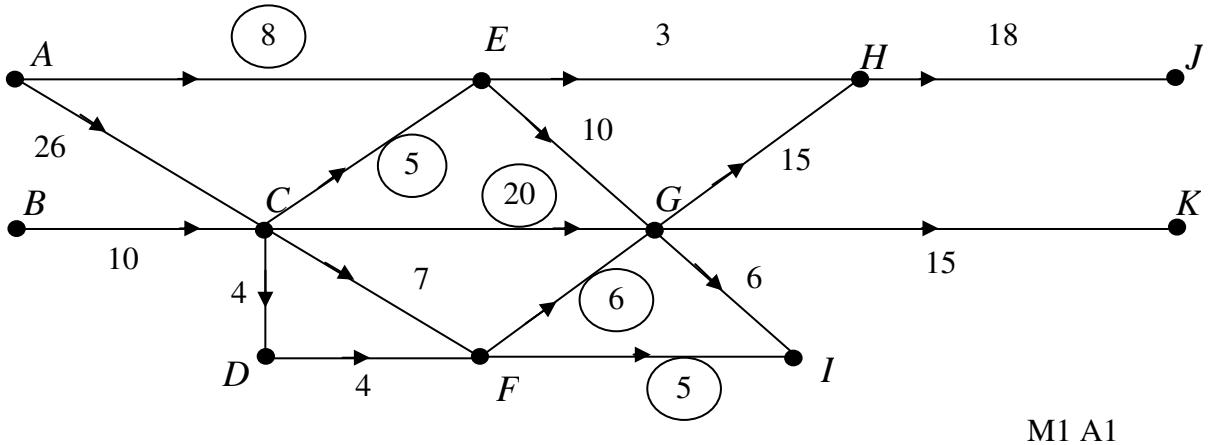
Question number	Scheme	Marks
1.	e.g.  Finding a Hamiltonian cycle, e.g. *A C E B D A* Re-drawing graph – Hamiltonian cycle at least Separating arcs into two sets correctly All correctly drawn	B1 M1 A1 A1 (4) **(4 marks)**
2. (*a*)		B1 B1 (2)
(*b*)	 changing status, the possible alternating paths are (i) $Y = D - H = P$ or (ii) $Y = D - H = F - T = S - M = P$ giving the following matching (i) or (ii) $H - P$ $J - G$ $M - S$ $T - F$ $Y - D$ $H - F$ $J - G$ $M - P$ $T - S$ $Y - D$  	M1 A1 A1 A1 (4) **(6 marks)**

Question number	Scheme	Marks
3.	$y + z \leq \frac{1}{2}x \quad \Rightarrow \quad 2(y+z) \leq x$	B1 (1)
	$y \geq \frac{10}{100}(x+y+z) \quad \Rightarrow \quad x + z \leq 9y$	M1 A1 (2)
	$y \geq \frac{20}{100}(x+y+z) \quad \Rightarrow \quad x + z \geq 4y$	M1 A1 (2)
	$z \geq \frac{1}{2}y \quad \Rightarrow \quad 2z \geq y$	B1
	$x \geq 0,\ y \geq 0,\ z \geq 0,$	
	$x + y + z \geq 250$	B1
	objective function: minimise; $c = 20x + 26y + 36z$	B1; B1 (4)
		(9 marks)
4. (*a*)	*B* and *E* are the only odd vertices, repeating a route between them will make them even	B1 (1)
(*b*)	$BA + AE = 17 + x$	
	$BD + DE = 2x + 9$	
	$BC + CE = 21$	M1 A1 (2)
(*c*)	$2x + 9 < x + 17$ and $2x + 9 < 21$	
	$x < 8$ and $x < 6$	M1 A1
	$\therefore\ 0 < x < 6$ for both to be true in context	A1 (3)
(*d*)	If $x = 7$, repeated route is $BC + CE$	B1
	Total time is $(3(7) + 47) + 21 = 89$	M1 A1 (3)
		(9 marks)

Question number	Scheme	Marks
5. (*a*)	$x = 31$, $y = 17$	B1 B1 (2)
(*b*)	A — E, J — L, C — D — G	M1 A1 (2)
(*c*)	$107 \div 38 = 2.8$ (1 d.p.) $\therefore$ 3 workers	M1 A1 (2)
(*d*)	For example,  	M1 A1 (critical value) A1 A1 (4) **(10 marks)**
6. (*a*)(i)	left to right **or** right to left	
(ii)	25 22 30 18 29 21 27 21 25 30 22 18 29 21 27 21 25 30 22 29 18 21 27 21 25 30 22 29 21 18 27 21 25 30 22 29 21 27 18 21 25 30 22 29 21 27 21 18 30 25 29 22 27 21 21 18 30 29 25 27 22 21 21 18 30 29 27 25 22 21 21 18 30 29 27 25 22 21 21 18 25 22 30 18 29 21 27 21 25 22 30 18 29 27 28 21 25 22 30 29 18 27 21 21 25 30 22 29 18 27 21 21 30 25 22 29 18 27 21 21 30 29 25 22 27 18 21 21 30 29 27 25 22 21 18 21 30 29 27 25 22 21 21 18 30 29 27 25 22 21 21 18	M1 A1 (1st pass) A1 A1 A1 cso (5)
(*b*)(i)	rod 1 30 18 2 29 21 3 27 22 4 25 21	M1 (to the 22) A1 (2)
(ii)	$193 \div 50 = 3.86$, $\therefore$ 4 rods needed, so minimum	M1 A1 (2) **(9 marks)**

Question number	Scheme	Marks
7. (*a*)		M1 A1 A1 (3)
(*b*)(i)		M1 A1 A1 (3)
	For example,	
	S B C D F I W – 3	M1 A1
	S A C G H J W – 5	A1
	S A C E G H J W – 1	A1 (4)
(ii)	Maximum flow 44	B1 (2)
	States valid cut *AE*, *CE*, *CG*, *FG*, *FI*	B1 (2)
(*c*)		M1 A1 (2)
		(14 marks)

Question number	Scheme	Marks
8. (*a*)	$2x + 3y + 4z \leq 8$	B1
	$3x + 3y + z \leq 10$	B1
	$P = 8x + 9y + 5z$	B1 (3)
(*b*)	↓	

b.v	x	y	z	r	s	Value
r	2	(3)	4	1	0	8
s	3	3	1	0	1	10
P	–8	–9	–5	0	0	0

↓

b.v	x	y	z	r	s	Value		
y	$\frac{2}{3}$	1	$\frac{4}{3}$	$\frac{1}{3}$	0	$\frac{10}{3}$	$R_1 \div 3$	A1
s	(1)	0	–3	–1	1	2	$R_2 - 3R_1$	M1
P	–2	0	7	3	0	24	$R_3 + 9R_1$	A1

b.v	x	y	z	r	s	Value		
y	0	1	$\frac{10}{3}$	1	$-\frac{2}{3}$	$\frac{4}{3}$	$R_1 - \frac{2}{3}R_2$	A1
x	1	0	–3	–1	1	2		M1
P	0	0	1	1	2	28	$R_3 + 2R_2$	A1 (8)

(*c*)	$P = 28$	M1
	$x = 2, \quad y = \frac{4}{3}$	A1
	$z = 0, \quad r = 0, \quad s = 0$	A1 (3)
		(14 marks)