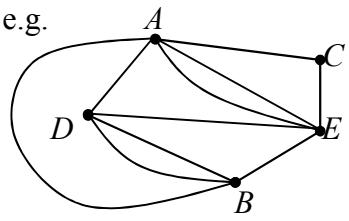
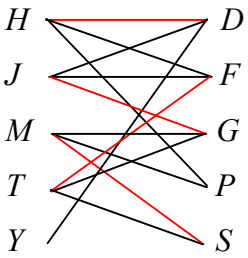
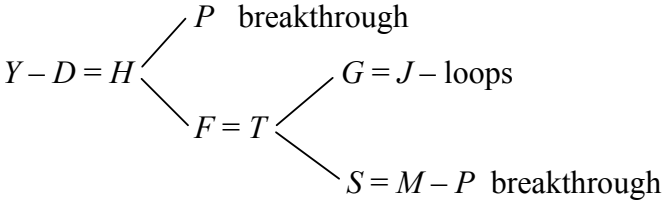
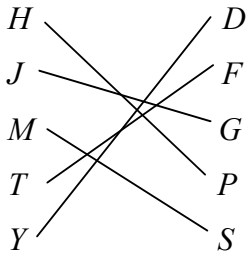
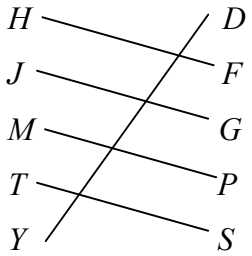
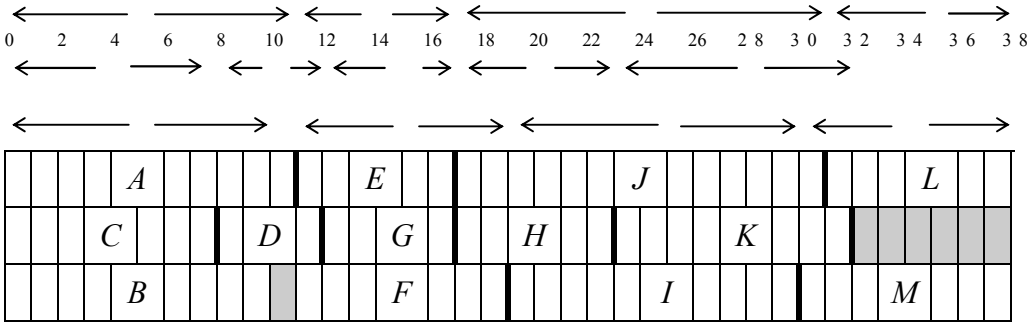
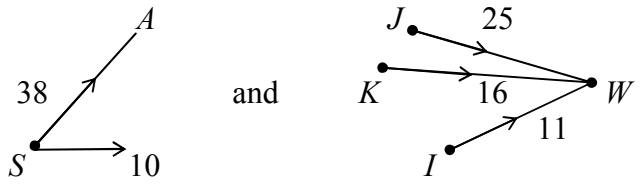
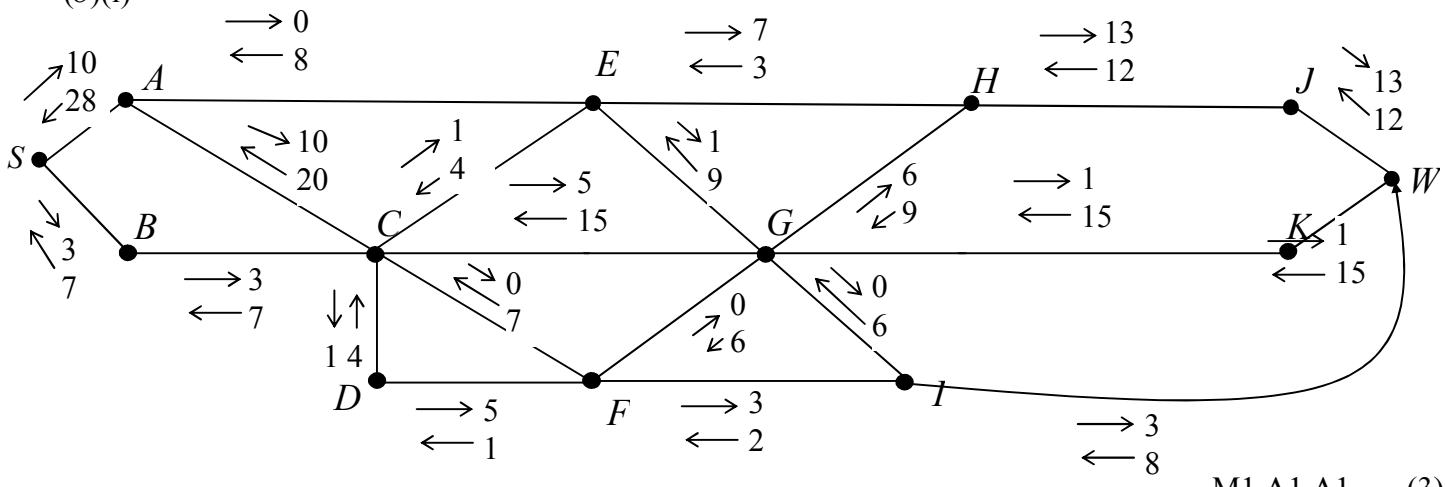
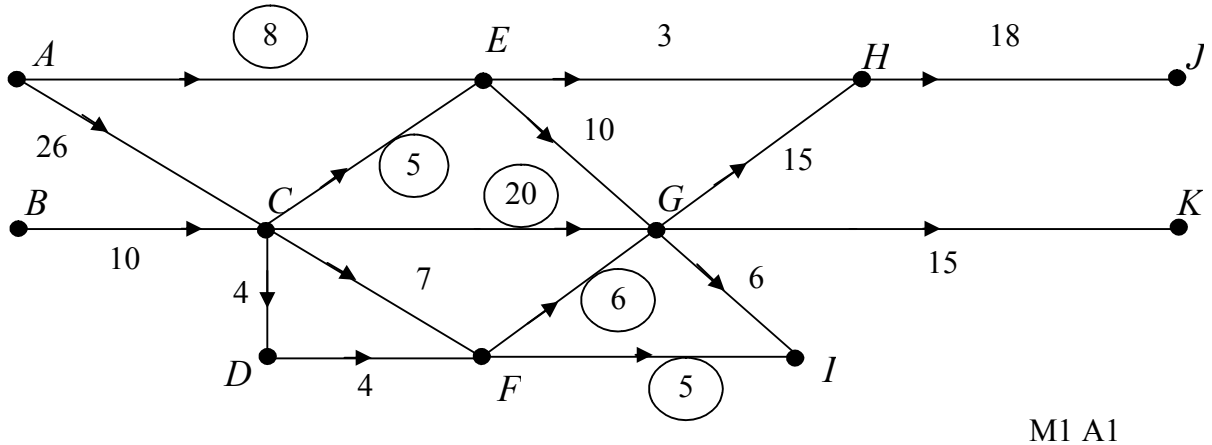
Question number	Scheme	Marks
1.	e.g.  Finding a Hamiltonian cycle, e.g. *A C E B D A* Re-drawing graph – Hamiltonian cycle at least Separating arcs into two sets correctly All correctly drawn	B1 M1 A1 A1 (4) **(4 marks)**
2. (*a*)		B1 B1 (2)
(*b*)	 changing status, the possible alternating paths are (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 25 22 30 18 29 21 27 21 — 25 22 30 18 29 21 27 21 25 30 22 18 29 21 27 21 — 25 22 30 18 29 27 28 21 25 30 22 29 18 21 27 21 — 25 22 30 29 18 27 21 21 25 30 22 29 21 18 27 21 — 25 30 22 29 18 27 21 21 25 30 22 29 21 27 18 21 — 30 25 22 29 18 27 21 21	M1 A1 (1st pass)
(ii)	25 30 22 29 21 27 21 18 — 30 29 25 22 27 18 21 21 30 25 29 22 27 21 21 18 — 30 29 27 25 22 21 18 21 30 29 25 27 22 21 21 18 — 30 29 27 25 22 21 21 18 30 29 27 25 22 21 21 18 — 30 29 27 25 22 21 21 18 30 29 27 25 22 21 21 18	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)

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	

M1

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

M1

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)