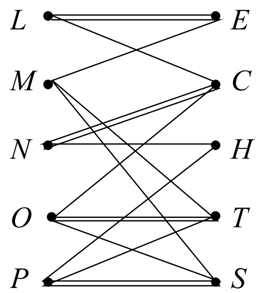
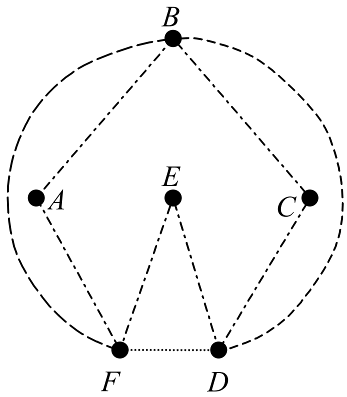
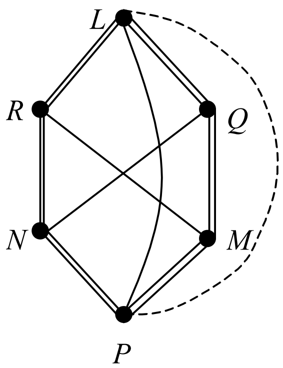
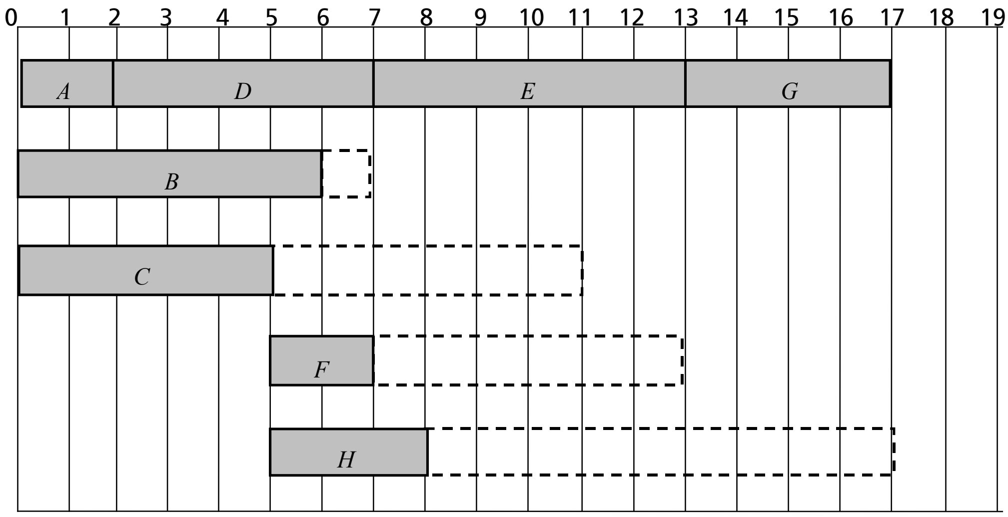
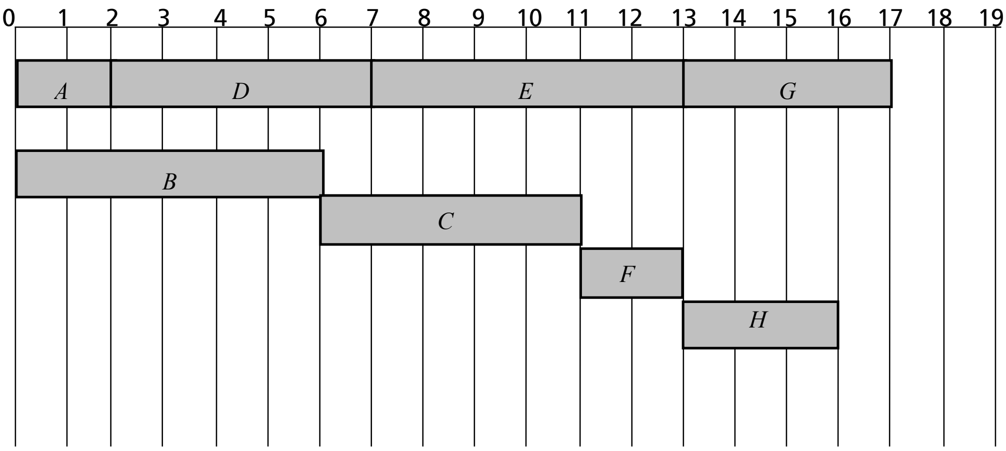
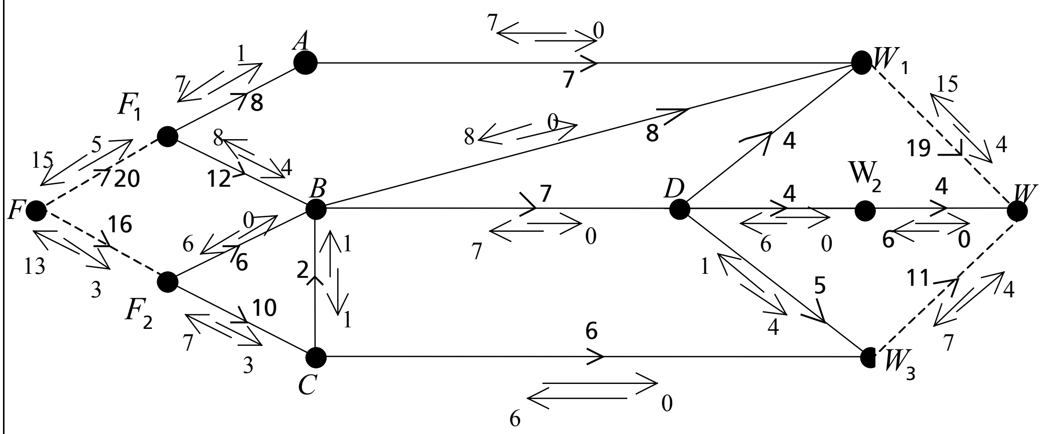
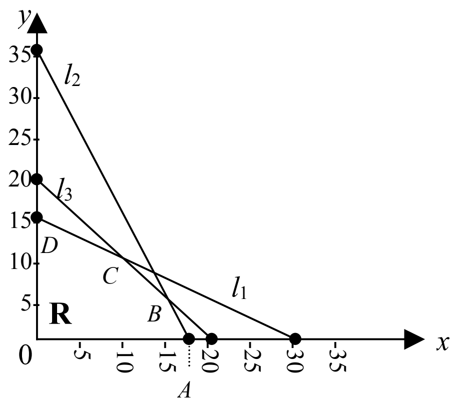
Question number	Scheme	Marks
1. (*a*)		
	Bipartite graph	B1 (1)
(*b*)	Initial matching	B1 (1)
(*c*)	Alternating path	
	$M - E = L - C = N - H$ (breakthrough)	M1 A1
	(Changing status) $M = E - L = C - N = H$	
	Complete Matching: Nice—Ham, Oliver—Tuna, Patel—Salmon, Moore—Egg, Large—Cheese	M1 A1 (4)
		(6 marks)
2. (*a*)	Vertices of odd valency $C(3)$, $D(3)$, $T(3)$, $N(3)$	M1
	Possible pairings (i) C & D and T & N	
	$13 + 2 = 15$	A1
	(ii) C & T and D & N	
	$4 + 12 = 16$	A1
	(iii) C & N and D & T	
	$3 + 10 = 13$	A1
	(iii) is min. So repeat CN & DT	M1
	Min distance $(7 + 6 + 4 + 10 + 8 + 8 + 2 + 3) + 13 = 61$ km	(5)
(*b*)	Possible route *ADTDBNTCNCA*	M1 A1 (2)
		(7 marks)

Question number	Scheme	Marks
3.	As there are 11 names in list, middle location is [(11 + 1)/2] = 6, i.e. FULLER	M1 A1
	GREGORY must occur <u>after</u> FULLER if at all, so list reduces to:	
	7 GRANT	
	8 GREGORY	
	9 LEECH	
	10 PENNY	
	11 THOMPSON	A1
	Middle location now [(11 + 7)/2] = 9, i.e. LEECH	
	GREGORY must occur before LEECH if at all, so list reduces to	
	7 GRANT	
	8 GREGORY	M1 A1
	Middle location now [(8 + 7)/2] = 8, i.e. GREGORY	
	The name GREGORY has been found at position 8	M1 A1 (7)
		(7 marks)

Question number	Scheme	Marks
4. (i)	Identify Hamiltonian circuit	
	Leave *FD* outside	
	Move *BD* outside	B1
	 Move *BF* outside	
	Now no intersections and so graph is planar	M1 A1 A1
	Redraw graph	M1
	Identify	
	 Hamiltonian circuit by the double line	B1
	Move *LP* outside	
	Leave *RM* inside	
	NQ crosses *RM* if inside and *LP* if outside $\therefore$ Non planar	M1 A1 A1 (9)
		(9 marks)

Question number	Scheme	Marks
5. (*a*)	Critical activities *ADEG*	
	Length of critical path 17 days	M1 A1 (2)
(*b*)	Floats B: $7 - 0 - 6 = 1$	
	C: $11 - 0 - 5 = 6$	
	F: $13 - 5 - 2 = 6$	
	H: $17 - 5 - 3 = 9$	M1 A1 A1 (3)
(*c*)		M1 A1 A1 A1 (4)
(*d*)		M1 A1
	Using its float of 6 activity C can be started when B is completed. Activity F also has a float of 6 and so can start when C has finished and can be completed without delaying the project. We only need to use 8 of the float on H to start H when F has finished. Therefore only 2 workers are required to complete project in given time.	A1 (3)
		(12 marks)

Question number	Scheme	Marks
6. (*a*)	Add F & W Capacities are $FF_1 \geq 20,\ FF_2 \geq 16$ $W_1W \geq 19,\ W_2W \geq 6,\ W_3W \geq 11$	M1 A1 A1 (3)
(*b*)		M1 A4
	In this pattern no further flow into W_1 possible, or into D, or into W_3. Suggests flow is maximal.	M1
	A flow value 28 is shown on above diagram. This flow is maximal as there is a cut consisting of arcs AW_1(7), BW_1 (8), BD (7) and CW_3 (6) of capacity 28. [Or there is a partition of the vertices $\{FF_1F_2ABC\}$ and $\{W_1W_2W_3DW\}$]	M1 A1 (8)
(*c*)	From maximal flow pattern (i) Number of lorry loads leaving F_1 is 8 + 7 = 15 Number of lorry loads leaving F_2 is 6 + 7 = 13	M1 A1
	(ii) Reaching W_1 15 lorry loads Reaching W_2 6 lorry loads Reaching W_3 7 lorry loads	M1 A1
	(iii) 8+6+1 or 8+7 = 15 lorry loads	B1 (5)
		(16 marks)

Question number		Scheme	Marks	
7.	(*a*)	Objective Max $P = 2.5x + 3.0y$	B1	
		Dept *A* $1.5x + 3y \le 45; 3x + 6y \le 90$	B1	
		Dept *B* $2x + y \le 35$	B1	
		Dept *C* $0.25x + 0.25y \le 5; x + y \le 20$	B1	
		$x \ge 0 \quad y \ge 0$	B1	(5)
	(*b*)	l_1 $3x + 6y = 90$ through $(0,15)(30,0)$	B1	
		l_2 $2x + y = 35$ through $(0,35)\left(17\frac{1}{2},0\right)$	B1	
		l_3 $x + y = 20$ through $(0,20)(20,0)$	B1	
				
		Feasible region	B1	(4)
	(*c*)	Vertices *O* is (0, 0)		
		A is $\left(17\frac{1}{2},0\right)$, *D* is $(0,15)$	B1	
		B intersection of $\left.\begin{array}{r}2x + y = 35\\ x + y = 20\end{array}\right\}\begin{array}{l}x = 15\\ y = 5\end{array}$		
		C intersection of $\left.\begin{array}{r}3x + 6y = 90\\ x + y = 20\end{array}\right\}\begin{array}{l}y = 10\\ x = 10\end{array}$	M1 A1 A1	
		$P_o = 0,\ P_A = 43.75,\ P_B = 52.5$		
		$P_C = 55,\ P_D = 45$	M1 A1	
		Max value *P* is £55 at $x = 10, y = 10$	A1	(7)
	(*d*)	l_1 & l_3 intersect at *C* and so are tight. Dept *B* (l_2) therefore has spare time. $35 - 2(10) - 10 = 5$ hrs.	M1 A1	(2)
				(18 marks)