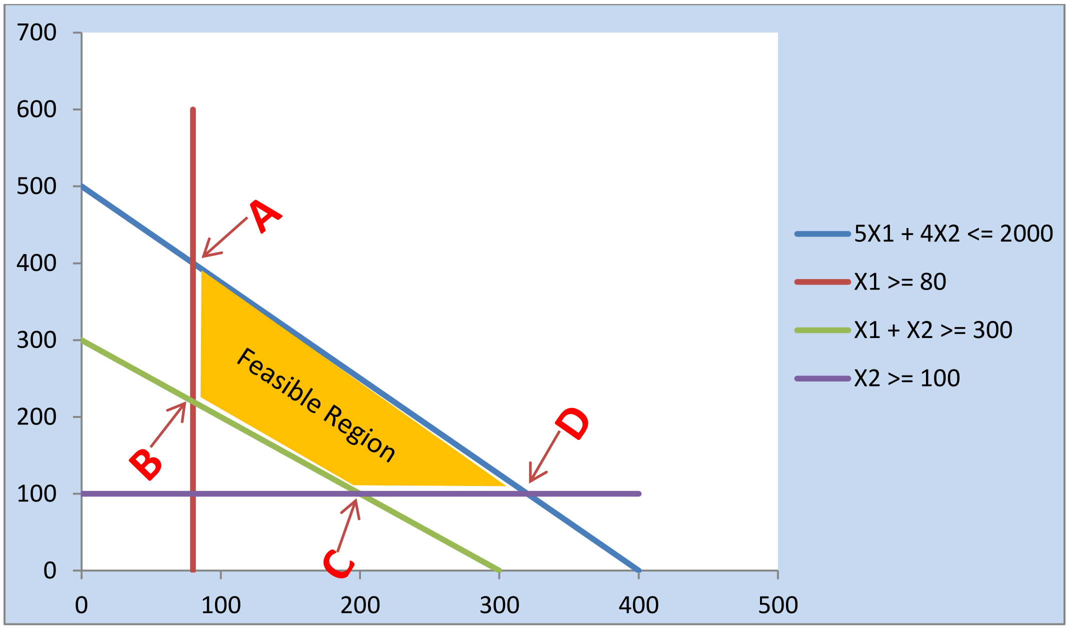
1)

a)



b) Point C (X_1 = 200, X_2 = 100) is the optimal point in the feasible region and the value of the objective function at that point is 7600.

Point	**X_1**	**X_2**	**Objective Function**
A	80	400	24(80) + 28(400) = 13120
B	80	220	24(80) + 28(220) = 8080
C	200	100	24(200) + 28(100) = 7600
D	320	100	24(300) + 28(100) = 10000

c) Constraints 3 and 4 are binding because the optimal point C occurs at the intersection of these two constraints. Also, the LHS and RHS of these constraints are equal indicating that there is no surplus whatsoever.

2) The question asks us to determine the optimal order quantity without any discounts; thus, we employ the basic EOQ model to solve it. We have the following information from the question:
D = 1,200 PCs
S = $450
H = $170 per PC per year

$$Q_{opt} = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2(1200)(450)}{170}} = 79.7 \approx 80$$

$$TC = \frac{D}{Q_{opt}}(S) + \frac{Q_{opt}}{2}(H) = \frac{1200}{80}(450) + \frac{80}{2}(170) = \$13{,}550$$

3) Since the question is about manufacturing, we use the EPQ model to solve it. We have the following information from the question:
D = 20,000 yards
H = $2.75 per yard
S = $720 per run
d = 2000/360 = 55.56 yards per day
p = 400 yards per day

Optimal run quantity, $Q_{opt} = \sqrt{\frac{2DS}{H}\left(\frac{p}{p-d}\right)} = \sqrt{\frac{2(20000)(720)}{2.75}\left(\frac{400}{400-55.56}\right)} = 3487.4\ yards$

Maximum inventory level, $I_{max} = \frac{Q_{opt}}{p}(p-d) = \frac{3487.4}{400}(400-55.56) = 3003\ yards$

Total inventory cost, $TC = \frac{D}{Q_{opt}}(S) + \frac{I_{max}}{2}(H) = \frac{20000}{3487.4}(720) + \frac{3003}{2}(2.75) = \$8258.28$

Run length = $\frac{Q_{opt}}{p} = \frac{3487.4}{400} = 8.72\ days\ per\ order$

4) First, we compute the EPQ for each price starting with the lowest price.

$$EOQ_{9.00} = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2(2000)(30)}{.35(9.00)}} = 195 \text{ (too small thus not feasible EOQ)}$$

$$EOQ_{9.50} = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2(2000)(30)}{.35(9.50)}} = 190 \text{ (feasible EOQ)}$$

$$EOQ_{10.00} = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2(2000)(30)}{.35(10.00)}} = 185 \text{ (too large thus not feasible EOQ)}$$

We now investigate the total costs at the feasible EOQ (190 units) and 500 units with the lowest price.

$$TC_{190} = \frac{D}{Q_{opt}}(S) + \frac{Q_{opt}}{2}(H) + RD = \frac{2000}{190}(30) + \frac{190}{2}(.35)(9.50) + 9.50(2000) =$$
\$19,631.67

$$TC_{500} = \frac{D}{Q_{opt}}(S) + \frac{Q_{opt}}{2}(H) + RD = \frac{2000}{500}(30) + \frac{500}{2}(.35)(9.00) + 9.00(2000) =$$
\$18,907.50

Hence, 500 valves is a better EOQ since the total cost is less than the EOQ of 190 valves.

5) Scenario 1 (only overtime and back order):

			1	2	3	4	5	6	Total
Forecast			400	200	300	400	500	200	2000
Output									
Regular			280	280	280	280	280	280	1680
Part-time									
Overtime			40	40	40	40	40	40	
Subcontracting									
Output – Forecast			-80	120	20	-80	-180	120	
Inventory									
Beginning			40	0	80	100	20	0	240
Ending			0	80	100	20	0	0	200
Average			20	40	90	60	10	0	220
Backorder		0	40	0	0	0	160	40	240
Costs									
Regular	@	20	5600	5600	5600	5600	5600	5600	33600
Part-time	@								0
Overtime	@	30	1200	1200	1200	1200	1200	1200	7200
Subcontracting	@								0
Hire/Layoff	@								0
Inventory	@	1	20	40	90	60	10	0	220
Backorder	@	5	200	0	0	0	800	200	1200
Total									42220

Scenario 2 (combination of overtime and subcontracting, and back order):

			1	2	3	4	5	6	Total
Forecast			400	200	300	400	500	200	2000
Output									
Regular			280	280	280	280	280	280	1680
Part-time									
Overtime			40	0	0	40	40	0	
Subcontracting			40	0	0	20	100	0	
Output – Forecast			-40	80	-20	-60	-80	80	
Inventory									
Beginning			40	0	80	60	0	0	180
Ending			0	80	60	0	0	0	140
Average			20	40	70	30	0	0	160
Backorder		0	0	0	0	0	80	0	80
Costs									
Regular	@	20	5600	5600	5600	5600	5600	5600	33600
Part-time	@								0
Overtime	@	30	1200	0	0	1200	1200	0	3600
Subcontracting	@	40	1600	0	0	800	4000	0	6400
Hire/Layoff	@								0
Inventory	@	1	20	40	70	30	0	0	160
Backorder	@	5	0	0	0	0	400	0	400
Total									44160

6)

Level	Item	W (1 unit) Quantity	W (100 units) Quantity
0	W	1	100
1	A	1	100
	B	2	200
	C	4	400
2	E	5 (4+1)	500
	F	2	200
	G	8	800
3	D	22 (2+12+8)	2200

An item's level is considered to be the lowest level that it appears in the BOM. In this case, item D is in level 3.

7) ***EOQ Method:***

In this method, the economic order quantity based on the following data is computed. Whenever there is a planned order release, it is made for this EOQ value. The data given in the problem are listed below.

Initial on-hand quantity = 35 units
The average demand/week (D) = 27 units
Carrying cost per unit per week (H) = \$1.00
Set-up cost per setup (S) = \$100.00

$$EOQ = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2 \times 27 \times 100}{1}} = 73.48 \approx 73\ units(approx.)$$

As per the assumption of planned order release amount equal to this EOQ value of 73 units, the MRP calculations for all the planned order releases, as shown in the following table.

Period		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Gross Requirement		35	30	40	-	10	40	30	-	30	55
Scheduled Receipts											
Projected on-hand	35	35	0	43	3	3	66	26	69	69	39
Net Requirement			30			7		4			16
Planned order receipts			73			73		73			73
Planned order release		73			73		73			73	

Part Period Method:

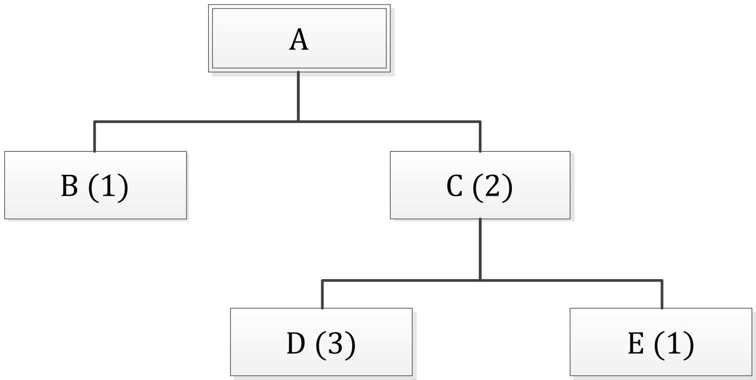
EPP = Setup cost/Holding cost = 100/1 = 100 units

Period when order is received**	**Demand**	**Lot Size (cumulative net requirement)**	**Extra Inventory**	**Period Carried**	**Part Period**	**Cumulative Part Period**
1	35	35	0	0	0	0
2**	30	30	0	0	0	0
3	40	70	40	1	40	40
4	0	70	40	1	40	40
5	10	80	10	3	30	70
6	40	120	40	4	160	230
6**	40	40	0	0	0	0
7	30	70	30	1	30	30
8	0	70	30	1	30	30
9	30	100	30	2	60	90
10	55	155	55	3	165	255
10**	55	55	0	0	0	0

MRP table based on the part period method:

Period		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Gross Requirement		35	30	40	-	10	40	30	-	30	55
Scheduled Receipts											
Projected on-hand	35	35	0	50	10	10	0	60	30	30	0
Net Requirement		0	30	0	0	0	40	0	0	0	55
Planned order receipts			80				100				55
Planned order release		80				100				55	

8) Product tree diagram:



Item A LT=1		Period (weeks)					
		1	**2**	**3**	**4**	**5**	**6**
Gross Requirement					250		100
Scheduled Receipts							
Projected on-hand	100	100	100	100	100	50	50
Net Requirement					150		100
Planned order receipts					200		200
Planned order release				200		200	

Item B LT=2		Period (weeks)					
		1	**2**	**3**	**4**	**5**	**6**
Gross Requirement				200		200	
Scheduled Receipts							
Projected on-hand					300	300	100
Net Requirement				200			
Planned order receipts				500			
Planned order release		500					

Item C LT=1		Period (weeks)					
		1	2	3	4	5	6
Gross Requirement				400		400	
Scheduled Receipts							
Projected on-hand	300	300	300	300	200	200	100
Net Requirement				100		200	
Planned order receipts				300		300	
Planned order release			300		300		

Item D LT=2		Period (weeks)					
		1	2	3	4	5	6
Gross Requirement			900		900		
Scheduled Receipts			2000				
Projected on-hand	100	100	100	1200	1200	300	300
Net Requirement							
Planned order receipts							
Planned order release							

Item E LT=1		Period (weeks)					
		1	2	3	4	5	6
Gross Requirement			300		300		
Scheduled Receipts							
Projected on-hand	50	50	50	250	250	450	450

Net Requirement		250		50		
Planned order receipts		500		500		
Planned order release	500		500			

9) <u>SPT rule:</u>
The job sequence is: A-D-E-C-B.

	(1)	(2)	(3)	(2) - (3)
Job sequence	**Processing time**	**Flow time**	**Due date**	**Days late (0 if negative)**
A	4	4	6	0
D	9	13	13	0
E	11	24	12	12
C	14	38	18	20
B	17	55	20	35
Total	**55**	**134**		**67**

- Average flow time: 134/5 = 26.8 days
- Average days late: 67/5 = 13.4 days
- Average WIP: 134/55 = 2.44 jobs

<u>EDD rule:</u>
The job sequence is: A-E-D-C-B.

	(1)	(2)	(3)	(2) - (3)
Job sequence	**Processing time**	**Flow time**	**Due date**	**Days late (0 if negative)**
A	4	4	6	0
E	11	15	12	3
D	9	24	13	11
C	14	38	18	20
B	17	55	20	35
Total	**55**	**136**		**69**

- Average flow time: 136/5 = 27.2 days

- Average days late: 69/5 = 13.8 days
- Average WIP: 136/55 = 2.47 jobs

<u>MST rule:</u>
The job sequence is: E-A-B-C-D or E-A-B-D-C.

	(1)	(2)	(3)	(3) – (1)	(2) - (3)
Job sequence	**Processing time**	**Flow time**	**Due date**	**Slack**	**Days late (0 if negative)**
E	11	11	12	1	0
A	4	15	6	2	9
B	17	32	20	3	12
C	14	46	18	4	28
D	9	55	13	4	42
Total	**55**	**159**			**91**

- Average flow time: 159/5 = 31.8 days
- Average days late: 91/5 = 18.2 days
- Average WIP: 159/55 = 2.89 jobs

<u>CR rule:</u>
The job sequence is: E-B-C-D-A.

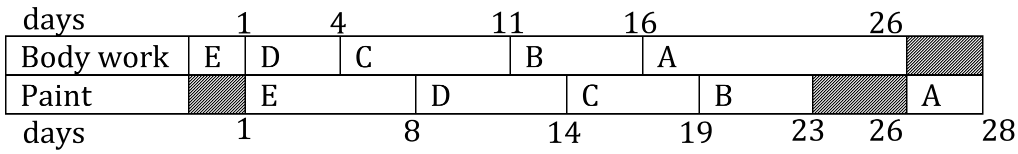
	(1)	(2)	(3)	(3) / (1)	(2) - (3)
Job sequence	**Processing time**	**Flow time**	**Due date**	**Critical Ratio**	**Days late (0 if negative)**
E	11	11	12	1.09	0
B	17	28	20	1.18	8
C	14	42	18	1.29	24
D	9	51	13	1.44	42
A	4	55	6	1.5	49
Total	**55**	**187**			**123**

- Average flow time: 187/5 = 37.4 days
- Average days late: 123/5 = 24.6 days
- Average WIP: 187/55 = 3.4 jobs

10)

a) Sequence of the jobs using the Johnson's rule:

E	D	C	B	A



b) Total Makespan = 28 days

c) Total idle time = 1+3+2 = 6 days