ENGINEERING TRIPOS PART IIA

Module 3E10: Operations Management for Engineers

Examples Paper III – CRIB

<u>Question 1</u>:

(a)

Boiler	Now	1	2	3	4	5	6	7	8	9
Gross requirements				10	10					20
Scheduled receipts			2				2			
Projected available balance	4	4	6	0	0	0	2	2	2	0
Net requirements				4	10					18
Planned order releases		4	10					18		

Assembly A	Now	1	2	3	4	5	6	7	8	9
Gross requirements		8	20					36		
Scheduled receipts				8		8			8	
Projected available balance	7	0	0	8	8	16	16	0	8	8
Net requirements		1	20					20		
Planned order releases		20					20			

Component B	Now	1	2	3	4	5	6	7	8	9
Gross requirements		240					240			
Scheduled receipts			60			60			60	
Projected available balance	60	0	60	60	60	120	0	0	60	60
Net requirements		180					120			
Planned order releases		180					120			

Component C	Now	1	2	3	4	5	6	7	8	9
Gross requirements		400					400			
Scheduled receipts		500				500				500
Projected available balance	900	1000	1000	1000	1000	1500	1100	1100	1100	1600
Net requirements										
Planned order releases										

(b) Various problems are evident with the above data:

- The requirement for 8 of sub-assembly A at beginning of week 1 cannot be met from stock and there is no time to make more. Part of the first delivery will be late.
- Stock level for Component C seems very high.
- Demand for products and components seem lumpy, e.g., zero demand in most weeks, and suddenly incurred large demand occasionally.
- MRP does not take into account capacity, so assumes this lumpy demand can be met. If this is indeed the case, the factory has excessive capacity. If not, the factory may fail to meet the requirements.

Various options to manage lumpy demand:

- If work force is multi-skilled, we can shift them between assembling A to assembling the boiler, thus smoothing the workload. If not workers will be idle most of the time.
- Sales force should negotiate smoother delivery plans – to stage the orders.
- Stock control should be improved, particularly for component C.
- Supplier relationships can be made better to negotiate deliveries to match requirements. All deliveries seem to be occurring with fixed batch sizes, maybe a flexible contract could be negotiated. (One of the criticisms Toyota receives, is that it is not Just-In-Time production along the whole supply chain, but Just-In-Time supply, i.e. while Toyota does not hold inventory, its suppliers do. This criticism is partly justified, but not completely as Toyota's suppliers still outperform other suppliers.)

(c) The company is far from JIT at the moment, with high stock levels and push scheduling. It can only use JIT if sufficient capacity existed to meet orders in short time. For example, could 20 boilers be delivered in week 9? If yes, JIT could be implemented. If no, it is of questionable relevance, as production would have to be triggered by a combination of lead-times, order size, and existing work load to meet due dates. In general, TPS tries to reduce:

1) Unpredictable downtime or yields
2) Time-consuming setups
3) Volatility in the mix and volume of customer demand

But principles of JIT, e.g., aiming to reduce stock and reduced set up times are good practice that could be implemented even if scheduling remains MRP.

(d) The requirement of batch size of one, no stock and full utilisation means that:

- All production requirements can be broken into tasks with fixed durations and there is no variability in production times.
- Every product must require exactly the same set of processes or must work with other products so that they can be combined to require one task at every station.
- There are no setup times.
- There are no defects or breakdowns.

- Schedules do not interact to cause delays.
- Customers require or accept products in the same rate as the system can produce them.
- All suppliers can supply materials one at a time, at exactly same rate without defects.
- The workforce can perform tasks without any variability or error.

These requirements are very strong and either impossible or very expensive to implement:

- All processes will contain some variability so perfect utilisation is impossible.
- It is unlikely that the system would make just one product without any variations, and variants are likely to create either some variation in process times and scheduling. It is also unlikely that only one product will have constant demand sufficiently long time, hence in reality flexibility will be needed.
- No process is perfectly reliable, hence defects and breakdowns can occur. The key feature of TPS is that the process is designed to minimise this (poke yoke). Further, TPS is designed to cope with uncertainty with its JIT scheduling, hence it does not assume defects will not occur.
- It is unlikely demand will be constant, so buffer stock must be kept to ensure excess demand can be handled, and production lines will be stopped to ensure no excess stock is produced when demand is less than normal.
- Humans are unlikely not to make any errors.

(e) The main lessons learned from JIT that apply universally are:

- Eliminate waste by thinking about material, equipment, handling and time
- Build self-repair and improvement into the process. Design the system thinking that deviations from the ideal will occur and these are opportunities to learn and can be pursued to design improvements.

- JIT motivates a different approach to operators – identifying and solving problems, collaborating to improve production efficiency, emphasising quality – all of which are relevant.

<u>Question 2</u>:

Pencil casings

Quarter		**1**	**2**	**3**	**4**
Gross Requirements		1000	1000	1000	1000
Scheduled Receipts			500		
On-hand	1600	600	100		
Net Requirements				900	1000
Planned Order Releases		900	1000		

Lead

Quarter		**1**	**2**	**3**	**4**
Gross Requirements		5000	5000	5000	5000
Scheduled Receipts					
On-hand	7500	2500			
Net Requirements			2500	5000	5000
Planned Order Releases		7,500		5,000	

<u>Week 1</u>:

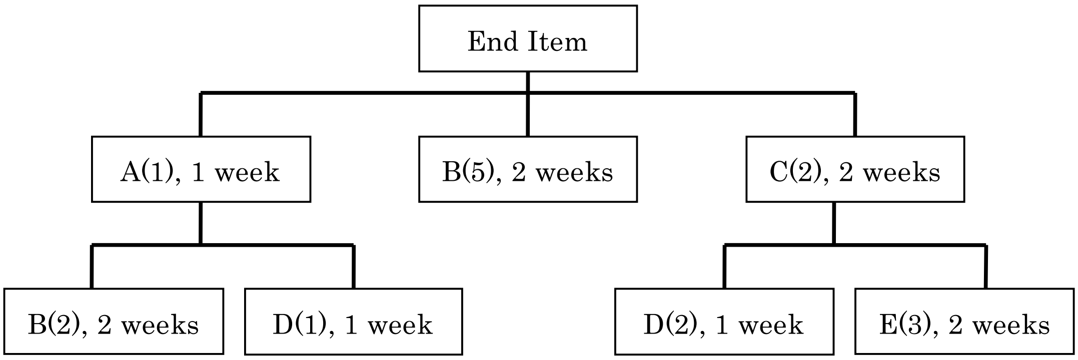
$c(1) = 150/2500 = 0.06$

$c(2) = (150+5000*0.5*0.05)/7500 = 0.036$ **(STOP!)**

$c(3) = (150+5000*0.5*0.05+5000*0.5*0.05*2)/12500 = .042$

<u>Question 3</u>:

(a)



(b) 4 weeks

(c)

Item A	1	2	3	4	5	6	7	8	9	10	11	12
Gross Requirements				100	50	100	200	100	50	100	200	100
Scheduled Receipts												
Net Requirements				100	50	100	200	100	50	100	200	100
Planned Order Release			100	50	100	200	100	50	100	200	100	

Item B	1	2	3	4	5	6	7	8	9	10	11	12
Gross Requirements			200	600	450	900	1200	600	450	900	1200	500
Scheduled Receipts				200		100						
Net Requirements			200	400	450	800	1200	600	450	900	1200	500
Planned Order Release	200	400	450	800	1200	600	450	900	1200	500		

<u>Question 4</u>: Lean approaches do have some potential disadvantages.

- Reputation and intangible effects may also make lean manufacturing less appealing. It is likely that any shop with a store on, e.g., Regent Street or Oxford Street in London incurs large wasted transportation costs due to the high traffic and limited access problems for delivery. However, due to the reputation of these shopping venues, it is profitable for the company to incur this waste.
- Lead times may be really important, e.g., MK Electric was happy to incur higher transportation costs and motion costs to fly plugs to the Middle East if a low lead time was of significant value to the deal.
- Inventory has several benefits - it is a buffer against uncertainty of supply or

demand, allows lower commodity costs/economics of scale to be taken advantage of, and allows the EOQ model to be used. These benefits may all suggest that inventory "waste" will be financially viable and increase stability in volatile markets, e.g., Mars and cocoa buying.

- Competitive effects - Nokia bought up the whole remaining stock when a key component provider's factory burnt down, forcing Ericsson to be bailed out by Sony as this was the sole provider. This was not lean but allowed them market domination.

Question 5:

(a)

$$1 - \rho = 1 - \frac{\lambda}{\mu} = 1 - \frac{4}{6} = 0.333.$$

(b)

$$W_q = \frac{\rho}{\mu(1-\rho)} = \frac{4/6}{6(1-4/6)} = \frac{1}{3}\ hours = 20\ mins$$

(c) 1.33.

$$L_q = \lambda\, W_q = 4 * \frac{1}{3} = 1.33$$

(d) At least one other student waiting in line is the same as at least two in the system. This probability is $1 - (P_0 + P_1)$.

$$P_n = \left(1 - \frac{\lambda}{\mu}\right)\left(\frac{\lambda}{\mu}\right)^n$$

$$P_0 = \left(1 - \frac{\lambda}{\mu}\right) = 0.3333$$

$$P_1 = \left(1 - \frac{\lambda}{\mu}\right)\left(\frac{\lambda}{\mu}\right) = 0.222$$

Probability of at least one in line is 1 - (0.3333 + 0.2222) = 0.4444.

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