ENGINEERING TRIPOS PART IIA

Module 3E10: Operations Management for Engineers

Examples Paper I - CRIB

Question 1:

A cement firm has a fixed cost of setting up production of £1,500 and a variable cost of production of £5.84 per kg. The company uses an interest rate of 13 percent to account for the cost of capital, and the annual cost of storage of cement amounts to 12 percent of the cement's value. The production is set up as a continuous process and runs all year round. The firm can manufacture at a rate of 10,000 kg per day, and faces an average daily demand of 2,400kg.

a) What is the optimal production quantity for the firm?

Answer:

demand	2400	
set up cost	1500	
variable cost of production	5.84	
interest	0.13	
	0.12	
rate of production	10000	
holding cost year	1.46	per kg per year
holding cost daily	0.004	per kg per day
Q	48666.42634	

b) What is the maximum level of on-hand inventory?

Answer:

batch q	48666
rate of production	10000
demand	2400
max inv	36986.16

c) What is the annual average cost of holding plus set up?

Answer:

daily		
demand		2400
set up cost		1500
batch q		48666
holding cost		0.004
rate of production		10000
	production cost	73.97361608
	inv cost	73.97232
total cost	per day	147.9459361
total cost	year	54000.26667

d) What percentage of each cycle consists of the production portion of the cycle?

Answer: 24%

e) If the variable costs of production were to change to £7.50 per kg, and the firm were to adjust its production accordingly so as to produce optimally, what percentage of each cycle would then consist of the production portion of the cycle?

Answer: It does not affect as only two variables are D and P.

f) Briefly discuss at least three reasons why the application of the EOQ is not always appropriate for deciding order sizes.

Answer: EOQ has rigid assumptions!

1. Demand is constant and steady, and continues indefinitely
2. EOQ assumes whole replenishment lot arrives at same time
3. Replenishment lead-time is known
4. Order size is not constrained by supplier, no min/max restrictions
5. Holding cost per item per period is a constant
6. Cost of ordering/setup is a constant
7. Item is independent of others; benefits from joint reviews are ignored
8. Doesn't encourage us to decrease fixed ordering/setup costs

Question 2:

The MS&E department coordinator who purchases blank paper for the copy machines must decide among three different suppliers. She can purchase paper from supplier A for £2.50 per pack, independent of the number of packs ordered. Supplier B provides paper for £2.40 per pack, but they do not accept orders for fewer than 3,000 packs. Supplier C provides paper for £2.30 per pack; however they do not accept orders for fewer than 4,000 packs. Assume a setup (ordering) cost of £100 and an annual requirement of 20,000 packs of paper. Also assume a 20% annual interest rate for holding cost calculations.

a) Which supplier should the coordinator order paper from? What should be the optimal order quantity of each order?

Answer: The coordinator should order papers from the supplier C and the optimal quantity of order equals to 4,000.

$$EOQ_A = \sqrt{\frac{2*100*20{,}000}{2.5*0.2}} = 2{,}828.42 \approx 2{,}828$$

Annual Cost of Ordering from the supplier A =

$$100*\frac{20{,}000}{2{,}828} + 2.5*0.2*\frac{2{,}828}{2} + 2.5*20{,}000 = 51{,}414.2$$

$EOQ_B = \sqrt{\frac{2*100*20{,}000}{2.4*0.2}} = 2{,}886.7 \approx 2{,}887$, which is less than 3,000. Thus, the optimal lost size with the supplier B would be 3,000.

Annual Cost of Ordering from the supplier B =

$$100*\frac{20{,}000}{3{,}000} + 2.4*0.2*\frac{3{,}000}{2} + 2.4*20{,}000 = 49{,}386.6$$

$EOQ_C = \sqrt{\frac{2*100*20{,}000}{2.3*0.2}} = 2{,}948.8 \approx 2{,}949$, which is less than 4,000. Thus the optimal lost size with the supplier C would be 4,000.

Annual Cost of Ordering from the supplier C =

$$100*\frac{20{,}000}{4{,}000} + 2.3*0.2*\frac{4{,}000}{2} + 2.3*20{,}000 = 47{,}598.2$$

b) If the replenishment lead-time for paper is 2 months, determine the reorder point.

Answer: R = 20,000*0.1667 yrs = 3,333

c) Now suppose there exists only Supplier A from part (a) and a new supplier, Supplier D (Suppliers B and C do not exist). Supplier D's cost per pack is £2.55. However, Supplier D has an online ordering interface which may significantly reduce the MS&E coordinator's ordering cost. Determine the ordering cost at which the coordinator is indifferent between Supplier A and Supplier D.

Answer: Let K be the ordering cost from the supplier D. From part (a), we already have calculated the optimal annual cost with the supplier A, which is 51,414.2

Then we want to find out K which satisfies

$$\boldsymbol{K * \frac{20,000}{\sqrt{\frac{2 * K * 20,000}{2.55 * 0.2}}} + 2.55 * 0.2 * \frac{\sqrt{\frac{2 * K * 20,000}{2.55 * 0.2}}}{2} + 2.55 * 20,000 = 51,414.2}$$

After simplification, we get $142.82\sqrt{K} = 414.2$, thus K = 8.4.

Question 3:

A manufacturing company is setting up a new factory and considering two options for the key processing equipment:

Processing Option 1: A single machine A directly feeding a single machine B;
Processing Option 2: Four machines C in parallel, directly feeding any one of four machines D in parallel.

The product produced by the route AB is identical to that produced by the route CD. The factory works for eight hours per day. Processing and setup times for the four machine types are given in the table below:

Processing Option	Machine	Process time (seconds)	Setup time (seconds)
1	A B	6 8	1500 1000
2	C D	40 50	50 20

a) For both processing options above, calculate the daily capacity of the new factory, for the cases where batch size is 10 and 500.

b) For both processing options, and for both batch sizes:

(i) Calculate the utilisation rate for all four machine types, defined as the % of time in which the machine is processing.
(ii) Explain why your results differ for the two batch sizes.

Answer: Assuming

- set ups done on machines C and D in series [i.e., by one person]
- dividing production evenly between all C and D machines; e.g., batch of 10 will be completed on each C machine with 2.5 items [on average]
- setting up in between batches of the same product seems odd but it can happen – for example – due to different maintenance policies

1 (a)

Option		Machine	Process Time	Set up Time	
	1	A	6	1500	
		B	8	1000	
	2	C	40	50	
		D	50	20	
Batch Size			10	500	
Option 1					
Total time on A			1560	4500	all calcs per batch
Total time on B			1080	5000	
Longer Time			1560	5000	
Ave Time / Prod			156	10	
Daily Capacity			184	2880	
Option 2					
Total time on C			300	5200	
Total time on D			205	6330	
Longer Time			300	6330	
Ave Time / Prod			30	12.66	
Daily Capacity			960	2274	

1 (b)

Option		Machine	Process Time	Set up Time	
	1	A	6	1500	
		B	8	1000	
	2	C	40	50	
		D	50	20	
Batch Size			10	500	
Option 1					
Total process time on A			60	3000	all calcs per batch
% utilisation A			4	60	
Total process time on B			80	4000	
% utilisation B			5	80	
Option 2					
Total process time on C			100	5000	
% utilisation A			33	79	
Total process time on D			125	6250	
% utilisation B			42	99	

Question 4:

Trimble Navigation produces a Global Positioning Unit (GPU) which is used in automobile navigation systems by other manufacturers. The demand and cost data for GPU over the next six weeks are as follows.

Week	1	2	3	4	5	6
Demand	150	100	200	160	200	80
Set-up Cost	150	150	150	150	200	100
Holding Cost	0.5	0.6	0.5	0.6	0.5	0.6

Initial and final inventory are zero, and the holding cost is per unit held/period for all periods. Assume that the production lead-time is equal to zero and that no shortages are allowed. Holding costs are incurred at the end of a period. Determine production lot sizes over the next 6 periods using the Least Unit Cost (LUC) heuristic. Show your calculations. What is the total cost?

Answer: The solution is (1, 0, 1, 0, 1, 0) = (250, 0, 360, 0, 280, 0). The total cost is: (150+100*.5) + (150+160*.5) + (200+80*.5) = 200+230+240= $670. See the calculations below:

Week 1:
$c(1) = 150/150 = 1$
$c(2) = (150+100*.5)/250 = 0.8$ **(STOP!)**
$c(3) = (150+100*.5+200*1.1)/450 = .933$

Week 3:
$c(3) = 150/200 = 0.75$
$c(4) = (150+160*.5)/360 = .64$ **(STOP!)**
$c(5) = (150+160*.5+200*1.1)/560=0.804$

Week 5:
$c(5) = 200/200 = 1$
$c(6) = (200+80*.5)/280 = 0.86$