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1.) (a) ① $M = P - 20$

② $D = 80 - P + A$

③ $C_{ad} = A^2$

decision variable => • P = price

• A = advertising //

objective function => max $z = (P-20)(80-P+A) - A^2$

⇓

lagrangian multiplier => $P + A \leq 50$ => $\lambda(50 - P - A)$

max $z = (P-20)(80-P+A) - A^2$

subjected to $P + A \leq 30$ //

(b) $z = (P-20)(80-P+A) - A^2$

$L = (P-20)(80-P+A) - A^2 + \lambda(50-P-A)$

$\frac{\partial L}{\partial z} = 100 - 2P + A - \lambda = 0$ ... ①

$\frac{\partial L}{\partial A} = P - 20 - 2A - \lambda = 0$ ... ②

$\frac{\partial L}{\partial \lambda} = 50 - P - A = 0$ ... ③

① & ②

$100 - 2P + A - \lambda = 0$

$-(P - 20 - 2A - \lambda) = 0$

$120 - 3P + 3A = 0$

$40 - P + A = 0$

$A = P - 40$

subs ③

$50 - P - (P - 40) = 0$

$-2P + 90 = 0$

$P = 45$ //

$A = 45 - 40$

$A = 5$ //

$z = (45-20)(80-45+5) - 5^2$

$= \$\,975$ //

(c) • $\pi = P - 20 - 2A$
$= 45 - 20 - 10$
$= 15$

Jadi, setiap max. cap tumbuh 1, laba akan naik seberar $ 15 per unit.

2.) • $w_1 + w_2 + w_3 + w_4 \leq 5$
• $w_1, w_2, w_3, w_4 = 0$ or 1
• max $v_i = w_1 + w_2 + w_3 + w_4$

① stage 1 [coffee bean]

S1	D1	W1	R1	E
5	1	4	80	
4	1	4	80	
3	0	0	0	
2	0	0	0	
1	0	0	0	
0	0	0	0	

② stage 2 (coffee bean + Beef rendang)

S2	D2	W2	R2	SISA	S1	R1	E
5	1	3	60	2	0	0	
4	1	3	60	1	0	0	
3	1	3	60	0	0	0	
2	0	0	0	2	0	0	
1	0	0	0	1	0	0	
0	0	0	0	0	0	0	

② stage 1 (coffee bean + beef rendang)

S2	D2	W2	R2	SISA	D1	R1	E
5	1	3	60	2	0	0	60
	0	0	0	5	1	4	80
4	1	3	60	1	0	0	60
	0	0	0	4	1	4	80
3	1	3	60	0	0	0	60
2	0	0	0	2	0	0	0
1	0	0	0	1	0	0	0
0	0	0	0	0	0	0	0

③ stage 3 (coffee bean + beef rendang + lapis cake)

S3	D3	W3	R3	sisa	B2	R1+R2	ξ
5	2	4	100	1	0	0	100
	1	2	50	3	1	60	110
4	2	4	100	0	0	0	100
	1	2	50	2	0	0	50
3	1	2	50	1	0	0	50
	0	0	0	3	1	60	60
2	1	2	50	1	0	0	50
1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

④ stage 4 (coffee bean + beef rendang + lapis cake + batik skirt)

S4	D4	W4	R4	sisa	D3	R1+R2+R3	ξ
5	5	5	100	0	0	0	100
3	3	3	60	2	1	50	110
1	1	1	20	4	2	100	120
4	4	4	80	1	0	0	80
2	2	2	40	3	1	50	90
0	0	0	0	0	0	0	0

Batik = 1 kg => 1 pcs

lapis cake = 4 kg => 2 pcs

3.)

	A to	B to	C to
A	0,7	0,3	0,1
B	0,2	0,6	0,4
C	0,1	0,1	0,5

(a) Transition matrix

$$P = \begin{bmatrix} P_{AA} & P_{AB} & P_{AC} \\ P_{BA} & P_{BB} & P_{BC} \\ P_{CA} & P_{CB} & P_{CC} \end{bmatrix}$$

$$= \begin{bmatrix} 0,7 & 0,2 & 0,1 \\ 0,3 & 0,6 & 0,1 \\ 0.10 & 0,4 & 0,5 \end{bmatrix}$$

(b) week 0 => $A_A(0) = 1$

$B_A(0) = 0$

$C_A(0) = 0$

$w_0 \; [A_A(0) \; B_A(0) \; C_A(0)] = [1 \; 0 \; 0]$

$w_1 \; [A_A(1) \; B_A(1) \; C_A(1)] = [1 \; 0 \; 0] \begin{bmatrix} 0,7 & 0,2 & 0,1 \\ 0,3 & 0,6 & 0,1 \\ 0,1 & 0,4 & 0,5 \end{bmatrix}$

$= [0,7 \quad 0,2 \quad 0,1]$

$w_2 \; [A_A(2) \; B_A(2) \; C_A(2)] = [0,7 \quad 0,2 \quad 0,1] \begin{bmatrix} 0,7 & 0,2 & 0,1 \\ 0,3 & 0,6 & 0,1 \\ 0,1 & 0,4 & 0,5 \end{bmatrix}$

$= [0,56 \quad 0,3 \quad 0,14]$

$B_A(2) = 0,3$ //

(c) $[A_A \; B_A \; C_A] = [A_A \; B_A \; C_A] \begin{bmatrix} 0,7 & 0,2 & 0,1 \\ 0,3 & 0,6 & 0,1 \\ 0,1 & 0,4 & 0,5 \end{bmatrix}$

- $A_A = 0,7A_A + 0,3B_A + 0,1C_A \quad \times 10 \Rightarrow 7A_A + 3B_A + C_A \; \ldots ①$
- $B_A = 0,2A_A + 0,6B_A + 0,4C_A \quad \times 10 \Rightarrow 2A_A + 6B_A + C_A \; \ldots ②$
- $C_A = 0,1A_A + 0,1B_A + 0,5C_A \quad \times 10 \Rightarrow 1A_A + 3B_A + 5C_A \; \ldots ③$

$A_A + B_A + C_A = 1 \; \ldots ④$

① C_A => $A_A = -B_A - 5C_A$

② $-2B_A - 10C_A + 6B_A + C_A = 0$

$4B_A - 9C_A = 0$

$B_A = \frac{9}{4} C_A$

① $7A_A - 3A_A - 15C_A + C_A = 0$

$4A_A = 14C_A$

$A_A = \frac{14}{4} C_A$

④ $\Rightarrow \frac{14}{4} C_A + \frac{9}{4} C_A + C_A = 1$

$C_A = \frac{4}{27} = 0,148 \approx 0,15$

② B_A => ② - ③

$2A_A + 6B_A + C_A = 0$

$2A_A + 2B_A + 10C_A = 0$ -

$4B_A - 9C_A = 0$

$4B_A = 9C_A$

$B_A = \frac{9}{4} \times \frac{4}{27}$

$B_A = 0,33$

③ AA = 1 - 0,33 - 0,15
AA = 0,52

Jadi, AA = 0,52 ≈ 52 %.
BA = 0,33 ≈ 33 %.
CA = 0,15 ≈ 15 %. //

4.) (a) Average number of customer & time
- Arrival rate (λ) = 1/5 × 60 = 12 cust / hour
- service rate (M) = 1/4 × 60 = 15 cust / hour
- cust. waiting cust = 20 / hour / customer
- officer salary = 12 / hour / officer

Normal single server
- Avg number of customer (L) = $\frac{\lambda}{M-\lambda} = \frac{12}{15-12}$ = 4 hours //
- Avg. time in system (W) = $\frac{L}{\lambda} = \frac{4}{12} = \frac{1}{3}$ = 20 mins //

(b) c = 2 servers

$$P_0 = \left[\sum \frac{1}{n!}\left(\frac{\lambda}{M}\right)^n + \frac{1}{a}\left(\frac{\lambda}{M}\right)^c \left(\frac{cM}{cM-\lambda}\right)\right]^{-1}$$

$$= \left[\frac{1}{0!}\left(\frac{12}{15}\right)^0 + \frac{1}{1!}\left(\frac{12}{15}\right)^1 + \frac{1}{2!}\left(\frac{12}{15}\right)^2 \left(\frac{2(15)}{2(15)-12}\right)\right]^{-1}$$

$$= [(1+0,8) + 0,533]^{-1}$$

$$= 3/7 \approx 0,429 \text{ //}$$

(c) $W_c = W - \frac{1}{M} = L_q/\lambda$

$L_q = L - \lambda/M$

$$= \frac{\lambda M (\lambda/M)^c}{(c-1)!\,(cM-\lambda)^2}(P_0) + \frac{\lambda}{M}$$

$$= \frac{12(15)(12/15)^2}{(2-1)!\,(2(15)-12)^2}\left(\frac{3}{7}\right) + \frac{12}{15}$$

$$= \frac{20}{21} \approx 0,952$$

$W = \frac{L_q}{\lambda}$ $\quad W = 100/21 \approx 4,76$

$$= \frac{\frac{20}{21}}{12}$$

(d)	1 officer	2 officer
W	20 m	4,8 m
L	4	1
waiting cust / hours	$ 80	$ 20
officer cost	$ 12	$ 24

1 officer cost / hour = $ 92
2 officer cost / hour = $ 44
saving / hour = $ 48

Ya, segar bugar express perlu menambah 1 officer lagi agar dia dapat menghemat $ 48 per jam.

5.) ~~demand / outcome~~ / demand PROB A / ΣP(A) / Range (A)

Demand outcome	P(A)	ΣPA	Range A	P(B)	ΣP(B)	Range B
4 Batches	0,4	0,4	00-39	0,3	0,3	00-29
6 Batches	0,6	1	40-99	0,7	1	30-99

simulation table

Day	Range A	DO A	Range B	DO B
1	25	4 batcher	88	6 batches
2	63	6 batches	12	4 batches
3	85	6 batcher	95	6 batches
4	10	4 batches	45	6 batches
5	50	6 batches	70	6 batches

	Cost	Price	Stockout	Inventory
P(A)	300	500	100	20
P(B)	500	800	200	40

Table A

Day	DO A	Surplus	Shortage	Rev A	Stockout	Inventory	Cost	Profit
1	B 4	1		2000	0	20	1.500	980
2	B 6		1	2500	100	0	1500	900
3	B 6		1	2500	100	0	1500	900
4	B 4	1		2000	0	20	1500	480
5	B 6		1	2500	100	0	1500	900

Table B

Day	DO B	surplus	shortage	Rev B	stockout	inventory	cost	Profit
1	B 6		1	4.000	200	0	2500	1.300
2	B 4	1		3200	0	40	2500	660
3	B 6		1	4000	200	0	2500	1300
4	B 6		1	4000	200	0	2500	1300
5	B 6		1	4000	200	0	2500	1300

Profit

Day	Profit A	Profit B	Σ Profit
1	480	1.300	1.780
2	900	660	1.560
3	900	1300	2.200
4	480	1300	1.780
5	900	1300	2.200

//

queuing & machine time (inter-arrival time)

outcomes	Probability	RN Range
45	0,3	00 - 29
50	0,4	30 - 69
55	0,3	70 - 99

service time

outcomes	Probability	RN - Range
45	0,2	00 - 19
50	0,6	20 - 79
55	0,2	80 - 99

Batch	RNIA	IA	ΣIA	RNS	service	Start	Finish	wait	time
1	15	45	45	92	55	45	100	0	55
2	54	50	95	50	50	100	150	5	55
3	88	55	150	10	45	150	195	0	45
4	40	50	195	65	50	200	250	0	50
5	05	45	240	85	55	250	305	5	60
								10	265

Avg waiting time = $10/5$ = 2 mins
Avg time in system = $265/5$ = 53 mins
Avg service time = $255/5$ = 51 mins