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1a) Fixed:

	M/C1 €k	M/C2 €k
Purchase	50	100
Salvage	5	10
Maintenance	1	1.5

Annual Costs ⇒ $\boxed{50k + 5(PWF') + 1(PWF)}\boxed{CRF}$ - M/C1

$PWF_1 = 3.352 \quad PWF_1' = 0.\cancel{4}97$

$= 16.66k$

$PWF_2 = 4.487 \quad PWF_2' = 0.327$

M/C2 ⇒ $= 24.52k$

Costs per Component:

Machine operation	2.67	1.20
Raw materials	2	2
Overheads	1	0.60
	5.67	3.80

Equal Economy:

$$16.66k + 5.67q = 24.52k + 3.8q$$

$$q = 4203 \text{ items}$$

b) d=6,000 Tax = 25% Gross rev. = €54k

Cost M/C1 = €50,680 Dep. = €12.5k

Cost M/C2 = €47,320

Var. Cost M/C2 = €22,800

Gross Profit = 54k - 22.8k - 1.5k

= 29.7k

After tax profit from sale = €7,500

After tax = €22,275 + 12.5k(0.25)

= €25,400

PV = -100k + 25.4k[PWF] + 7.5k[PWF']

= 13.98k ⇒ Criterion is met

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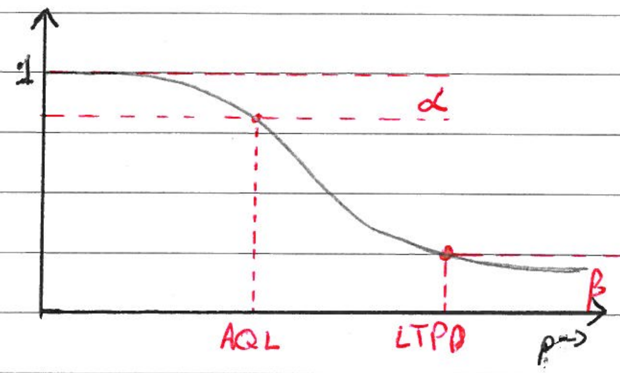
2.c) Producer's Risk: The probability that a good batch will be rejected

Consumer's Risk: The probability that a bad batch will be accepted on the findings of sampling

AQL: The maximum number of defects that may be present in an acceptable batch

Operating Characteristic Curve:



Poisson: $P(r) = \frac{1}{r!} e^{-z} z^{r}$

$c \le 2$

$AQL = 2\%$ $\quad \alpha = 1$

$LTPD = 7\%$ $\quad \beta = 3.5$

Producer's Risk:

$$P(A) = e^{-1} + \cancel{z}e^{-1} + \frac{1}{2}e^{-1}$$
$$= 0.9197$$

Producer's Risk $= 1 - 0.9197 = 8.03\%$

2 b) Allowable drift is the area between the upper and lower production means, $\bar{x}_u$ & $\bar{x}_L$, from which an item is still deemed acceptable.

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3. $p = 15{,}000$ $\quad LT = 4$ weeks

$d = 1{,}000$ $\quad \delta = 1$ week

$M = €2$ $\quad z = 2{\cdot}327$

$C_s = €500$ $\quad C_H = €0{\cdot}01\bar{2}$ /wk

$$R.O.L. = d\,LT + z\,\delta_{LT}$$

$$= 6{,}327$$

Safety Stock = 2,327 items

Average stock = $B + \frac{x}{2}$

Cost of holding = $C_H\left(B + \frac{x}{2}\right)$

$x = T_p(p-d)$, $Q = pT_p$

Cost of holding avg. stock = $C_H\left[B + \frac{Q}{2}(1 - d/p)\right]$

Setup cost p.u. time = $\frac{C_s}{T_c} = \frac{C_s d}{Q}$

Total Cost = $Md + C_H\left[B + \frac{Q}{2}(1-d/p)\right] + \frac{C_s d}{Q}$

Optimum $\rightarrow \frac{dC}{dQ} = 0$

$$\frac{C_s d}{Q^2} = \frac{C_H}{2}(1 - d/p)$$

$$Q_{EOQ} = \sqrt{\frac{2C_s d}{C_H(1-d/p)}} = 10{,}351 \text{ items}$$

Min $C_{var} = C_H\left[\frac{Q}{2}(1-d/p)\right] + \frac{C_s d}{Q}$

$= €96{\cdot}61$

$1{\cdot}1\,C_{var} = €106{\cdot}27 \Rightarrow 0{\cdot}004\dot{6}\,Q + \frac{1}{Q}(5\times10^5)$

$Q = 16{,}129$ or $6{,}642$

3b) $M = €2 \cdot 50$

$C_S = €70$

Average Stock $= \frac{Q}{2} + B$

$$Q_{eoq} = \sqrt{\frac{2C_S d}{C_H}} = 3,741$$

$$C_1 = Md + C_H\left[B + \frac{Q}{2}\left(1 - \frac{d}{p}\right)\right] + \frac{C_S d}{Q}$$

$$= €2119.88$$

$$C_2 = Md + C_H\left[B + \frac{Q}{2}\right] + \frac{C_S d}{Q}$$

$$= €2,560.69$$

Manufacture is cheaper

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4a) Cost control using crash cost:

- The critical path is shortened first
- The element with the lowest crash cost is shortened
- Other paths may become critical as the original critical path is shortened
- All critical paths must then be shortened ~~toget~~ simultaneously

Activity	Mean	δ^2	Total Float
A	4	$4/36$	16
B	6	$16/36$	3
C	9	$64/36$	0
D	3	$4/36$	11
E	14	$36/36$	0
F	3	$4/36$	11

$$\text{Mean} = \frac{a+b+4m}{6}$$

$$\delta = \frac{(b-a)^2}{36}$$

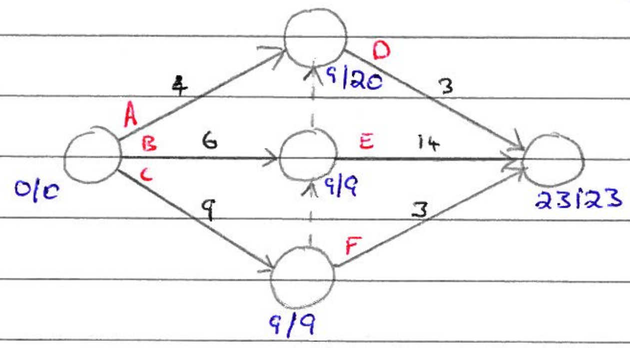
Critical Path = C-Dummy-E

$$Z = \frac{-2}{\delta_{cp}} = -0.72$$

Area under curve

$= 1 - 0.7642$

$\Rightarrow 23.58\%$



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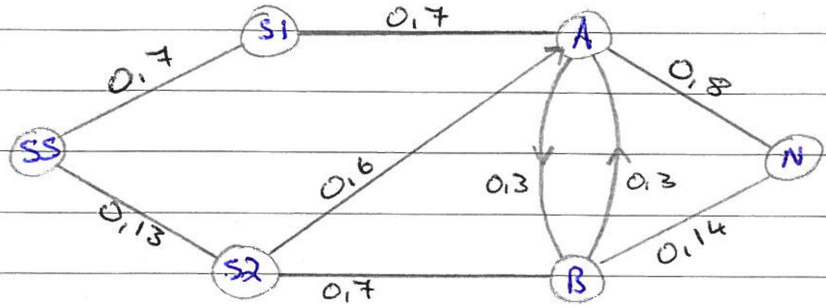
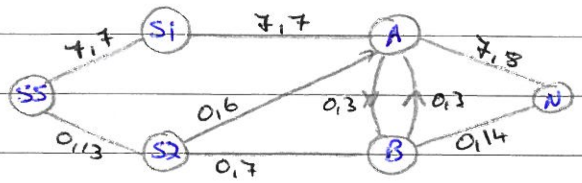
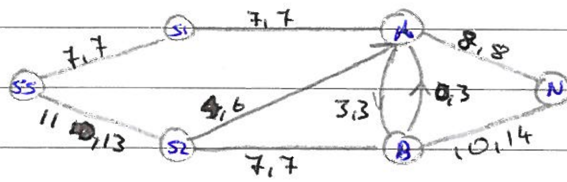
4 b)





SS-S1-A-N = 7



SS-S2-A-N = 1

SS-S2-A-B-N = 3

SS-S2-B-N = 7

Maximal Total Flow = 18

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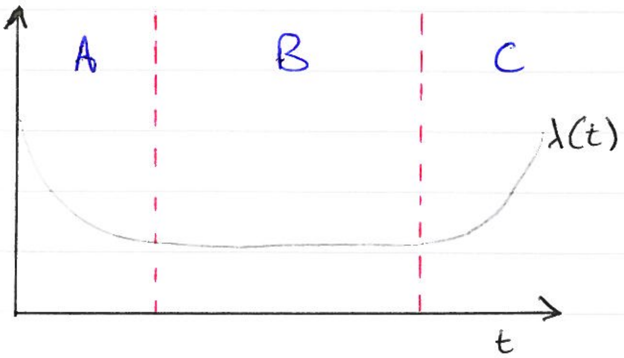
6a) $\bar{x} = 40.1mm$ $\quad L_{AV} = K[s^2 + (\bar{x}-u)^2]$

$s = 0.12mm$ $\quad \frac{L}{k} = 2.44\%$

b) This is also known as the 'bathtub curve' as shown below. There are 3 main areas:



A:
- Infant mortality region where manufacturing defects are found

B:
- Normal operating region where $\lambda(t)$ = constant & failures due to random causes

C:
- 'Wear-out' region. Replacement & maintenance policies apply here

$R = e^{-\lambda t}$

$$R_{CD} = \cancel{1 - R_C R_D} \; 1 - (1-R_C)(1-R_D)$$

$$\lambda_B = \lambda_D = 0.00015 \Rightarrow R_{250} = 0.963$$

$$\lambda_C = \lambda_A = 0.0001 \Rightarrow R_{250} = 0.975$$

$$R_{CD} = 0.9991$$

$$R_{SYS} = R_A R_B R_{CD} = 0.938 \Rightarrow \lambda_{SYS} = 0.000256$$

$$MTBF = \int_0^T R(t)\,dt = -\frac{1}{\lambda} e^{-\lambda t} \Big|_0^{250}$$

$$= -3906 e^{-0.064}$$

$$= 3{,}663.85 \text{ hours}$$

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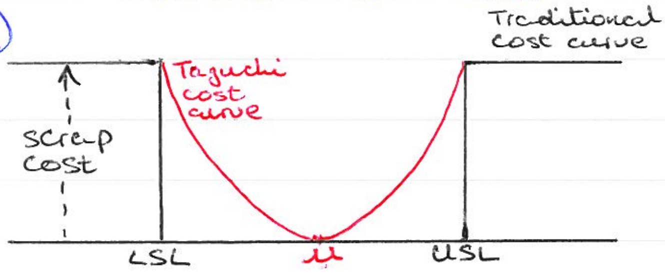
6 a) The Taguchi loss function hypothesizes that any deviation from the design optimum value results in a loss to society. This is contrary to the "goal post syndrome", of conformity to predetermined upper or lower specific limits. The Taguchi method emphasises uniformity of product rather than conformity to this range. There are 3 defined loss functions:

① Nominal is better
② Higher is better
③ Lower is better

①

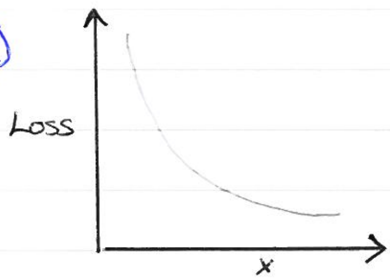


$$\text{Loss} = k(y-\mu)^2$$

μ = nominal value

$$\text{Loss}|\text{batch} = k\left[s^2 + (\bar{x}-\mu)^2\right]$$

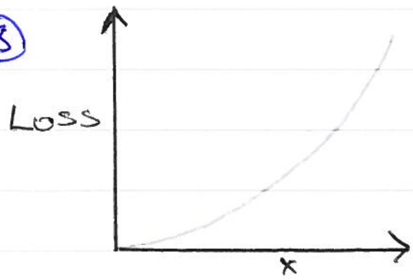
②



$$\text{Loss}|\text{item} = k\left(\frac{1}{x^2}\right)$$

$$\text{Loss}|\text{batch} = k\left(\frac{1}{\bar{x}^2}\right)\left[\frac{\bar{x}^2+s^2}{\bar{x}^2}\right]$$

③



$$\text{Loss}|\text{item} = k\,x^2$$

$$\text{Loss}|\text{batch} = k\,(s^2+x^2)$$