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Mathematics

WARM-UPS

$$1 \sum_{j=1}^5 (j+1)^2 - 1 = (1+1)^2 - 1 + (2+1)^2 - 1 + (3+1)^2 - 1 + (4+1)^2 - 1 + (5+1)^2 - 1$$

$$= 2^2 + 3^2 + 4^2 + 5^2 + 6^2 - 5 = 85$$

2 THE ACTUAL VALUE IS

$$y(2.7) = 3(2.7)^{.93} + 4.2 = 11.756$$

$$y(2) = 3(2)^{.93} + 4.2 = 9.916$$

$$y(3) = 3(3)^{.93} + 4.2 = 12.534$$

THE ESTIMATED VALUE IS

$$9.916 + .7(12.534 - 9.916) = 11.749$$

THE ERROR IS

$$\frac{11.756 - 11.749}{11.756} = .0006 \text{ OR } .06\%$$

3 LET d BE THE DIAMETER

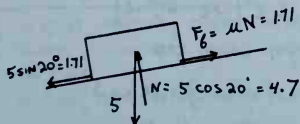
$$V_{\text{SPHERE}} = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi \left(\frac{d}{2}\right)^3 = .524d^3$$

$$V_{\text{CONE}} = \frac{\pi}{3}r^2h = \frac{\pi}{3}\left(\frac{d}{2}\right)^2h = .262d^2h$$

$$\text{BUT } .524d^3 = .262d^2h$$

$$h = 2.00d$$

4



5 EXPAND BY 2ND COLUMN

$$-2 \begin{vmatrix} 4 & 3 \\ 9 & 5 \end{vmatrix} = -2(20 - 27) = 14$$

6 FROM EQN 6.3

$$250^\circ + 460^\circ = 710^\circ R$$

$$\frac{5}{9}(250 - 32) = 121.1^\circ C$$

FROM PAGE 1-42, BTU
 $R = \frac{BTU}{FT^2 \cdot HR \cdot R^2}$
 $(1.71 \cdot 10^{-9} \frac{BTU}{FT^2 \cdot HR \cdot R^2}) (17.5)^2 \frac{WATT \cdot MIN}{BTU} \left(\frac{1}{60} \frac{HR}{MIN}\right)$
 $(0.3048 \frac{M}{FT})^2 (5/9 \frac{K}{R})^4$
 $= 5.66 \cdot 10^{-8} \frac{WATTS}{M^2 \cdot K^4}$

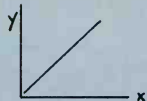
8 $y = 6 + .75(2.6) = 3.0$

9 THE SLOPE IS $\frac{9.5 - 3.4}{8.3 - 1.7} = .924$
 USING THE FIRST POINT,
 $(y - 3.4) = .924(x - 1.7)$

10 LET x BE THE NUMBER OF ELAPSED PERIODS OF .1 SECOND. LET Y_x BE THE AMOUNT PRESENT AFTER x PERIODS
 $Y_1 = 1.001 \%$
 $Y_2 = (1.001)^2 \%$
 $Y_N = (1.001)^N \%$
 NOW $\frac{Y_x}{Y_0} = 2 = (1.001)^N$
 $\log(2) = N \log(1.001)$
 $N = 693.5 \text{ PERIODS}$
 $t = 69.35 \text{ SECONDS}$

CONCENTRATES
1 FIRST, REARRANGE
 $x + y = -4$
 $x + z = 1$
 $3x - y + 2z = 4$
 NOW, USE CRAMER'S RULE (PAGE 1-6)
 $\begin{vmatrix} 1 & 1 & 0 \\ 1 & 0 & 1 \\ 3 & -1 & 2 \end{vmatrix} = 1 \begin{vmatrix} 0 & 1 \\ -1 & 2 \end{vmatrix} - 1 \begin{vmatrix} 1 & 1 \\ 3 & 2 \end{vmatrix} = (0 \cdot 1) - (-2 \cdot 3) = 14 = 2$
 $\begin{vmatrix} -4 & 1 & 0 \\ 1 & 0 & 1 \\ 4 & -1 & 2 \end{vmatrix} = -2 \begin{vmatrix} 1 & 1 \\ 3 & 2 \end{vmatrix} = -6 \begin{vmatrix} 1 & 1 & 4 \\ 1 & 0 & 1 \\ 3 & -1 & 4 \end{vmatrix} = 4$
 $x^* = \frac{-2}{2} = -1 \quad y^* = \frac{-6}{2} = -3 \quad z^* = \frac{4}{2} = 2$

2 ALWAYS GRAPH THE DATA FIRST TO SEE IF IT IS A STRAIGHT LINE. IN THIS CASE, IT IS.



USE LINEAR REGRESSION (PAGE 1-13)

$$N=7$$

$$\sum X = 12550$$

$$\bar{X} = 1792.9$$

$$\sum X^2 = 3.117 \text{ EE7}$$

$$(\sum X)^2 = 1.575 \text{ EE8}$$

$$\sum Y = 12300$$

$$\bar{Y} = 1757.1$$

$$\sum Y^2 = 3.017 \text{ EE7}$$

$$(\sum Y)^2 = 1.513 \text{ EE8}$$

$$\sum XY = 3.067 \text{ EE7}$$

$$M = \frac{7(3.067 \text{ EE7}) - (12550)(12300)}{7(3.117 \text{ EE7}) - (12550)^2} = .994$$

$$b = 1757.1 - .994(1792.9) = -25.0$$

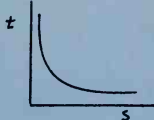
$$\text{so } y = .994x - 25.0$$

THE CORRELATION COEFFICIENT IS

$$r = \frac{7(3.067 \text{ EE7}) - (12550)(12300)}{\sqrt{[7(3.117 \text{ EE7}) - (12550)^2][7(3.017 \text{ EE7}) - (12300)^2]}}$$

$$= \sim 1.00$$

3 UPON GRAPHING THE DATA, WE SEE THAT IT IS NOT A STRAIGHT LINE



IT LOOKS LIKE AN EXPONENTIAL WITH FORM

$$t = b e^{ms}$$

OR PERHAPS

$$\log t = b + ms$$

TRY MAKING THE VARIABLE TRANSFORMATION
 $R = \log t$

S	R
20	1.633
18	2.149
16	2.585
14	3.041

$$N=4$$

$$\sum S = 68$$

$$\bar{S} = 17$$

$$\sum S^2 = 1176$$

$$(\sum S)^2 = 4624$$

$$\sum SR = 155.28$$

$$\sum R = 9.408$$

$$\bar{R} = 2.352$$

$$\sum R^2 = 23.25$$

$$(\sum R)^2 = 88.51$$

$$M = \frac{4(155.28) - (68)(9.408)}{4(1176) - (68)^2} = -.2328$$

$$b = 2.352 + .2328(17) = 6.3096$$

$$\text{so } R = 6.3096 - .2328S$$

$$\text{OR } \log t = 6.3096 - .2328S$$

4 THIS IS A FIRST-ORDER LINEAR DIFFERENTIAL EQUATION. (PAGE 1-31)

$$u = \exp\left[\int -1 dx\right] = e^{-x}$$

$$y = e^x \left[2 \int e^{-x} x e^{2x} dx + c \right]$$

$$= e^x \left[2xe^x - 2e^x + c \right]$$

BUT $y=1$ WHEN $x=0$

$$1 = 1[0 - 2 + c] \text{ OR } c = 3$$

$$\text{so } y = 2e^{2x}(x-1) + 3e^x$$

5 SOLVE THE CHARACTERISTIC QUADRATIC EQUATION:

$$R^2 - 4R - 12 = 0$$

$$R = 6, -2$$

$$\text{so } y = a_1 e^{6x} + a_2 e^{-2x}$$

6 LET X_t = POUNDS OF SALT IN TANK AT TIME t
 $X_0 = 60$

X' = RATE AT WHICH SALT CONTENT CHANGES

2 = POUNDS OF SALT ENTERING EACH MINUTE

3 = GALLONS LEAVING EACH MINUTE.

THE SALT LEAVING EACH MINUTE IS

$$3 \left(\frac{\text{CONCENTRATION}}{\text{IN LB/GAL}} \right) = 3 \left(\frac{\text{SALT CONTENT}}{\text{VOLUME}} \right) = 3 \left(\frac{X}{100-t} \right)$$

$$X' = 2 - 3 \left(\frac{X}{100-t} \right)$$

OR $X' + \frac{3X}{100-t} = 2$

THIS IS FIRST ORDER LINEAR (PAGE 1-31)

$$u = \exp \left[3 \int \frac{dt}{100-t} \right] = (100-t)^{-3}$$

$$X = (100-t)^3 \left[2 \int \frac{dt}{(100-t)^3} + K \right]$$

$$= 100 - t + K (100-t)^3$$

BUT $X=60$ AT $t=0$

$$\text{SO } K = -.00004$$

$$X = 100 - t - .00004 (100-t)^3$$

$$X_{60} = 37.44 \text{ POUNDS}$$

7 IF C IS POSITIVE, THEN $N(\infty) = \infty$, WHICH IS CONTRARY TO THE GIVEN DATA. SO $C \leq 0$.

IF $C > 0$, THEN $N(\infty) = \frac{a}{1+b} = 100$

WHICH IS POSSIBLE DEPENDING ON a, b

IF $C = 0$, THEN $N(t) = \frac{a}{1+b} = 10$, WHICH CONFLICTS WITH THE PREVIOUS STEP.

SO $C < 0$, THEN $N(\infty) = a$, SO $a = 100$

NOW $N(0) = \frac{a}{1+b} = \frac{100}{1+b} = 10$, SO $b = 9$

$$\frac{dN}{dt} = -100(1+9e^{ct-2})(9)e^{ct}(c)$$

IF $t = 0$, THEN $c = -.0556$

8 $\frac{dy}{dx} = 3x^2 - 18y$

$$3x^2 - 18y = 0 \text{ AT ALL EXTREME POINTS}$$

$$x^2 - 6x = 0 \text{ AT } x=0, x=6$$

$$\frac{d^2y}{dx^2} = 6x - 18$$

$$6x - 18 = 0 \text{ AT INFLECTION POINTS}$$

$$x = 3 \text{ IS AN INFLECTION POINT}$$

$$6(0) - 18 = -18, \text{ SO } x=0 \text{ IS A MAXIMUM}$$

$$6(6) - 18 = 18, \text{ SO } x=6 \text{ IS A MINIMUM}$$

9 THE ENERGY CONTAINED IN ONE GRAM OF ANY SUBSTANCE IS

$$E = mc^2 = (.001) \text{ KG } (3 \text{ EE } 8)^2 (\text{M/S})^2$$

$$= 9 \text{ EE } 13 \text{ JOULES}$$

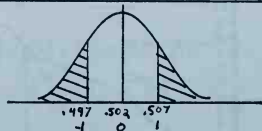
$$(9 \text{ EE } 13) \text{ J } \left(\frac{1}{1000} \right) \frac{\text{KJ}}{\text{J}} (9.478) \frac{\text{BTU}}{\text{KJ}}$$

$$= 8.53 \text{ EE } 10 \text{ BTU}$$

$$\text{# TONS} = \frac{8.53 \text{ EE } 10 \text{ BTU}}{(13,000) \frac{\text{BTU}}{\text{LB}} (2000) \frac{\text{LB}}{\text{TON}}}$$

$$= 3281 \text{ TONS}$$

10



THE STANDARD NORMAL VARIABLES ARE

$$z_1 = \frac{.502 - .497}{.005} = 1$$

$$z_2 = \frac{.507 - .502}{.005} = 1$$

a) $P\{\text{DEFECTIVE}\} = 2[.5 - .3173] = .3174$

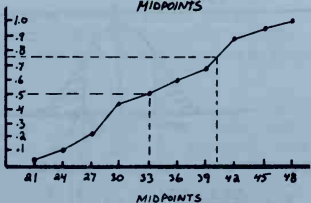
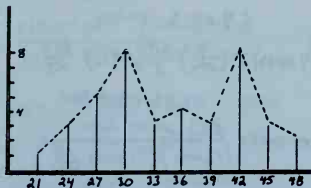
b) $P\{3, 2\} = \frac{3!}{(3-2)! 2!} (.3174)^2 (1 - .3174)$
 $= .2063$

c) $(8)(200)(.3174) = 507.8$

11

THE RANGE OF SPEEDS IS $(48-20)=28$, SINCE THERE ARE NOT A LOT OF OBSERVATIONS, 10 CELLS WOULD BE BEST. CHOOSE THE CELL WIDTH AS $(\frac{28}{10}) \approx 3$

INTERVAL	MID-POINT	FREQ.	CUM. FREQ.	CUM. %
20-22	21	1	1	.03
23-25	24	3	4	.10
26-28	27	5	9	.23
29-31	30	8	17	.43
32-34	33	3	20	.50
35-37	36	4	24	.60
38-40	39	3	27	.68
41-43	42	8	35	.88
44-46	45	3	38	.95
47-49	48	2	40	1.00

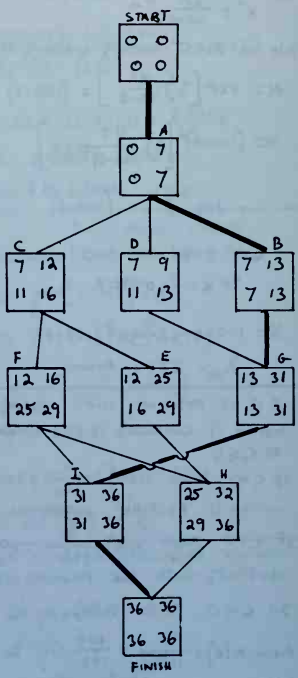


- 8) USE THE CUMULATIVE DISTRIBUTION GRAPH. FOR 75% (.75), THE CELL MID-POINT IS APPROXIMATELY 40
- 9) USE THE CUMULATIVE GRAPH TO FIND THE MID-POINT FOR 50%. THIS OCCURS AT APPROXIMATELY 33.

$\sum X_i = 1390$, SO MEAN = $\frac{1390}{40} = 34.75$

h) $\sum X^2 = 50496$
 $\sigma = \sqrt{\frac{\sum X^2}{N} - (\frac{\sum X}{N})^2} = 7.405$
 i) $S = \sqrt{\frac{N}{N-1}} (\sigma) = \sqrt{\frac{40}{39}} (7.405) = 7.500$
 j) $S^2 = 56.25$

12) NO CONTRACT DEADLINE WAS GIVEN, SO ASSUME 36 AS A SCHEDULED TIME. LOOK FOR A PATH WHERE (LS-ES)=0 EVERYWHERE



- c) 36
- d) 36
- e) 0
- f) FLOAT IS SAME AS SLACK = 0

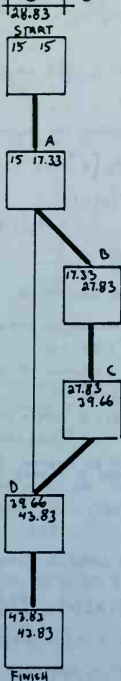
13 TO SOLVE THIS AS A REGULAR CPM PROBLEM, IT IS NECESSARY TO CALCULATE t_{MEAN} AND σ FOR EACH ACTIVITY. FOR ACTIVITY A,

$$t_{MEAN} = \frac{1}{6} [1 + (4)(2) + 5] = 2.33$$

$$\sigma_A = \frac{1}{6} (5-1) = .67$$

THE FOLLOWING TABLE IS GENERATED IN THE SAME MANNER.

ACTIVITY	t_{MEAN}	σ
START	0	0
A	2.33	.67
B	10.5	2.17
C	11.83	2.17
D	4.17	.83
FINISH	0	0



BY OBSERVATION, THE CRITICAL PATH IS START-A-B-C-D-FINISH, THE PROJECT VARIANCE IS

$$\sigma^2 = (67)^2 + (2.17)^2 + (2.17)^2 + (.83)^2 = 10.56$$

THE PROJECT STANDARD DEVIATION IS

$$\sigma = \sqrt{10.56} = 3.25$$

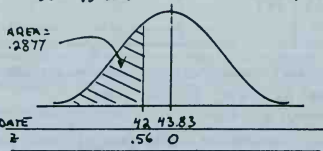
SO, WE ASSUME THE COMPLETION TIMES ARE NORMALLY DISTRIBUTED WITH A MEAN OF 28.83 AND A STANDARD DEVIATION OF 3.25

THE STANDARD NORMAL VARIABLE IS

$$z = \frac{28.83 - 15 - 4.2}{3.25} = .56$$

AREA UNDER TAIL FOR $z = .56$ IS .2123

$$\text{SO, } .5 - .2123 = .2877 \text{ (28.77\%)}$$



14 $\lambda = 20$

FROM PAGE 1-22,

$$(a) P\{X=17\} = f(17) = \frac{e^{-20} (20)^{17}}{17!} = .076$$

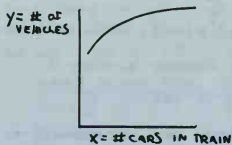
$$\begin{aligned}
 (b) P\{X \leq 3\} &= f(0) + f(1) + f(2) + f(3) \\
 &= \frac{e^{-20} (20)^0}{0!} + \frac{e^{-20} (20)^1}{1!} + \frac{e^{-20} (20)^2}{2!} + \frac{e^{-20} (20)^3}{3!} \\
 &= 2.8E-9 + 4.12EE-8 + 4.12EE-7 + 2.75EE-6 \\
 &= 3.2EE-6
 \end{aligned}$$

15 FROM PAGE 1-22,

$$u = 1/23$$

$$P\{X > 25\} = 1 - F(25) = e^{-\left(\frac{1}{23}\right)(25)} = .337$$

16 FIRST, PLOT THE DATA TO SEE IF IT IS LINEAR

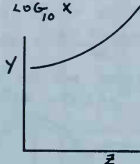


IT DOESN'T LOOK LINEAR, SO TRY THE FORM

$$y = a + bz$$

$$\text{WHERE } z = \log_{10} X$$

Z	Y
.3	14.8
.7	18.0
.9	20.4
1.08	23.0
1.43	29.9

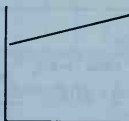


THAT ISN'T LINEAR EITHER, WE'RE 'OVERCONDENSED' THE CURVE, TRY THE FORM

$$y = a + bw$$

$$\text{WHERE } w = z^2 = (\log_{10} X)^2$$

W	Y
.09	14.8
.49	18.0
.81	20.4
1.17	23.0
2.04	29.9



FROM PAGE 1-13

$$\sum w_i = 4.6$$

$$\sum Y_i = 106.1$$

$$(\sum w_i)^2 = 21.16$$

$$(\sum Y_i)^2 = 11257.2$$

$$\sum w_i^2 = 6.43$$

$$\sum Y_i^2 = 2382.2$$

$$\bar{w} = \frac{4.6}{5} = .92$$

$$\bar{Y} = \frac{106.1}{5} = 21.22$$

$$\sum w_i Y_i = 114.58$$

$$m = \frac{(5)(114.58) - (4.6)(106.1)}{(5)(6.43) - 21.16} = \frac{84.84}{10.99}$$

$$= 7.72$$

$$b = 21.22 - (7.72)(.92) = 14.12$$

$$\text{SO, } y = 14.12 + 7.72 w$$

$$= 14.12 + 7.72 z^2$$

$$= 14.12 + 7.72 (\log_{10} X)^2$$

THE CORRELATION COEFFICIENT IS

$$r = \frac{(5)(114.58) - (4.6)(106.1)}{\sqrt{[(5)(6.43) - 21.16][(5)(2382.2) - 11257.2]}} \approx 0.999$$

{ THE TRANSFORMATION $y = a + b\sqrt{x}$ yields $y = 9.11 + 4\sqrt{x}$ AND $r = 0.999$, EQUALLY GOOD. }

17

(a) USE THE 'CHARACTERISTIC EQUATION' METHOD TO SOLVE THE HOMOGENEOUS CASE, (IT IS FASTER QUICKER TO USE LAPLACE TRANSFORMS, HOWEVER)

$$X'' + 2X' + 2X = 0 \quad \text{DIFF. EQ.}$$

$$R^2 + 2R + 2 = 0 \quad \text{CHARACTERISTIC EQ.}$$

COMPLETE THE SQUARE TO FIND R

$$R^2 + 2R = -2$$

$$(R+1)^2 = -2+1$$

$$R+1 = \pm \sqrt{-1}$$

$$R = -1 \pm i$$

SO,

$$X(t) = A_1 e^{-t} \cos t + A_2 e^{-t} \sin t$$

NOW USE THE INITIAL CONDITIONS TO FIND A_1 AND A_2 .

$$X(0) = 0$$

$$0 = A_1(1)(1) + A_2(1)(0)$$

$$\text{SO, } A_1 = 0$$

DIFFERENTIATING THE SOLUTION,

$$X'(t) = A_2 [e^{-t} \cos t - \sin t e^{-t}]$$

$$\text{USING } X'(0) = 1$$

$$1 = A_2 [(1)(1) - (0)(1)]$$

$$\text{SO, } A_2 = 1$$

AND, THE SOLUTION IS $X(t) = e^{-t} \sin t$

(b) WITH NO DAMPING, THE DIFFERENTIAL EQUATION WOULD BE

$$X'' + 2X = 0$$

THIS HAS A SOLUTION OF $X = \sin \sqrt{2} t$, SO $\omega_{\text{nat}} = \sqrt{2}$

(c) $X(t) = e^{-t} \sin t$

$$X'(t) = e^{-t} \cos t - \sin t e^{-t} = e^{-t} (\cos t - \sin t)$$

FOR X TO BE MAXIMUM, $X'(t) = 0$. SINCE e^{-t} IS NOT ZERO UNLESS t IS VERY LARGE, $\cos t - \sin t$ MUST BE ZERO. THIS OCCURS AT $t = .785$ RADIANS, SO

$$X(.785) = e^{-.785} \sin(.785) = .322$$

(d) USE THE LAPLACE TRANSFORM METHOD

$$X'' + 2X' + 2X = \sin t$$

$$f(X'') + 2f(X') + 2f(X) = f(\sin t)$$

$$s^2 f(X) - 1 + 2S f(X) + 2f(X) = \frac{1}{s^2 + 1}$$

$$f(X) [s^2 + 2S + 2] - 1 = \frac{1}{s^2 + 1}$$