2.1

$C = 299{,}792{,}458 \text{ m/s} \quad (p. 27)$

a)

$$C = 299{,}792{,}458 \frac{m}{s} \times \frac{1 \text{ km}}{1000 m} \times \frac{1 \text{ mile}}{1.609344 \text{ km}} \times \frac{3600 s}{hr}$$

$$C = \underline{670{,}616{,}630 \text{ mile}} /hr$$

b)

$$C = 299{,}792{,}458 \frac{m}{s} \times \frac{1 \text{ ft}}{.3048 m}$$

$$C = \underline{983{,}571{,}100} \text{ ft/s}$$

2.2

a) $°K = °C + 273.15°$

$°C = 100°C$

$°K = 100° + 273.15° = \underline{373.15°K}$

b)

$°C = 5/9(°F - 32°)$

$100°F = 37.78°C$

$°K = °C + 273.15° = 37.78° + 273.15°$
$= \underline{310.93°K}$

2.2 (Cont)

c)

$$°R = °F + 459.67°$$

$$°K = °C + 273.15°$$

$$°C = 5/9(°F - 32)$$

$$°K = 5/9\,[595° - 491.67] + 273.15°$$

$$= \underline{330.55\,°K} \quad \text{for } 595°R$$

2.3

a) From Fig 2.1

$$T_{tin} = 231.928°C = 449.47°F$$

$$= \underline{909.14\,°R}$$

b)

$$T_{al} = 660.323°C = 1{,}220.581°F$$

$$= \underline{1{,}680.251\,°R}$$

c)

$$T_{cu} = 1084.62°C = 1{,}984.316°F$$

$$= \underline{2{,}443.986\,°R}$$

2.4

$$F = ma = \frac{0.5\ lbf}{32.17\ ft/sec^2} \times \frac{5\ ft}{sec^2} = \underline{0.0777\ lbf}$$

2.5

$$m = 200\,gm \times \frac{1\,kg}{1000\,gm} = .2\,kg$$

$$a = 25\,\frac{cm}{sec^2} \times \frac{1\,m}{100\,cm} = .25\,m/s^2$$

$$F = ma = .2\,kg \times .25\,\frac{m}{s^2} = .05\,\frac{kg\cdot m}{s^2} = .05\,N$$

$$F = .05\,N \times \frac{1\,lbf}{4.448\,N} = \underline{0.01124}\ lbf$$

2.7

See Appendix A

a)

$$\underline{\frac{lbf}{in^2} \times 6{,}894.38 = \frac{N}{m^2} = Pa}$$

2.8

$$1\,\frac{cm^3}{s} = 1\,\frac{cm^3}{s} \times \left(\frac{1\,m}{100\,cm}\right)^3 \times \left(\frac{1\,gal}{3.785412 \times 10^{-3}\,m^3}\right) \times \frac{60\,s}{min}$$

$$= \underline{1.585032 \times 10^{-2}}\ \frac{gal}{min}$$

or

$$\underline{1\,\frac{gal}{min} = 63.0902\,\frac{cm^3}{s}}$$

2.9

$$R = 1545 \frac{ft-lbf}{lbm\ mole - °R}$$

$$R = 1545 \frac{ft-lbf}{lbm\ mole - °R} \times 9.8066 \frac{lbm/lbf}{kg \cdot N} \times .3048 \frac{m}{ft} \cdot \frac{°K}{°R}$$

$$\approx 8313 \frac{N \cdot m}{kg\ mole - °K}$$

3.1

$\mu = 200 \qquad \sigma = 20$

@ $p = 0.3 \qquad z \approx .842 \qquad$ Table 3.2

$z = \frac{x-\mu}{\sigma} \rightarrow x = \mu \pm z\sigma$

$= 200 \pm 20 \times .842$

$\underline{x = 183.2 \rightarrow 216.8}$

3.2 $\quad \mu = 303 \qquad \sigma = 33 \qquad x > 350$

Eqn 3.10

$z = \frac{x-\mu}{\sigma} = \frac{350-303}{33} = 1.42 \rightarrow p = .4222$

Prob $= .5 + .4222$ or $.9222$ that $x < 350$

$\therefore$ 7.8% chance any $x > 350$

3.3

a)

$R_1 = [68 \pm 6.8] \times 10^{-3}$

$R_2 = [12 \pm 1.2] \times 10^{-3}$

$R = \frac{R_1 R_2}{R_1 + R_2} = \frac{12 \times 68}{68 + 12} \times 10^3 = \underline{10.2\,k\Omega}$

3.3 (cont)

$$u_R = \left[\left(\frac{\partial R}{\partial R_1} u_{R_1}\right)^2 + \left(\frac{\partial R}{\partial R_2} u_{R_2}\right)^2\right]^{1/2}$$

$$\frac{\partial R}{\partial R_1} = \frac{R_2^2}{(R_1+R_2)^2} \qquad \frac{\partial R}{\partial R_2} = \frac{R_1^2}{(R_1+R_2)^2}$$

$$\frac{\partial R}{\partial R_1} = .0225 \qquad \frac{\partial R}{\partial R_2} = .7225$$

$$\underline{u_R \approx \pm .88\,k\Omega}$$

3.4

$$R = R_1 + R_2 + R_3 + R_4 + R_5 = \underline{500\,\Omega}$$

$$\frac{\partial R}{\partial R_n} = 1 \qquad n = 1, 2, 3, 4, 5$$

$$u_R = \left[\sum_{n=1}^{5} \left(\frac{\partial R}{\partial R_n} u_{R_n}\right)^2\right]^{1/2} = \sqrt{5(5)^2}$$

$$\underline{u_R = \pm 11.2\,\Omega} \qquad 500\,\Omega \pm 11.2\,\Omega$$

3.5

$$R_n = 1000\,\Omega \quad \sigma_{R_n} = 50 \qquad n = 1, 2, 3$$

$$R = \frac{R_1 R_2 R_3}{R_1R_2 + R_1R_3 + R_2R_3} \longrightarrow R = 333\,\Omega$$

$$\frac{\partial R}{\partial R_n} = 1/9 \qquad n = 1, 2, 3$$

3.5 (Cont)

$$u_R = \sqrt{\sum_{n=1}^{3}\left(\frac{\partial R}{\partial R_n} u_{R_n}\right)^2} = \sqrt{3\left(\frac{1}{9}\times 50\right)^2}$$

$$\underline{u_R = \pm 9.6\,\Omega}$$

3.6

a) $R_1 = 47\,\Omega$ $\quad u_{R_1} = .47\,\Omega$

$R_2 = 100\,\Omega$ $\quad u_{R_2} = 1\,\Omega$

$R_3 = 180\,\Omega$ $\quad u_{R_3} = 1.8\,\Omega$

$$R = R_1 + \frac{R_2 R_3}{R_2 + R_3} = 111.3\,\Omega$$

$$\frac{\partial R}{\partial R_1} = 1.0 \quad \frac{\partial R}{\partial R_2} = .4133 \quad \frac{\partial R}{\partial R_3} = .1276$$

$$u_R = \left[(.47)^2 + (.4133)^2 + (.1276 \cdot 1.8)^2\right]^{1/2}$$

$$\underline{u_R = 0.67\,\Omega}$$

$$R = 111.3\,\Omega \pm 0.67\,\Omega$$

b) $u_{R_1} = 4.7 \quad u_{R_2} = 1.0 \quad u_{R_3} = 9$

$$u_R = \left[(4.7)^2 + (.4133)^2 + (.1276 \times 9)^2\right]^{1/2}$$

$$\underline{u_R = \pm 4.86\,\Omega}$$

3.7

a) $C_1 = 0.05\mu F \qquad u_{C_1} = 0.005\mu F$

$C_2 = 0.1\mu F \qquad u_{C_2} = 0.01\mu F$

$\underline{C = C_1 + C_2 = 0.15\mu F}$

$$\frac{\partial C}{\partial C_1} = \frac{\partial C}{\partial C_2} = 1.0$$

$$u_C = \left[\sum_{n=1}^{2}\left(\frac{\partial C}{\partial C_n} u_n\right)^2\right]^{1/2}$$

$$u_C = \left[(.005)^2 + (0.01)^2\right]^{1/2} = \underline{\pm .011\mu F}$$

b)

$$C = \frac{C_1 C_2}{C_1 + C_2} = \frac{.05 \times .1}{.15} = \underline{0.033\mu F}$$

$$\frac{\partial C}{\partial C_1} = \frac{C_2^2}{(C_1+C_2)^2} \qquad \frac{\partial C}{\partial C_2} = \frac{C_1^2}{(C_1+C_2)^2}$$

$$u_C = \left[(.444 \times .005)^2 + (.111 \times .01)^2\right]^{1/2}$$

$\underline{u_C = \pm 0.0025\mu F}$

3.8

$L_1 = .5 mH \qquad u_{L_1} = .1 mH$

$L_2 = 1.0 mH \qquad u_{L_2} = .2 mH$

$$L = \frac{L_1 L_2}{L_1 + L_2} = .5/1.5 = \underline{0.333 mH}$$

3.8 (Cont.)

$$\frac{\partial L}{\partial L_1} = .444 \qquad \frac{\partial L}{\partial L_2} = .111$$

$$u_L = \left[(.444 \times .1)^2 + (.111 \times .2)^2\right]^{1/2}$$

$$\underline{u_L = \pm .0497 \text{ mH}}$$

3.9

$$P = I^2 R \qquad \frac{u_I}{I} = .5\% \qquad \frac{u_R}{R} = .1\%$$

$$\frac{u_P}{P} = \left[\left(2\frac{u_I}{I}\right)^2 + \left(\frac{u_R}{R}\right)^2\right]^{1/2} = \sqrt{(.2)^2 + (.5)^2}$$

$$\frac{u_P}{P} = \underline{.54}\%$$

$$P = VI \qquad \frac{u_I}{I} = .5\% \qquad \frac{u_V}{V} = .5\%$$

$$\frac{u_P}{P} = \left[\left(\frac{u_I}{I}\right)^2 + \left(\frac{u_V}{V}\right)^2\right]^{1/2} = \sqrt{2(.5)^2}$$

$$\frac{u_P}{P} = \underline{.71}\%$$

$P = I^2R$ is most accurate here

3.10

	d	ℓ
$\bar{X}$	3.9942	4.5066
S_x	.0045	.0126

$$P_x = t_{\alpha/2,\nu} \frac{S_x}{\sqrt{n}}$$

$n = 4$

$\nu = n - 1 = 3$

$\alpha/2 = \frac{1-.95}{2} = .025$

$t_{.025,3} = 3.182$

$$P_d = 3.182 \frac{.0045}{2} = .0072$$

PRECISION ERROR

$$P_\ell = 3.182 \frac{.0126}{2} = .0260$$

$$\frac{P_d}{d} \times 100 = \frac{.0072}{3.9942} \times 100 = .18\%$$

$$\frac{P_d}{\ell} \times 100 = \frac{.026}{4.5066} \times 100 = .445\%$$

Bias Error

$$V = \frac{\pi d^2}{4} \ell \, ; \quad \frac{u_d}{d} = .5\% = \frac{u_\ell}{\ell}$$

$$\frac{u_V}{V} = \sqrt{\left(2\frac{u_d}{d}\right)^2 + \left(\frac{u_\ell}{\ell}\right)^2}$$

TOTAL ERROR

$$\frac{U_V}{V} = \left[\left(\frac{U_d}{d}\right)^2 + \left(\frac{U_\ell}{\ell}\right)^2\right]^{1/2}$$

3.10 (Cont)

$$\frac{U_d}{d} = \left(\frac{P_d \times 100}{d}\right)^2 + \left(2\frac{u_d}{d}\right)^2 = (.18)^2 + (2(.5))^2 = 1.032\%$$

$$\frac{U_\ell}{\ell} = \left(\frac{P_\ell \times 100}{\ell}\right)^2 + \left(\frac{u_\ell}{\ell}\right)^2 = (.445)^2 + (.5)^2 = 0.448\%$$

$$\frac{U_V}{V} = \sqrt{(1.48)} \approx \underline{\underline{1.22\%}}$$

3.11

$$V = \frac{\pi}{4}(d_o^2 - d_i^2) \times \ell$$

$$\frac{u_\ell}{\ell} = \frac{.5}{52} = .96\% \qquad \frac{u_{d_o}}{d_o} = \frac{.04}{20} = .2\%$$

$$\frac{u_{d_i}}{d_i} = \frac{.08}{15} = .53\%$$

$$\frac{u_V}{V} = \left[\left(2\frac{u_{d_o}}{d_o}\right)^2 + \left(2\frac{u_{d_i}}{d_i}\right)^2 + \left(\frac{u_\ell}{\ell}\right)^2\right]^{1/2}$$

$$\frac{u_V}{V} = \underline{\pm 1.49\%}$$

3.12

$$\sigma = \frac{Mc}{I} \qquad I/c = \frac{\pi d^3}{32}$$

$$\sigma = \frac{32FL}{\pi d^3}$$

3.12 (Cont)

$$\frac{u_F}{F} = \frac{5}{350} = 1.43\% \qquad \frac{u_L}{L} = \frac{1.5}{6 \cdot 12} = 2.08\%$$

$$\frac{u_d}{d} = \frac{.08}{2.5} = 3.27\%$$

$$\frac{u_\sigma}{\sigma} = \left[\left(\frac{u_F}{F}\right)^2 + \left(\frac{u_L}{L}\right)^2 + \left(\frac{3u_d}{d}\right)^2\right]^{1/2}$$

$$= \left[(1.43)^2 + (2.08)^2 + (3 \times 3.27)^2\right]^{1/2}$$

$$\frac{u_\sigma}{\sigma} = \underline{\underline{\pm 9.93}}\%$$

3.13

$$\frac{u_\sigma}{\sigma} = 6\%$$

$$\frac{u_\sigma}{\sigma} = \left[\left(\frac{u_F}{F}\right)^2 + \left(\frac{u_L}{L}\right)^2 + \left(3\frac{u_d}{d}\right)^2\right]^{1/2}$$

$$\left(\frac{u_d}{d}\right)^2 = \frac{1}{9}\left[6^2 - (1.43)^2 - (2.08)^2\right]$$

$$\frac{u_d}{d} = \underline{\underline{\pm 1.81}}\%$$

3.14

$\bar{X}_A = 30 \qquad S_A = 2 \qquad n_A = 21$

$\bar{X}_B = 34 \qquad S_B = 6 \qquad n_9$

$\alpha = 1 - .95 = .05$

$$v = \frac{\left[\left(S_A^2/n_A\right) + \left(S_B^2/n_B\right)\right]^2}{\dfrac{\left(S_A^2/n_A\right)^2}{n_A - 1} + \dfrac{\left(S_B^2/n_B\right)^2}{n_B - 1}} = \frac{\left[2^2/21 + 6^2/9\right]^2}{\dfrac{\left(2^2/21\right)^2}{20} + \dfrac{\left(6^2/9\right)^2}{8}}$$

$v = 8.77 = 8$

$$t = \frac{\bar{X}_A - \bar{X}_B}{\sqrt{S_A^2/n_A + S_B^2/n_B}} = \frac{30 - 34}{\sqrt{2^2/21 + 6^2/9}}$$

$t = -1.954$

$t_{\alpha/2, v} = t_{.025, 8} = 2.306$

Since $-t_{.025,8} \le t \le t_{.025,8}$ there is no significant difference at 95% confidence level

3.15

$n = 150 \quad \bar{X} = \mu = 10 \quad S_{\bar{x}} = \sigma = 3.4$

$@\ x = 15 \quad z = \frac{x-\mu}{\sigma} = \frac{15-10}{3.4} \approx 1.471$

$z = 1.471 \longrightarrow P_x = .4293$

$150 \times .4293 = 64.4$

Between $10 \rightarrow 15$ 64 marbles

3.16

$\bar{D} = 10.25 \quad S_D = 0.25 \quad n = 10$

$\bar{t} = 0.25 \quad S_t = 0.05 \quad n = 10$

$P = 100 \pm 10\ psi \rightarrow \frac{u_P}{P} = 10\%$

For this case $\frac{B_D}{D} = \frac{B_t}{t} = \frac{P_P}{P} = 0$

$\sigma_\theta = \frac{PD}{2t} = \frac{100 \times 10.25}{2 \times .025} = \underline{20.5}\ kpsi$

Assume 95% Confidence

$\alpha = 1 - .95 = .05$

$t_{\alpha/2, \nu} = t_{.025, 9} = 2.262$ (Table 3.6)

$P_x = t_{\alpha/2,\nu} \frac{S_x}{\sqrt{n}}$ Precision Error.

$\frac{P_D}{D} = \frac{2.262 \times .25}{10.25\sqrt{10}} = 1.7\%$

$\frac{P_t}{t} = \frac{2.262 \times .05}{.25\sqrt{10}} = 14.3\%$

3.16 (Cont)

$$\frac{u_{T_\theta}}{T_\theta} = \left[\left(\frac{u_P}{P}\right)^2 + \left(\frac{P_D}{D}\right)^2 + \left(\frac{P_t}{t}\right)^2\right]^{1/2}$$

$$= \sqrt{10^2 + 1.7^2 + 14.3^2} = \underline{17.5\%}$$

3.17

$$P = I^2 R = 3.2^2 \times 1000 = 10.24\ KW$$

From Prob 3.9

$$\frac{u_P}{P} = \pm .54\% = \pm .0054$$

$$u_P = \pm .0054 \times 10.24\ KW = \pm \underline{.06}\ KW$$

3.18

$n = 120$ Assume $\bar{x} = \mu = 39$
$S_x = \sigma = 4.0$

$$z_1 = \frac{35-39}{4} = -1 \qquad P_1 = .3413 \quad \text{Table 3.2}$$

$$z_2 = \frac{45-39}{4} = 1.5 \qquad P_2 = .4332$$

$$P = P_1 + P_2 = .7745$$

Number $35 \rightarrow 45 = 120 \times .7745 \approx \underline{93}$

3.19

prob 3.19	Data Set 1	Data Set 2
# Samples	6	6
Raw Data		
1	2.48	2.18
2	2.76	2.48
3	2.96	2.38
4	2.72	2
5	2.62	2.1
6	2.65	2.28
7		
8		
9		
10		
11		
12		
13		
14		
15		
Average	2.69833333	2.23666667
Standard Dev	0.16055113	0.17862437
Eq. 3.25a Num	9.2427E-05	
3.25a Denom	9.3471E-06	
Nu	9	
t	4.70846091	

From Spreadsheet

	w	w/o
n	6	6
$\bar{x}$	2.70	2.24
S_x	0.16	0.17

$\nu = 9$

$\alpha = 1 - .99 = .01$

$t_{\alpha/2,\nu} = 3.250$

$\nu = 9$ Eqn 3.25a

$t = 4.708$ Eqn 3.25

3.19 (Cont)

$t > t_{.005,9}$

There is a significant difference

3.20

prob 3.20	Data Set 1	Data Set 2
# Samples	6	5
Raw Data		
1	93.52	92.38
2	92.81	93.21
3	94.32	92.55
4	93.77	92.05
5	93.57	92.54
6	93.12	
7		
8		
9		
10		
11		
12		
13		
14		
15		
Average	93.5183333	92.546
Standard Dev	0.52327494	0.42264642
Eq. 3.25a Num	0.00661979	
3.25a Denom	0.00073562	
Nu	8	
t	3.40882001	

From Spreadsheet See Next Page

3.20 (Cont)

	A	B
n	6	5
$\bar{x}$	93.5	92.5
S_x	0.52	0.42

$\alpha = 1 - .99 = .01$

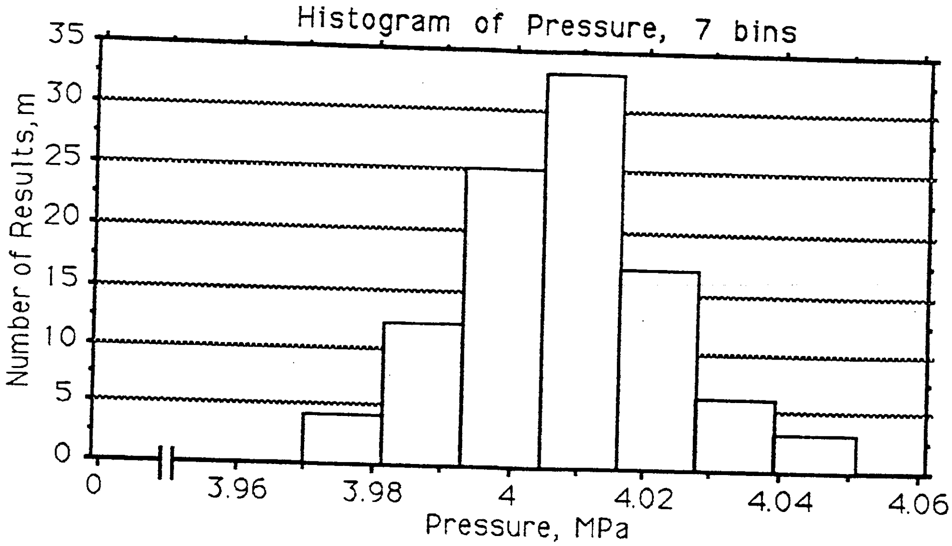
Eqn 3.25a $\quad \nu = 8$

Eqn 3.25 $\quad t = 3.409$

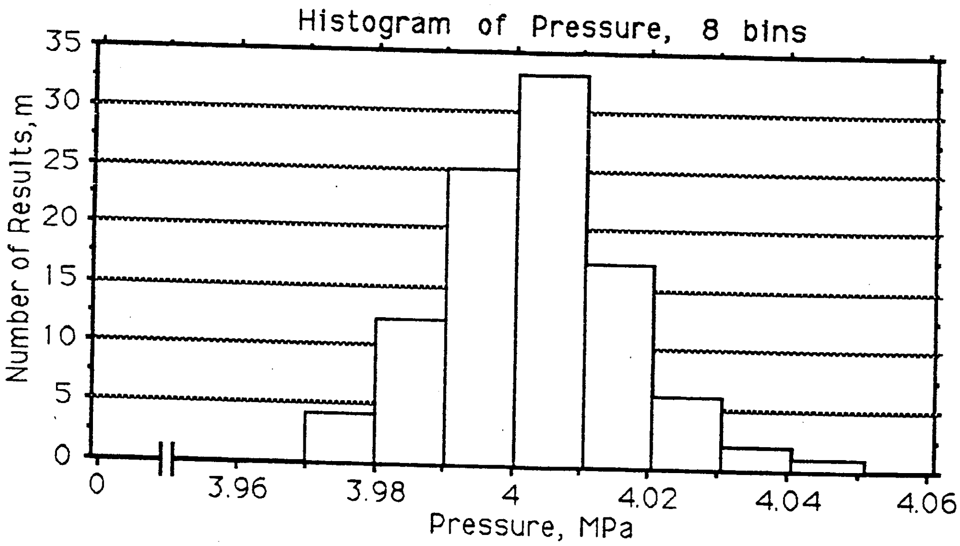
$t_{\alpha/2,\nu} = t_{.005,8} = 3.355$ (Table 3.6)

Since $t > 3.355$ → Significant Difference.

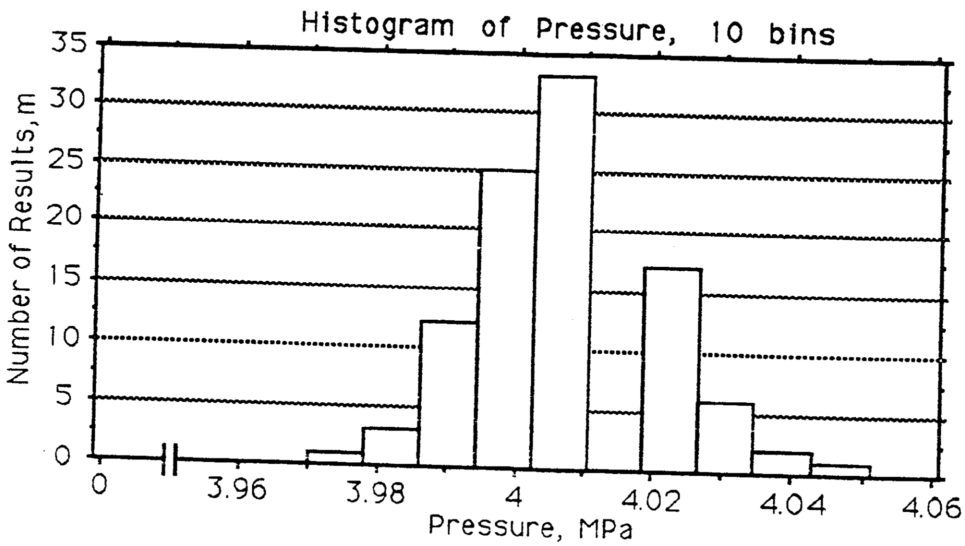
3.21



Histogram of Pressure, 7 bins
Number of Results, m
35
30
25
20
15
10
5
0
0
3.96
3.98
4
4.02
4.04
4.06
Pressure, MPa



Histogram of Pressure, 8 bins
Number of Results, m
35
30
25
20
15
10
5
0
0
3.96
3.98
4
4.02
4.04
4.06
Pressure, MPa



Histogram of Pressure, 10 bins
Number of Results, m
35
30
25
20
15
10
5
0
0
3.96
3.98
4
4.02
4.04
4.06
Pressure, MPa

3.22

$n = 9$ $\quad$ $v = n - 1 = 8$ $\quad$ $\alpha = 1 - .95 = .05$

$\bar{X} = 68.06$ $\quad$ $S_x = 0.846$

$t_{\alpha/2, v} = t_{.025, 8} = 2.306$

Range $\bar{X} \pm t_{\alpha/2, v} \frac{S_x}{\sqrt{n}} = 68.06 \pm 2.306 \frac{.846}{\sqrt{9}}$

$\underline{67.4 < \mu < 68.7}$

3.23 $\quad$ $\alpha = .10$ $\quad$ $n = 12$ $\quad$ $V = 11$

$\bar{X} = 1.257$ $\quad$ $S_x = 0.034$

$t_{\alpha/2, v} = t_{.05, 11} = 1.796$

Range $\bar{X} \pm t_{\alpha/2, v} \frac{S_x}{\sqrt{n}} = 1.257 \pm 1.796 \frac{.034}{\sqrt{11}}$

$\underline{1.239 < \mu < 1.275}$

3.24

See Spreadsheet Next Page

	A	B	
n	10	10	$V = 17$
$\bar{X}$	56.8	57.8	$t = -0.194$
S_x	11.9	11.17	$\alpha = 1 - .99 = .01$

$t_{\alpha/2, v} = t_{.005, 17} = 2.898$ $\quad$ Table 3.6

3.24 (Cont)

prob 3.24	Data Set 1	Data Set 2
# Samples	10	10
Raw Data		
1	72	73
2	43	45
3	54	56
4	75	75
5	50	53
6	48	50
7	73	72
8	55	54
9	48	48
10	50	52
11		
12		
13		
14		
15		
Average	56.8	57.8
Standard Dev	11.8958443	11.1733811
Eq. 3.25a Num	709.45282	
3.25a Denom	39.5683665	
Nu	17	
t	-0.1937622	

3.24 (Cont)

Since $|t| < 2.898 \rightarrow$ No Significant Difference

3.25

$$y = 1.0 - 0.2x + .01x^2 \quad (0 \le x \le 3)$$

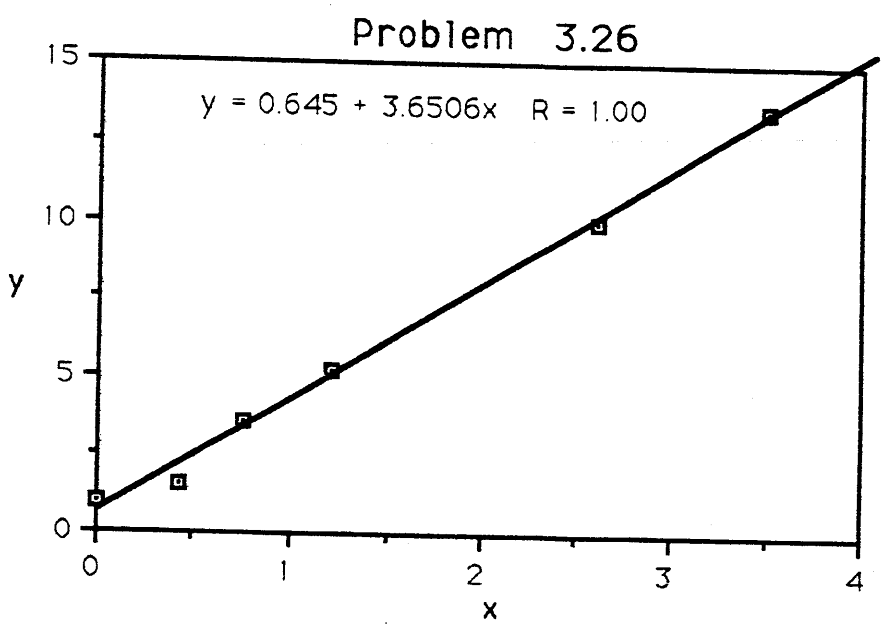
$$\frac{u_x}{x} = .02$$

$$u_y = \left| \frac{\partial y}{\partial x} u_x \right| = |(-.2 + .02x)(.02x)|$$

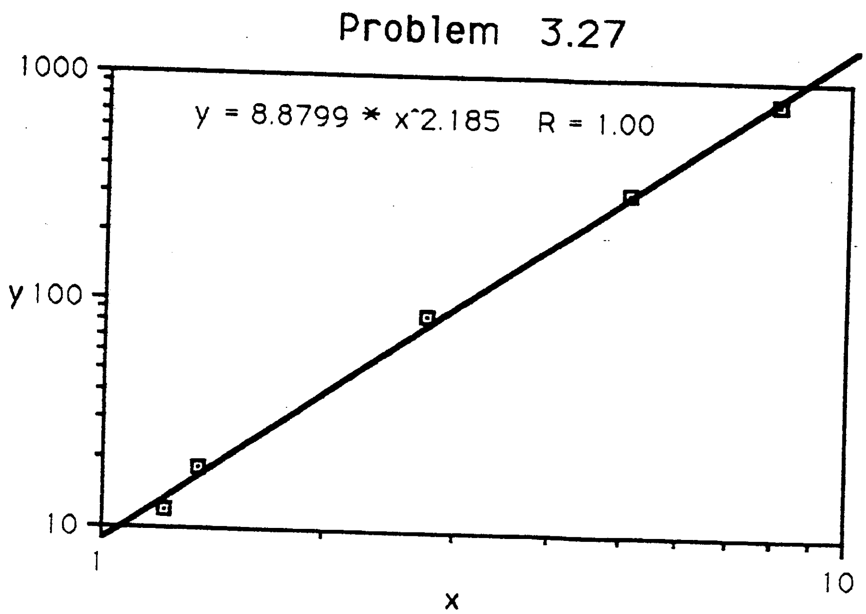
$$u_y = |-.004x + .0004x^2|$$

$$\underline{u_{y\,max} = u_y(x=3) = \pm 0.0084}$$

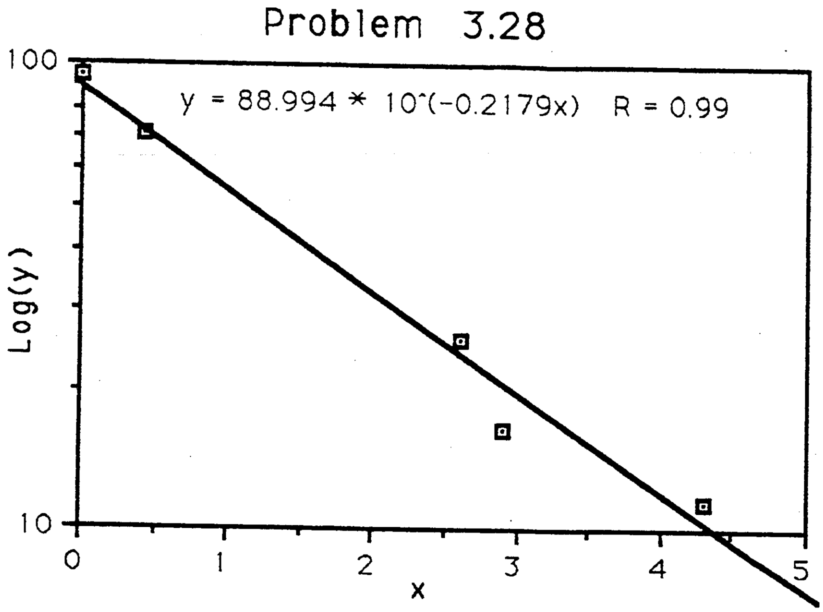
3.26


Problem 3.26
y = 0.645 + 3.6506x R = 1.00
15
10
5
0
y
0
1
2
3
4
x

3.27


Problem 3.27
y = 8.8799 * x^2.185 R = 1.00
1000
y 100
10
1
10
x

3.28



3.29

prob 3.29	Data Set 1	Data Set 2
# Samples	7	7
Raw Data		
1	3475	1813
2	4326	3145
3	2262	4140
4	7415	6867
5	3418	3842
6	4404	3984
7	3788	3053
8		
9		
10		
11		
12		
13		
14		
15		
Average	4155.42857	3834.85714
Standard Dev	1604.2936	1553.72707
Eq. 3.25a Num	5.0772E+11	
3.25a Denom	4.2354E+10	
Nu	11	
t	0.37976785	

	Small	Large
n	7	9
$\bar{X}$	4155	3835
S_x	1604	1554

$\alpha = 1 - .95 = .05$

$\nu = 11$ Eqn 3.25a $t = 0.380$ Eqn 3.25

$t_{\alpha/2, \nu} = t_{.025, 11} = 2.201$

$|t| < 2.201$ No Sig. Diff