TABLE E2.1 Wire Bond Data for Exercise 2.3

y	x_1	x_2	x_3	x_4	x_5	x_6
8.0	5.2	19.6	29.6	94.9	2.1	2.3
8.3	5.2	19.8	32.4	89.7	2.1	1.8
8.5	5.8	19.6	31.0	96.2	2.0	2.0
8.8	6.4	19.4	32.4	95.6	2.2	2.1
9.0	5.8	18.6	28.6	86.5	2.0	1.8
9.3	5.2	18.8	30.6	84.5	2.1	2.1
9.3	5.6	20.4	32.4	88.8	2.2	1.9
9.5	6.0	19.0	32.6	85.7	2.1	1.9
9.8	5.2	20.8	32.2	93.6	2.3	2.1
10.0	5.8	19.9	31.8	86.0	2.1	1.8
10.3	6.4	18.0	32.6	87.1	2.0	1.6
10.5	6.0	20.6	33.4	93.1	2.1	2.1
10.8	6.2	20.2	31.8	83.4	2.2	2.1
11.0	6.2	20.2	32.4	94.5	2.1	1.9
11.3	6.2	19.2	31.4	83.4	1.9	1.8
11.5	5.6	17.0	33.2	85.2	2.1	2.1
11.8	6.0	19.8	35.4	84.1	2.0	1.8
12.3	5.8	18.8	34.0	86.9	2.1	1.8
12.5	5.6	18.6	34.2	83.0	1.9	2.0

TABLE E2.2 Gain Data for Exercise 2.4

x_1 Emitter RS	x_2 Base RS	x_3 E-to-B RS	y hFE
14.620	226.00	7.000	128.40
15.630	220.00	3.375	52.62
14.620	217.40	6.375	113.90
15.000	220.00	6.000	98.01
14.500	226.50	7.625	139.90
15.250	224.10	6.000	102.60
16.120	220.50	3.375	48.14
15.130	223.50	6.125	109.60
15.500	217.60	5.000	82.68
15.130	228.50	6.625	112.60
15.500	230.20	5.750	97.52
16.120	226.50	3.750	59.06
15.130	226.60	6.125	111.80
15.630	225.60	5.375	89.09
15.380	234.00	8.875	171.90

TABLE E2.3 Electric Power Consumption Data for Exercise 2.5

y	x_1	x_2	x_3	x_4
240	25	24	91	100
236	31	21	90	95
290	45	24	88	110
274	60	25	87	88
301	65	25	91	94
316	72	26	94	99
300	80	25	87	97
296	84	25	86	96
267	75	24	88	110
276	60	25	91	105
288	50	25	90	100
261	38	23	89	98

2.5 The electric power consumed each month by a chemical plant is thought to be related to the average ambient temperature (x_1), the number of days in the month (x_2), the average product purity (x_3), and the tons of product produced (x_4). The past year's historical data are available and are presented in Table E2.3.

(a) Fit a multiple linear regression model to the data.

(b) Predict power consumption for a month in which $x_1 = 75°$F, $x_2 = 24$ days, $x_3 = 90\%$, and $x_4 = 98$ tons.

2.6 Heat treating is often used to carburize metal parts, such as gears. The thickness of the carburized layer is considered an important feature of the gear, and it contributes to the overall reliability of the part. Because of the critical nature of this feature, two different lab tests are performed on each furnace load. One test is run on a sample pin that accompanies each load. The other test is a destructive test, where an actual part is cross-sectioned. This test involved running a carbon analysis on the surface of both the gear pitch (top of the gear tooth) and the gear root (between the gear teeth). The data in Table E2.4 are the results of the pitch carbon analysis test for 32 parts.

(a) Fit a linear regression model relating the results of the pitch carbon analysis test (PITCH) to the five regressor variables.

(b) Test for significance of regression. Use $\alpha = 0.05$.

2.7 A regression model $y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \varepsilon$ has been fitted to a sample of $n = 25$ observations. The calculated t-ratios $b_j/se(b_j)$, $j = 1, 2, 3$, are as follows: for β_1, $t_0 = 4.82$; for β_2, $t_0 = 8.21$; and for β_3, $t_0 = 0.98$.

(a) Find P-values for each of the t-statistics.

(b) Using $\alpha = 0.05$, what conclusions can you draw about the regressor x_3? Does it seem likely that this regressor contributes significantly to the model?

2.8 Consider the electric power consumption data in Exercise 2.5.

TABLE E2.4 Heat Treating Data for Exercise 2.6

TEMP	SOAKTIME	SOAKPCT	DIFFTIME	DIFFPCT	PITCH
1650	0.58	1.10	0.25	0.90	0.013
1650	0.66	1.10	0.33	0.90	0.016
1650	0.66	1.10	0.33	0.90	0.015
1650	0.66	1.10	0.33	0.95	0.016
1600	0.66	1.15	0.33	1.00	0.015
1600	0.66	1.15	0.33	1.00	0.016
1650	1.00	1.10	0.50	0.80	0.014
1650	1.17	1.10	0.58	0.80	0.021
1650	1.17	1.10	0.58	0.80	0.018
1650	1.17	1.10	0.58	0.80	0.019
1650	1.17	1.10	0.58	0.90	0.021
1650	1.17	1.10	0.58	0.90	0.019
1650	1.17	1.15	0.58	0.90	0.021
1650	1.20	1.15	1.10	0.80	0.025
1650	2.00	1.15	1.00	0.80	0.025
1650	2.00	1.10	1.10	0.80	0.026
1650	2.20	1.10	1.10	0.80	0.024
1650	2.20	1.10	1.10	0.80	0.025
1650	2.20	1.15	1.10	0.80	0.024
1650	2.20	1.10	1.10	0.90	0.025
1650	2.20	1.10	1.10	0.90	0.027
1650	2.20	1.10	1.50	0.90	0.026
1650	3.00	1.15	1.50	0.80	0.029
1650	3.00	1.10	1.50	0.70	0.030
1650	3.00	1.10	1.50	0.75	0.028
1650	3.00	1.15	1.66	0.85	0.032
1650	3.33	1.10	1.50	0.80	0.033
1700	4.00	1.10	1.50	0.70	0.039
1650	4.00	1.10	1.50	0.70	0.040
1650	4.00	1.15	1.50	0.85	0.035
1700	12.50	1.00	1.50	0.70	0.056
1700	18.50	1.00	1.50	0.70	0.068

2.9 Consider the bearing wear data in Exercise 2.1.

(a) Estimate σ^2 for the no-interaction model.

(b) Compute the t-statistic for each regression coefficient. Using $\alpha = 0.05$, what conclusions can you draw?

(c) Use the extra sum of squares method to investigate the usefulness of adding $x_2 =$ load to the model that already contains $x_1 =$ oil viscosity. Use $\alpha = 0.05$.

2.10 Consider the wire bond pull strength data in Exercise 2.3.

(a) Estimate σ^2 for this model.

(b) Find the standard errors for each of the regression coefficients.

2.11 Reconsider the semiconductor data in Exercise 2.4.

(a) Estimate σ^2 for the model you have fitted to the data.

(b) Find the standard errors of the regression coefficients.

(c) Calculate the t-test statistic for each regression coefficient. Using $\alpha = 0.05$, what conclusions can you draw?

2.12 Exercise 2.6 presents data on heat treating gears.

(a) Estimate σ^2 for the model.

(b) Find the standard errors of the regression coefficients.

(c) Evaluate the contribution of each regressor to the model using the t-test with $\alpha = 0.05$.

(d) Fit a new model to the response PITCH using new regressors $x_1 =$ SOAKTIME × SOAKPCT and $x_2 =$ DIFFTIME × DIFFPCT.

(e) Test the model in part (d) for significance of regression using $\alpha = 0.05$. Also calculate the t-test for each regressor and draw conclusions.

(f) Estimate σ^2 for the model from part (d), and compare this with the estimate of σ^2 obtained in part (b) above. Which estimate is smaller? Does this offer any insight regarding which model might be preferable?

2.13 Consider the wire bond pull strength data in Exercise 2.3.

(a) Find 95% confidence intervals on the regression coefficients.

(b) Find a 95% confidence interval on mean pull strength when $x_2 = 20$, $x_3 = 30$, $x_4 = 90$, and $x_5 = 2.0$.

2.14 Consider the semiconductor data in Exercise 2.4.

(a) Find 99% confidence intervals on the regression coefficients.

(b) Find a 99% prediction interval on hFE when $x_1 = 14.5$, $x_2 = 220$, and $x_3 = 5.0$.

(c) Find a 99% confidence interval on mean hFE when $x_1 = 14.5$, $x_2 = 220$, and $x_3 = 5.0$.

2.15 Consider the heat-treating data from Exercise 2.6.

(a) Find 95% confidence intervals on the regression coefficients.

(b) Find a 95% interval on mean PITCH on TEMP = 1650, SOAKTIME = 1.00, SOAKPCT = 1.10, DIFFTIME = 1.00, and DIFFPCT = 0.80.

2.16 Reconsider the heat treating in Exercise 2.6 and 2.12, where we fit a model to PITCH using regressors $x_1 =$ SOAKTIME × SOAKPCT and $x_2 =$ DIFFTIME × DIFFPCT.

(a) Using the model with regressors x_1 and x_2, find a 95% confidence interval on mean PITCH when SOAKTIME = 1.00, SOAKPCT = 1.10, DIFFTIME = 1.00, and DIFFPCT = 0.80.

(b) Compare the length of this confidence interval with the length of the confidence interval on mean PITCH at the same point from Exercise 2.15 part (b), where an additive model in SOAKTIME, SOAKPCT, DIFFTIME, and DIFFPCT was