1. (10%) The general manager of a chain of fast food chicken restaurants wants to determine how effective their promotional campaigns are. In these campaigns "20% off" coupons are widely distributed. These coupons are only valid for one week. To examine their effectiveness, the executive records the daily gross sales (in $1,000s) in one restaurant during the campaign and during the week after the campaign ends. The data is shown below.

| Day | Sales During Campaign | Sales After Campaign |
|---|---|---|
| Sunday | 18.1 | 16.6 |
| Monday | 10.0 | 8.8 |
| Tuesday | 9.1 | 8.6 |
| Wednesday | 8.4 | 8.3 |
| Thursday | 10.8 | 10.1 |
| Friday | 13.1 | 12.3 |
| Saturday | 20.8 | 18.9 |

(a) (5%) To test if the sales increase during the campaign, we use $t$ test. With hypotheses $H_0 : \mu_D = 0 \quad H_1 : \mu_D > 0$, what is the value of the test statistics?

(b) (5%) Estimate the 95% confidence interval of the mean difference.

2. (10%) An insurance company is considering opening a new branch in Lansing. The company will choose the final location from two locations within the city. One of the factors in the decision is the annual family income (in thousands of dollars) of five families randomly sampled from a radius of five miles from the potential locations.

| Area 1 | Area 2 |
|---|---|
| 73 | 74 |
| 48 | 50 |
| 46 | 81 |
| 53 | 49 |
| 51 | 61 |
| Average=54.2 | Average=63 |
| Sample Variance=117.7 | Sample Variance=203.5 |

(a) (5%) Suppose that both samples have equal variances. To test if the means of two samples are the same, we use $t$ test. What is the calculated $t$ value?

(b) (5%) What is the calculated $F$ value in a one-way AVOVA table?

3. (10%) A random sample of 10 observations was selected from each of four normal populations. A partial one-way ANOVA table is shown below:

(a) (5%) What is the calculated $F$ value?

| *Source of Variation* | *SS* | *df* | *MS* | *F* |
|---|---|---|---|---|
| Treatments | | | 270 | |
| Error | | | | xxxxx |
| Total | 1,350 | | xxxxx | xxxxx |

(b) (5%) At the 5% significance level, what is the critical $F$ value to reject the null hypothesis?

4. (20%) A professor of statistics is trying to determine which of three statistical software is the best for his students. He believes that the time (in hours) it takes a student to master particular software may be influenced by gender. A 3 X 2 factorial experiment with three replicates was designed, as shown below:

*Gender* ($X_2$)

| *Software* ($X_1$) | Male | Female | $\bar{Y}_{i\bullet\bullet}$ |
|---|---|---|---|
| 1 | 29, 24, 20 | 26, 32, 30 | 26.8333 |
| 2 | 32, 26, 21 | 23, 31, 25 | 26.3333 |
| 3 | 18, 20, 25 | 27, 22, 30 | 23.6667 |
| $\bar{Y}_{\bullet j\bullet}$ | 23.8889 | 27.3333 | $\bar{Y}_{\bullet\bullet\bullet}$=25.6111 |

To construct the ANOVA table, we need the following calculations:

(a) (5%) Mean square for factor $X_1$ (software) = ?

(b) (5%) Mean square for factor $X_2$ (gender) = ?

(c) (5%) Degrees of freedom for $X_1X_2$ = ?

(d) (5%) Degrees of freedom for error = ?

5. (26%) A regression was performed on a sample of 16 observations. The estimated equation is $\hat{Y} = 23.5 - 14.28X_1 + 6.72X_2 + 15.68X_3$ . The standard errors for the coefficients are $S_{b1} = 4.2$, $S_{b2} = 5.6$, and $S_{b3} = 2.8$. For this model, SST = 3809.6 and SSR = 3285.4.

(a) (6%) Compute the appropriate t ratios. ($t_1$ = ?, $t_2$ = ?, $t_3$ = ?)

(b) (5%) Test for the significance of $\beta_1$, $\beta_2$, and $\beta_3$ at the 5% level of significance.

(c) (5%) Do you think that any of the variables should be dropped from the model? Explain.

(d) (5%) Compute $R^2$.

(e) (5%) Test the significance of the relationship among the variables at the 5% level of significance.

6. (14%) In a regression analysis involving 18 observations and four independent variables, the following information was obtained:

Multiple R = 0.6

R Square = 0.36

Standard Error = 4.8

Based on the above information, fill in all the blanks in the following ANOVA table.

ANALYSIS OF VARIANCE

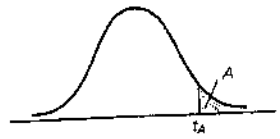
| *Source of Variation* | *Degrees of Freedom* | *Sum of Squares* | *Mean Squares* | *F* |
|---|---|---|---|---|
| Regression | a (2%) | c (2%) | e (2%) | g (2%) |
| Error | b (2%) | d (2%) | f (2%) | |

7. (10%) From a population of 2000 accounts receivable, a simple random sample of 120 accounts is selected. Thirty-six of the accounts in the sample were overdue.

(a) (5%) Estimate the standard error of the proportion of the overdue accounts.

(b) (5%) Develop an approximate 95% confidence interval for the proportion of overdue accounts in the population.

Table 4 Critical Values of $t$




| DEGREES OF FREEDOM | $t_{.100}$ | $t_{.050}$ | $t_{.025}$ | $t_{.010}$ | $t_{.005}$ |
|---|---|---|---|---|---|
| 1 | 3.078 | 6.314 | 12.706 | 31.821 | 63.657 |
| 2 | 1.886 | 2.920 | 4.303 | 6.965 | 9.925 |
| 3 | 1.638 | 2.353 | 3.182 | 4.541 | 5.841 |
| 4 | 1.533 | 2.132 | 2.776 | 3.747 | 4.604 |
| 5 | 1.476 | 2.015 | 2.571 | 3.365 | 4.032 |
| 6 | 1.440 | 1.943 | 2.447 | 3.143 | 3.707 |
| 7 | 1.415 | 1.895 | 2.365 | 2.998 | 3.499 |
| 8 | 1.397 | 1.860 | 2.306 | 2.896 | 3.355 |
| 9 | 1.383 | 1.833 | 2.262 | 2.821 | 3.250 |
| 10 | 1.372 | 1.812 | 2.228 | 2.764 | 3.169 |
| 11 | 1.363 | 1.796 | 2.201 | 2.718 | 3.106 |
| 12 | 1.356 | 1.782 | 2.179 | 2.681 | 3.055 |
| 13 | 1.350 | 1.771 | 2.160 | 2.650 | 3.012 |
| 14 | 1.345 | 1.761 | 2.145 | 2.624 | 2.977 |
| 15 | 1.341 | 1.753 | 2.131 | 2.602 | 2.947 |
| 16 | 1.337 | 1.746 | 2.120 | 2.583 | 2.921 |
| 17 | 1.333 | 1.740 | 2.110 | 2.567 | 2.898 |
| 18 | 1.330 | 1.734 | 2.101 | 2.552 | 2.878 |
| 19 | 1.328 | 1.729 | 2.093 | 2.539 | 2.861 |
| 20 | 1.325 | 1.725 | 2.086 | 2.528 | 2.845 |
| 21 | 1.323 | 1.721 | 2.080 | 2.518 | 2.831 |
| 22 | 1.321 | 1.717 | 2.074 | 2.508 | 2.819 |
| 23 | 1.319 | 1.714 | 2.069 | 2.500 | 2.807 |
| 24 | 1.318 | 1.711 | 2.064 | 2.492 | 2.797 |
| 25 | 1.316 | 1.708 | 2.060 | 2.485 | 2.787 |
| 26 | 1.315 | 1.706 | 2.056 | 2.479 | 2.779 |
| 27 | 1.314 | 1.703 | 2.052 | 2.473 | 2.771 |
| 28 | 1.313 | 1.701 | 2.048 | 2.467 | 2.763 |
| 29 | 1.311 | 1.699 | 2.045 | 2.462 | 2.756 |
| 30 | 1.310 | 1.697 | 2.042 | 2.457 | 2.750 |
| 35 | 1.306 | 1.690 | 2.030 | 2.438 | 2.724 |
| 40 | 1.303 | 1.684 | 2.021 | 2.423 | 2.705 |
| 45 | 1.301 | 1.679 | 2.014 | 2.412 | 2.690 |
| 50 | 1.299 | 1.676 | 2.009 | 2.403 | 2.678 |
| 60 | 1.296 | 1.671 | 2.000 | 2.390 | 2.660 |
| 70 | 1.294 | 1.667 | 1.994 | 2.381 | 2.648 |
| 80 | 1.292 | 1.664 | 1.990 | 2.374 | 2.639 |
| 90 | 1.291 | 1.662 | 1.987 | 2.369 | 2.632 |
| 100 | 1.290 | 1.660 | 1.984 | 2.364 | 2.626 |
| 120 | 1.289 | 1.658 | 1.980 | 2.358 | 2.617 |
| 140 | 1.288 | 1.656 | 1.977 | 2.353 | 2.611 |
| 160 | 1.287 | 1.654 | 1.975 | 2.350 | 2.607 |
| 180 | 1.286 | 1.653 | 1.973 | 2.347 | 2.603 |
| 200 | 1.286 | 1.653 | 1.972 | 2.345 | 2.601 |
| ∞ | 1.282 | 1.645 | 1.960 | 2.326 | 2.576 |

SOURCE: From M. Merrington, "Table of Percentage Points of the t-Distribution," *Biometrika* 32 (1941): 300. Reproduced by permission of the Biometrika Trustees.

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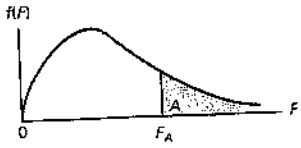
Table 6(a) Critical Values of $F$: $A = .05$




| DENOMINATOR DEGREES OF FREEDOM ($\nu_2$) \ NUMERATOR DEGREES OF FREEDOM ($\nu_1$) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 161.4 | 199.5 | 215.7 | 224.6 | 230.2 | 234.0 | 236.8 | 238.9 | 240.5 |
| 2 | 18.51 | 19.00 | 19.16 | 19.25 | 19.30 | 19.33 | 19.35 | 19.37 | 19.38 |
| 3 | 10.13 | 9.55 | 9.28 | 9.12 | 9.01 | 8.94 | 8.89 | 8.85 | 8.81 |
| 4 | 7.71 | 6.94 | 6.59 | 6.39 | 6.26 | 6.16 | 6.09 | 6.04 | 6.00 |
| 5 | 6.61 | 5.79 | 5.41 | 5.19 | 5.05 | 4.95 | 4.88 | 4.82 | 4.77 |
| 6 | 5.99 | 5.14 | 4.76 | 4.53 | 4.39 | 4.28 | 4.21 | 4.15 | 4.10 |
| 7 | 5.59 | 4.74 | 4.35 | 4.12 | 3.97 | 3.87 | 3.79 | 3.73 | 3.68 |
| 8 | 5.32 | 4.46 | 4.07 | 3.84 | 3.69 | 3.58 | 3.50 | 3.44 | 3.39 |
| 9 | 5.12 | 4.26 | 3.86 | 3.63 | 3.48 | 3.37 | 3.29 | 3.23 | 3.18 |
| 10 | 4.96 | 4.10 | 3.71 | 3.48 | 3.33 | 3.22 | 3.14 | 3.07 | 3.02 |
| 11 | 4.84 | 3.98 | 3.59 | 3.36 | 3.20 | 3.09 | 3.01 | 2.95 | 2.90 |
| 12 | 4.75 | 3.89 | 3.49 | 3.26 | 3.11 | 3.00 | 2.91 | 2.85 | 2.80 |
| 13 | 4.67 | 3.81 | 3.41 | 3.18 | 3.03 | 2.92 | 2.83 | 2.77 | 2.71 |
| 14 | 4.60 | 3.74 | 3.34 | 3.11 | 2.96 | 2.85 | 2.76 | 2.70 | 2.65 |
| 15 | 4.54 | 3.68 | 3.29 | 3.06 | 2.90 | 2.79 | 2.71 | 2.64 | 2.59 |
| 16 | 4.49 | 3.63 | 3.24 | 3.01 | 2.85 | 2.74 | 2.66 | 2.59 | 2.54 |
| 17 | 4.45 | 3.59 | 3.20 | 2.96 | 2.81 | 2.70 | 2.61 | 2.55 | 2.49 |
| 18 | 4.41 | 3.55 | 3.16 | 2.93 | 2.77 | 2.66 | 2.58 | 2.51 | 2.46 |
| 19 | 4.38 | 3.52 | 3.13 | 2.90 | 2.74 | 2.63 | 2.54 | 2.48 | 2.42 |
| 20 | 4.35 | 3.49 | 3.10 | 2.87 | 2.71 | 2.60 | 2.51 | 2.45 | 2.39 |
| 21 | 4.32 | 3.47 | 3.07 | 2.84 | 2.68 | 2.57 | 2.49 | 2.42 | 2.37 |
| 22 | 4.30 | 3.44 | 3.05 | 2.82 | 2.66 | 2.55 | 2.46 | 2.40 | 2.34 |
| 23 | 4.28 | 3.42 | 3.03 | 2.80 | 2.64 | 2.53 | 2.44 | 2.37 | 2.32 |
| 24 | 4.26 | 3.40 | 3.01 | 2.78 | 2.62 | 2.51 | 2.42 | 2.36 | 2.30 |
| 25 | 4.24 | 3.39 | 2.99 | 2.76 | 2.60 | 2.49 | 2.40 | 2.34 | 2.28 |
| 26 | 4.23 | 3.37 | 2.98 | 2.74 | 2.59 | 2.47 | 2.39 | 2.32 | 2.27 |
| 27 | 4.21 | 3.35 | 2.96 | 2.73 | 2.57 | 2.46 | 2.37 | 2.31 | 2.25 |
| 28 | 4.20 | 3.34 | 2.95 | 2.71 | 2.56 | 2.45 | 2.36 | 2.29 | 2.24 |
| 29 | 4.18 | 3.33 | 2.93 | 2.70 | 2.55 | 2.43 | 2.35 | 2.28 | 2.22 |
| 30 | 4.17 | 3.32 | 2.92 | 2.69 | 2.53 | 2.42 | 2.33 | 2.27 | 2.21 |
| 40 | 4.08 | 3.23 | 2.84 | 2.61 | 2.45 | 2.34 | 2.25 | 2.18 | 2.12 |
| 60 | 4.00 | 3.15 | 2.76 | 2.53 | 2.37 | 2.25 | 2.17 | 2.10 | 2.04 |
| 120 | 3.92 | 3.07 | 2.68 | 2.45 | 2.29 | 2.17 | 2.09 | 2.02 | 1.96 |
| ∞ | 3.84 | 3.00 | 2.60 | 2.37 | 2.21 | 2.10 | 2.01 | 1.94 | 1.88 |

SOURCE: From M. Merrington and C. M. Thompson, "Tables of Percentage Points of the Inverted Beta ($F$)-Distribution," *Biometrika* 33 (1943): 73–88. Reproduced by permission of the Biometrika Trustees.

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