



No. of Pages - 12

No of Questions - 08

SCHOOL OF ACCOUNTING AND BUSINESS
BSc. (APPLIED ACCOUNTING) GENERAL / SPECIAL DEGREE
PROGRAMME

END SEMESTER EXAMINATION – JULY 2017

BEC 30325 Managerial Economics

Date : 14th July 2017
Time : 5.30 p.m. - 8.00 p.m.
Duration : Two and a half (02 ½) hours

Instructions to Candidates:

- This paper consists of three sections. (A, B and C)
- Section A- Answer **ALL** questions in the sheet provided
- Section B- Answer only **Four (04)** questions
- Section C- Answer only **One (01)** question
- The total marks for the paper is 100
- The marks for each question are shown in brackets
- Answers should be written neatly and legibly.
- Statistics tables are attached to the paper for your reference

Section A

Answer **ALL** questions

Question No. 01

1. The modern theory of the firm holds that firms behave in a way that is designed to maximize;
 - a. gross profit
 - b. value of the firm
 - c. total revenue
 - d. management utility

2. Globalization of business is reflected in all of the following except;
 - a. international convergence of consumer tastes
 - b. online marketing and e-sales across countries
 - c. international payment systems
 - d. international trade embargoes

3. The income elasticity of demand measures;
 - a. the sensitivity of income to a particular change in demand
 - b. the sensitivity of demand of a commodity to changes in consumer income
 - c. the elasticity if income of a consumer changes
 - d. the relationship between income of a consumer and willingness to buy a good

4. In perfect competition, the market share for the firm is;
 - a. insignificant
 - b. growing through aggressive advertising
 - c. dependent on the elasticity of demand for the firm's product
 - d. dependent on brand loyalty

5. The difficulty of deriving the demand curve for a commodity from simple price quantity relationships is called;
 - a. identification problem
 - b. lemons problem
 - c. law of demand
 - d. imperfect demand
6. The main objective of economic forecasting is;
 - a. to maximize profits of firms
 - b. to reduce risk or uncertainty of the firm
 - c. to obtain forecasts to the future
 - d. to expand market share
7. The simplest form of time series analysis under forecasting is;
 - a. smoothing technique
 - b. exponential smoothing
 - c. trend projection
 - d. barometric method
8. The marginal product of labour curve shows the change in total product resulting from;
 - a. one-unit change in the quantity of a particular resource used, letting other resources vary.
 - b. one-unit change in the quantity of labour used, holding other resources constant.
 - c. change in the cost of a variable resource, while other variables are held constant
 - d. change in the cost of a fixed resource, while other variables are held constant
9. When marginal cost is less than average total cost,
 - a. marginal cost must be falling.
 - b. average total cost is falling.
 - c. average total cost is rising.
 - d. average variable cost must be falling.

10. Oligopoly is a/an _____ market wherein _____ dominate the market and sell _____ products.

- a. imperfect, few firms, homogeneous
- b. imperfect, few firms, heterogeneous
- c. perfect, many firms, heterogeneous
- d. imperfect, many firms, homogeneous

(Total 20 Marks)

Section B

Answer only **Four (04)** questions

Question No. 02

- a. “In the current dynamic and globalized business environment, Managerial Economics is considered relevant and beneficial for businesses”. Do you agree with this statement? Explain.

(4 marks)

- b. Explain the difference between economic and accounting profit in the context of managerial decision making. Use an example to support your answer.

(3 marks)

- c. State three main features that come under the “Theory of the firm”.

(3 marks)

- d. Samsons Company produces electronic items. Their fixed cost amounts to Rs. 25000 per month, while the average variable cost is Rs.4. The total revenue function of the company is $TR = 0.02 Q^2 + 0.8 Q + 33000$.

Find the profit maximizing level of output and the monthly profits.

(5 marks)

(Total 15 Marks)

Question No. 03

- a. Demand for a product is one of the most important aspects of managerial economics as a firm would not survive if sufficient demand for its product does not exist. Using a specific example from the real-world service sector, explain determinants of demand of that service and justify the reasons for selecting those factors.

(4 marks)

- b. The Demand of Axiaatar (Q_A), which is a well-known mobile phone, depends upon the price of an Axiaatar phone (P_A), average daily income of people (Y) and price of Boppo phone (P_B). Demand for Q_A is given by the equation below;

$$Q_A = 60000 - 8P_A + 3Y - 2P_B$$

Assume that, P_A is Rs.3000, Y is Rs.4000 and P_B is Rs.2000.

- i. Find the value of quantity demanded of Axiaatar and the price elasticity of demand at that quantity.

(2 marks)

- ii. Calculate Income elasticity of demand and Cross price elasticity of demand.

(2 marks)

- iii. Interpret the above results and state how the interpretation would affect the decisions of Axiaatar's managers.

(4 marks)

- c. Briefly explain the difference between Consumer Surveys and Market Experiments, in demand estimation.

(3 marks)

(Total 15 Marks)

Question No. 04

- a. Distinguish between Economies of Scale and Economies of Scope in the context of theory of cost. Use appropriate diagrams when necessary.

(4 marks)

- b. “Production is a process through which factor inputs are made into output that directly or indirectly satisfy consumer demand.” Graphically illustrate the long run production equilibrium.

(3 marks)

- c. Using the following data, calculate the marginal and average product of labour.

(2 marks)

| | | | | | | | | |
|---------------------|---|----|----|----|----|----|----|----|
| Labour Units | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Output | 0 | 10 | 17 | 22 | 25 | 26 | 25 | 23 |

- i. If the price of a final output is Rs. 550 and the wage rate per labour unit is Rs. 1650, find out the optimum level of labour inputs to be hired.

(3 marks)

- ii. Use your calculations and explain the concept of diminishing marginal returns to labour.

(3 marks)

(Total 15 Marks)

Question No. 05

- a. “Decisions that take into account the predicted reactions of rival firms are considered as an important segment of strategic behaviour of firms.” Briefly explain the following concepts related to strategic behaviour;
- The different types of games that firms face
 - Dominant Strategy of a firm
 - Nash Equilibrium
 - Prisoner’s dilemma
- (8 marks)
- b. An automobile industry consists of two firms; Fyunda Inc. and Kitzi Inc. The payoff matrix of potential profits, for two firms is given below. The two firms are faced with two alternative strategies; introduce hybrid cars or introduce fully electric cars.

| | | Fyunda Inc. | |
|-------------------|--------------------------------------|------------------------------|--------------------------------------|
| | | <i>Introduce hybrid cars</i> | <i>Introduce fully electric cars</i> |
| Kitzi Inc. | <i>Introduce hybrid cars</i> | 16 , 16 | 12 , 24 |
| | <i>Introduce fully electric cars</i> | 24 , 12 | 8 , 16 |

- Find out the optimal strategies of Kitzi Inc. and Fyunda Inc.

(4 marks)
- Do they have a dominant strategy each? If so what are they?

(2 marks)
- What is the Nash equilibrium?

(1 mark)

(Total 15 Marks)

Question No. 06

- a. “A perfectly competitive firm is a price taker.” Do you agree? Explain your answer with a suitable illustration.

(3 marks)

- b. “Perfectly competitive firms are more economically efficient than a monopoly firm.” Critically evaluate this statement with the aid of diagrams.

(5 marks)

- c. Briefly explain three sources of monopoly power using real world examples. Do you think that the government should regulate monopolies? Justify your answer.

(4 marks)

- d. Explain the concept of price rigidity using a suitable model in the oligopoly market structure.

(3 marks)

(Total 15 Marks)

Section C

Answer only One (01) question

Question No. 07

The following regression output is related to the sales of Yummy-berry jam bottles of Yummy Inc.

SUMMARY OUTPUT

| <i>Regression Statistics</i> | |
|------------------------------|-------------|
| Multiple R | 0.964651452 |
| R Square | 0.930552424 |
| Adjusted R Square | 0.920135288 |
| Standard Error | 3574.61126 |
| Observations | 34 |

| <i>ANOVA</i> | | | | | <i>Significance F</i> |
|--------------|-----------|-------------|-----------|----------|-----------------------|
| | <i>Df</i> | <i>SS</i> | <i>MS</i> | <i>F</i> | |
| Regression | 4 | 3424296693 | 1.140009 | 89.329 | 0.0004599 |
| Residual | 30 | 255556913.1 | 12777846 | | |
| Total | 34 | 3679853606 | | | |

| | <i>Coefficients</i> | <i>Standard Error</i> | <i>t Stat</i> | <i>P-value</i> | <i>Lower 95%</i> | <i>Upper 95%</i> | <i>Lower 95.0%</i> | <i>Upper 95.0%</i> |
|-----------|---------------------|-----------------------|---------------|----------------|------------------|------------------|--------------------|--------------------|
| Intercept | 71051.91394 | 21696.52424 | 3.274806 | 0.003789 | 25793.75744 | 116310.1 | 25793.76 | 116310.1 |
| Price_YB | 0.130597033 | 0.016300547 | 1.011819 | 1.14007 | 0.096594687 | 0.164599 | 0.096595 | 0.164599 |
| Price_Br | -221.036928 | 80.83787678 | -2.73432 | 0.012779 | 389.6617842 | -52.4121 | -389.662 | -52.4121 |
| Inc_H | 1194.839482 | 333.2529865 | 3.585383 | 0.00185 | 499.6859333 | 1889.993 | 499.6859 | 1889.993 |

Price_YB : Price of a Yummy-berry jam bottle

Price_Br : Price of a loaf of bread

Inc_H : Average monthly income of Household

Required;

- Construct and interpret the demand function for Yummy-berry jam bottles. Do you think that the estimated coefficients are in consistent with basic economic theory? Explain your answer.

(6 marks)

- ii. Test the significance of each independent variable at the 95% confidence level.
(3 marks)
 - iii. Test the overall significance of this regression model at 95% confidence level.
(3 marks)
 - iv. Write a short report to the Board of Management of Yummy Inc, on the regression output of this model and its relevance to decision making.
(8 marks)
- (Total 20 Marks)**

Question No. 08

Suppose Jack Daniel PLC manufactures salmon tins. They can sell their identical product in two different markets, international and local grocery stores. The inverse demand curve for the international market is given as P_1 while the inverse demand curve for the local grocery stores is P_2 .

$$P_1 = 80 - 0.01Q_1$$

$$P_2 = 60 - 0.01Q_2$$

The firm's variable cost is Rs.4 per salmon tin and total fixed cost is Rs. 20,000.

- i. Identify the relevant market structure for this firm. State reasons for your answer.
(2 marks)
 - ii. Briefly explain necessary conditions for this pricing strategy.
(4 marks)
 - iii. Calculate the prices to be charged in the two different markets and profits with and without this pricing strategy.
(10 marks)
 - iv. List down advantages of this pricing strategy for the firm.
(4 marks)
- (Total 20 Marks)**

Statistical Tables

TABLE A.2

t Distribution: Critical Values of t

| Degrees of freedom | Two-tailed test: One-tailed test: | Significance level | | | | | |
|--------------------|--------------------------------------|--------------------|--------|--------|--------|---------|---------|
| | | 10% | 5% | 2% | 1% | 0.2% | 0.1% |
| | | 5% | 2.5% | 1% | 0.5% | 0.1% | 0.05% |
| 1 | | 6.314 | 12.706 | 31.821 | 63.657 | 318.309 | 636.619 |
| 2 | | 2.920 | 4.303 | 6.965 | 9.925 | 22.327 | 31.599 |
| 3 | | 2.353 | 3.182 | 4.541 | 5.841 | 10.215 | 12.924 |
| 4 | | 2.132 | 2.776 | 3.747 | 4.604 | 7.173 | 8.610 |
| 5 | | 2.015 | 2.571 | 3.365 | 4.032 | 5.893 | 6.869 |
| 6 | | 1.943 | 2.447 | 3.143 | 3.707 | 5.208 | 5.959 |
| 7 | | 1.894 | 2.365 | 2.998 | 3.499 | 4.785 | 5.408 |
| 8 | | 1.860 | 2.306 | 2.896 | 3.355 | 4.501 | 5.041 |
| 9 | | 1.833 | 2.262 | 2.821 | 3.250 | 4.297 | 4.781 |
| 10 | | 1.812 | 2.228 | 2.764 | 3.169 | 4.144 | 4.587 |
| 11 | | 1.796 | 2.201 | 2.718 | 3.106 | 4.025 | 4.437 |
| 12 | | 1.782 | 2.179 | 2.681 | 3.055 | 3.930 | 4.318 |
| 13 | | 1.771 | 2.160 | 2.650 | 3.012 | 3.852 | 4.221 |
| 14 | | 1.761 | 2.145 | 2.624 | 2.977 | 3.787 | 4.140 |
| 15 | | 1.753 | 2.131 | 2.602 | 2.947 | 3.733 | 4.073 |
| 16 | | 1.746 | 2.120 | 2.583 | 2.921 | 3.686 | 4.015 |
| 17 | | 1.740 | 2.110 | 2.567 | 2.898 | 3.646 | 3.965 |
| 18 | | 1.734 | 2.101 | 2.552 | 2.878 | 3.610 | 3.922 |
| 19 | | 1.729 | 2.093 | 2.539 | 2.861 | 3.579 | 3.883 |
| 20 | | 1.725 | 2.086 | 2.528 | 2.845 | 3.552 | 3.850 |
| 21 | | 1.721 | 2.080 | 2.518 | 2.831 | 3.527 | 3.819 |
| 22 | | 1.717 | 2.074 | 2.508 | 2.819 | 3.505 | 3.792 |
| 23 | | 1.714 | 2.069 | 2.500 | 2.807 | 3.485 | 3.768 |
| 24 | | 1.711 | 2.064 | 2.492 | 2.797 | 3.467 | 3.745 |
| 25 | | 1.708 | 2.060 | 2.485 | 2.787 | 3.450 | 3.725 |
| 26 | | 1.706 | 2.056 | 2.479 | 2.779 | 3.435 | 3.707 |
| 27 | | 1.703 | 2.052 | 2.473 | 2.771 | 3.421 | 3.690 |
| 28 | | 1.701 | 2.048 | 2.467 | 2.763 | 3.408 | 3.674 |
| 29 | | 1.699 | 2.045 | 2.462 | 2.756 | 3.396 | 3.659 |
| 30 | | 1.697 | 2.042 | 2.457 | 2.750 | 3.385 | 3.646 |
| 32 | | 1.694 | 2.037 | 2.449 | 2.738 | 3.365 | 3.622 |
| 34 | | 1.691 | 2.032 | 2.441 | 2.728 | 3.348 | 3.601 |
| 36 | | 1.688 | 2.028 | 2.434 | 2.719 | 3.333 | 3.582 |
| 38 | | 1.686 | 2.024 | 2.429 | 2.712 | 3.319 | 3.566 |
| 40 | | 1.684 | 2.021 | 2.423 | 2.704 | 3.307 | 3.551 |
| 42 | | 1.682 | 2.018 | 2.418 | 2.698 | 3.296 | 3.538 |
| 44 | | 1.680 | 2.015 | 2.414 | 2.692 | 3.286 | 3.526 |
| 46 | | 1.679 | 2.013 | 2.410 | 2.687 | 3.277 | 3.515 |
| 48 | | 1.677 | 2.011 | 2.407 | 2.682 | 3.269 | 3.505 |
| 50 | | 1.676 | 2.009 | 2.403 | 2.678 | 3.261 | 3.496 |
| 60 | | 1.671 | 2.000 | 2.390 | 2.660 | 3.232 | 3.460 |
| 70 | | 1.667 | 1.994 | 2.381 | 2.648 | 3.211 | 3.435 |
| 80 | | 1.664 | 1.990 | 2.374 | 2.639 | 3.195 | 3.416 |
| 90 | | 1.662 | 1.987 | 2.368 | 2.632 | 3.183 | 3.402 |
| 100 | | 1.660 | 1.984 | 2.364 | 2.626 | 3.174 | 3.390 |
| 120 | | 1.658 | 1.980 | 2.358 | 2.617 | 3.160 | 3.373 |
| 150 | | 1.655 | 1.976 | 2.351 | 2.609 | 3.145 | 3.357 |
| 200 | | 1.653 | 1.972 | 2.345 | 2.601 | 3.131 | 3.340 |
| 300 | | 1.650 | 1.968 | 2.339 | 2.592 | 3.118 | 3.323 |
| 400 | | 1.649 | 1.966 | 2.336 | 2.588 | 3.111 | 3.315 |
| 500 | | 1.648 | 1.965 | 2.334 | 2.586 | 3.107 | 3.310 |
| 600 | | 1.647 | 1.964 | 2.333 | 2.584 | 3.104 | 3.307 |
| ∞ | | 1.645 | 1.960 | 2.326 | 2.576 | 3.090 | 3.291 |

TABLE A.3

F Distribution: Critical Values of F (5% significance level)

| v_1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 14 | 16 | 18 | 20 |
|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| v_2 | | | | | | | | | | | | | | | |
| 1 | 161.45 | 199.50 | 215.71 | 224.58 | 230.16 | 233.99 | 236.77 | 238.88 | 240.54 | 241.88 | 243.91 | 245.36 | 246.46 | 247.32 | 248.01 |
| 2 | 18.51 | 19.00 | 19.16 | 19.25 | 19.30 | 19.33 | 19.35 | 19.37 | 19.38 | 19.40 | 19.41 | 19.42 | 19.43 | 19.44 | 19.45 |
| 3 | 10.13 | 9.55 | 9.28 | 9.12 | 9.01 | 8.94 | 8.89 | 8.85 | 8.81 | 8.79 | 8.74 | 8.71 | 8.69 | 8.67 | 8.66 |
| 4 | 7.71 | 6.94 | 6.59 | 6.39 | 6.26 | 6.16 | 6.09 | 6.04 | 6.00 | 5.96 | 5.91 | 5.87 | 5.84 | 5.82 | 5.80 |
| 5 | 6.61 | 5.79 | 5.41 | 5.19 | 5.05 | 4.95 | 4.88 | 4.82 | 4.77 | 4.74 | 4.68 | 4.64 | 4.60 | 4.58 | 4.56 |
| 6 | 5.99 | 5.14 | 4.76 | 4.53 | 4.39 | 4.28 | 4.21 | 4.15 | 4.10 | 4.06 | 4.00 | 3.96 | 3.92 | 3.90 | 3.87 |
| 7 | 5.59 | 4.74 | 4.35 | 4.12 | 3.97 | 3.87 | 3.79 | 3.73 | 3.68 | 3.64 | 3.57 | 3.53 | 3.49 | 3.47 | 3.44 |
| 8 | 5.32 | 4.46 | 4.07 | 3.84 | 3.69 | 3.58 | 3.50 | 3.44 | 3.39 | 3.35 | 3.28 | 3.24 | 3.20 | 3.17 | 3.15 |
| 9 | 5.12 | 4.26 | 3.86 | 3.63 | 3.48 | 3.37 | 3.29 | 3.23 | 3.18 | 3.14 | 3.07 | 3.03 | 2.99 | 2.96 | 2.94 |
| 10 | 4.96 | 4.10 | 3.71 | 3.48 | 3.33 | 3.22 | 3.14 | 3.07 | 3.02 | 2.98 | 2.91 | 2.86 | 2.83 | 2.80 | 2.77 |
| 11 | 4.84 | 3.98 | 3.59 | 3.36 | 3.20 | 3.09 | 3.01 | 2.95 | 2.90 | 2.85 | 2.79 | 2.74 | 2.70 | 2.67 | 2.65 |
| 12 | 4.75 | 3.89 | 3.49 | 3.26 | 3.11 | 3.00 | 2.91 | 2.85 | 2.80 | 2.75 | 2.69 | 2.64 | 2.60 | 2.57 | 2.54 |
| 13 | 4.67 | 3.81 | 3.41 | 3.18 | 3.03 | 2.92 | 2.83 | 2.77 | 2.71 | 2.67 | 2.60 | 2.55 | 2.51 | 2.48 | 2.46 |
| 14 | 4.60 | 3.74 | 3.34 | 3.11 | 2.96 | 2.85 | 2.76 | 2.70 | 2.65 | 2.60 | 2.53 | 2.48 | 2.44 | 2.41 | 2.39 |
| 15 | 4.54 | 3.68 | 3.29 | 3.06 | 2.90 | 2.79 | 2.71 | 2.64 | 2.59 | 2.54 | 2.48 | 2.42 | 2.38 | 2.35 | 2.33 |
| 16 | 4.49 | 3.63 | 3.24 | 3.01 | 2.85 | 2.74 | 2.66 | 2.59 | 2.54 | 2.49 | 2.42 | 2.37 | 2.33 | 2.30 | 2.28 |
| 17 | 4.45 | 3.59 | 3.20 | 2.96 | 2.81 | 2.70 | 2.61 | 2.55 | 2.49 | 2.45 | 2.38 | 2.33 | 2.29 | 2.26 | 2.23 |
| 18 | 4.41 | 3.55 | 3.16 | 2.93 | 2.77 | 2.66 | 2.58 | 2.51 | 2.46 | 2.41 | 2.34 | 2.29 | 2.25 | 2.22 | 2.19 |
| 19 | 4.38 | 3.52 | 3.13 | 2.90 | 2.74 | 2.63 | 2.54 | 2.48 | 2.42 | 2.38 | 2.31 | 2.26 | 2.21 | 2.18 | 2.16 |
| 20 | 4.35 | 3.49 | 3.10 | 2.87 | 2.71 | 2.60 | 2.51 | 2.45 | 2.39 | 2.35 | 2.28 | 2.22 | 2.18 | 2.15 | 2.12 |
| 21 | 4.32 | 3.47 | 3.07 | 2.84 | 2.68 | 2.57 | 2.49 | 2.42 | 2.37 | 2.32 | 2.25 | 2.20 | 2.16 | 2.12 | 2.10 |
| 22 | 4.30 | 3.44 | 3.05 | 2.82 | 2.66 | 2.55 | 2.46 | 2.40 | 2.34 | 2.30 | 2.23 | 2.17 | 2.13 | 2.10 | 2.07 |
| 23 | 4.28 | 3.42 | 3.03 | 2.80 | 2.64 | 2.53 | 2.44 | 2.37 | 2.32 | 2.27 | 2.20 | 2.15 | 2.11 | 2.08 | 2.05 |
| 24 | 4.26 | 3.40 | 3.01 | 2.78 | 2.62 | 2.51 | 2.42 | 2.36 | 2.30 | 2.25 | 2.18 | 2.13 | 2.09 | 2.05 | 2.03 |
| 25 | 4.24 | 3.39 | 2.99 | 2.76 | 2.60 | 2.49 | 2.40 | 2.34 | 2.28 | 2.24 | 2.16 | 2.11 | 2.07 | 2.04 | 2.01 |
| 26 | 4.22 | 3.37 | 2.98 | 2.74 | 2.59 | 2.47 | 2.39 | 2.32 | 2.27 | 2.22 | 2.15 | 2.09 | 2.05 | 2.02 | 1.99 |
| 27 | 4.21 | 3.35 | 2.96 | 2.73 | 2.57 | 2.46 | 2.37 | 2.31 | 2.25 | 2.20 | 2.13 | 2.08 | 2.04 | 2.00 | 1.97 |
| 28 | 4.20 | 3.34 | 2.95 | 2.71 | 2.56 | 2.45 | 2.36 | 2.29 | 2.24 | 2.19 | 2.12 | 2.06 | 2.02 | 1.99 | 1.96 |
| 29 | 4.18 | 3.33 | 2.93 | 2.70 | 2.55 | 2.43 | 2.35 | 2.28 | 2.22 | 2.18 | 2.10 | 2.05 | 2.01 | 1.97 | 1.94 |
| 30 | 4.17 | 3.32 | 2.92 | 2.69 | 2.53 | 2.42 | 2.33 | 2.27 | 2.21 | 2.16 | 2.09 | 2.04 | 1.99 | 1.96 | 1.93 |
| 35 | 4.12 | 3.27 | 2.87 | 2.64 | 2.49 | 2.37 | 2.29 | 2.22 | 2.16 | 2.11 | 2.04 | 1.99 | 1.94 | 1.91 | 1.88 |
| 40 | 4.08 | 3.23 | 2.84 | 2.61 | 2.45 | 2.34 | 2.25 | 2.18 | 2.12 | 2.08 | 2.00 | 1.95 | 1.90 | 1.87 | 1.84 |
| 50 | 4.03 | 3.18 | 2.79 | 2.56 | 2.40 | 2.29 | 2.20 | 2.13 | 2.07 | 2.03 | 1.95 | 1.89 | 1.85 | 1.81 | 1.78 |
| 60 | 4.00 | 3.15 | 2.76 | 2.53 | 2.37 | 2.25 | 2.17 | 2.10 | 2.04 | 1.99 | 1.92 | 1.86 | 1.82 | 1.78 | 1.75 |
| 70 | 3.98 | 3.13 | 2.74 | 2.50 | 2.35 | 2.23 | 2.14 | 2.07 | 2.02 | 1.97 | 1.89 | 1.84 | 1.79 | 1.75 | 1.72 |
| 80 | 3.96 | 3.11 | 2.72 | 2.49 | 2.33 | 2.21 | 2.13 | 2.06 | 2.00 | 1.95 | 1.88 | 1.82 | 1.77 | 1.73 | 1.70 |
| 90 | 3.95 | 3.10 | 2.71 | 2.47 | 2.32 | 2.20 | 2.11 | 2.04 | 1.99 | 1.94 | 1.86 | 1.80 | 1.76 | 1.72 | 1.69 |
| 100 | 3.94 | 3.09 | 2.70 | 2.46 | 2.31 | 2.19 | 2.10 | 2.03 | 1.97 | 1.93 | 1.85 | 1.79 | 1.75 | 1.71 | 1.68 |
| 120 | 3.92 | 3.07 | 2.68 | 2.45 | 2.29 | 2.18 | 2.09 | 2.02 | 1.96 | 1.91 | 1.83 | 1.78 | 1.73 | 1.69 | 1.66 |
| 150 | 3.90 | 3.06 | 2.66 | 2.43 | 2.27 | 2.16 | 2.07 | 2.00 | 1.94 | 1.89 | 1.82 | 1.76 | 1.71 | 1.67 | 1.64 |
| 200 | 3.89 | 3.04 | 2.65 | 2.42 | 2.26 | 2.14 | 2.06 | 1.98 | 1.93 | 1.88 | 1.80 | 1.74 | 1.69 | 1.66 | 1.62 |
| 250 | 3.88 | 3.03 | 2.64 | 2.41 | 2.25 | 2.13 | 2.05 | 1.98 | 1.92 | 1.87 | 1.79 | 1.73 | 1.68 | 1.65 | 1.61 |
| 300 | 3.87 | 3.03 | 2.63 | 2.40 | 2.24 | 2.13 | 2.04 | 1.97 | 1.91 | 1.86 | 1.78 | 1.72 | 1.68 | 1.64 | 1.61 |
| 400 | 3.86 | 3.02 | 2.63 | 2.39 | 2.24 | 2.12 | 2.03 | 1.96 | 1.90 | 1.85 | 1.78 | 1.72 | 1.67 | 1.63 | 1.60 |
| 500 | 3.86 | 3.01 | 2.62 | 2.39 | 2.23 | 2.12 | 2.03 | 1.96 | 1.90 | 1.85 | 1.77 | 1.71 | 1.66 | 1.62 | 1.59 |
| 600 | 3.86 | 3.01 | 2.62 | 2.39 | 2.23 | 2.11 | 2.02 | 1.95 | 1.90 | 1.85 | 1.77 | 1.71 | 1.66 | 1.62 | 1.59 |
| 750 | 3.85 | 3.01 | 2.62 | 2.38 | 2.23 | 2.11 | 2.02 | 1.95 | 1.89 | 1.84 | 1.77 | 1.70 | 1.66 | 1.62 | 1.58 |
| 1000 | 3.85 | 3.00 | 2.61 | 2.38 | 2.22 | 2.11 | 2.02 | 1.95 | 1.89 | 1.84 | 1.76 | 1.70 | 1.65 | 1.61 | 1.58 |

TABLE A.3 (continued)

F Distribution: Critical Values of F (5% significance level)

| ν_1 | 25 | 30 | 35 | 40 | 50 | 60 | 75 | 100 | 150 | 200 |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| ν_2 | | | | | | | | | | |
| 1 | 249.26 | 250.10 | 250.69 | 251.14 | 251.77 | 252.20 | 252.62 | 253.04 | 253.46 | 253.68 |
| 2 | 19.46 | 19.46 | 19.47 | 19.47 | 19.48 | 19.48 | 19.48 | 19.49 | 19.49 | 19.49 |
| 3 | 8.63 | 8.62 | 8.60 | 8.59 | 8.58 | 8.57 | 8.56 | 8.55 | 8.54 | 8.54 |
| 4 | 5.77 | 5.75 | 5.73 | 5.72 | 5.70 | 5.69 | 5.68 | 5.66 | 5.65 | 5.65 |
| 5 | 4.52 | 4.50 | 4.48 | 4.46 | 4.44 | 4.43 | 4.42 | 4.41 | 4.39 | 4.39 |
| 6 | 3.83 | 3.81 | 3.79 | 3.77 | 3.75 | 3.74 | 3.73 | 3.71 | 3.70 | 3.69 |
| 7 | 3.40 | 3.38 | 3.36 | 3.34 | 3.32 | 3.30 | 3.29 | 3.27 | 3.26 | 3.25 |
| 8 | 3.11 | 3.08 | 3.06 | 3.04 | 3.02 | 3.01 | 2.99 | 2.97 | 2.96 | 2.95 |
| 9 | 2.89 | 2.86 | 2.84 | 2.83 | 2.80 | 2.79 | 2.77 | 2.76 | 2.74 | 2.73 |
| 10 | 2.73 | 2.70 | 2.68 | 2.66 | 2.64 | 2.62 | 2.60 | 2.59 | 2.57 | 2.56 |
| 11 | 2.60 | 2.57 | 2.55 | 2.53 | 2.51 | 2.49 | 2.47 | 2.46 | 2.44 | 2.43 |
| 12 | 2.50 | 2.47 | 2.44 | 2.43 | 2.40 | 2.38 | 2.37 | 2.35 | 2.33 | 2.32 |
| 13 | 2.41 | 2.38 | 2.36 | 2.34 | 2.31 | 2.30 | 2.28 | 2.26 | 2.24 | 2.23 |
| 14 | 2.34 | 2.31 | 2.28 | 2.27 | 2.24 | 2.22 | 2.21 | 2.19 | 2.17 | 2.16 |
| 15 | 2.28 | 2.25 | 2.22 | 2.20 | 2.18 | 2.16 | 2.14 | 2.12 | 2.10 | 2.10 |
| 16 | 2.23 | 2.19 | 2.17 | 2.15 | 2.12 | 2.11 | 2.09 | 2.07 | 2.05 | 2.04 |
| 17 | 2.18 | 2.15 | 2.12 | 2.10 | 2.08 | 2.06 | 2.04 | 2.02 | 2.00 | 1.99 |
| 18 | 2.14 | 2.11 | 2.08 | 2.06 | 2.04 | 2.02 | 2.00 | 1.98 | 1.96 | 1.95 |
| 19 | 2.11 | 2.07 | 2.05 | 2.03 | 2.00 | 1.98 | 1.96 | 1.94 | 1.92 | 1.91 |
| 20 | 2.07 | 2.04 | 2.01 | 1.99 | 1.97 | 1.95 | 1.93 | 1.91 | 1.89 | 1.88 |
| 21 | 2.05 | 2.01 | 1.98 | 1.96 | 1.94 | 1.92 | 1.90 | 1.88 | 1.86 | 1.84 |
| 22 | 2.02 | 1.98 | 1.96 | 1.94 | 1.91 | 1.89 | 1.87 | 1.85 | 1.83 | 1.82 |
| 23 | 2.00 | 1.96 | 1.93 | 1.91 | 1.88 | 1.86 | 1.84 | 1.82 | 1.80 | 1.79 |
| 24 | 1.97 | 1.94 | 1.91 | 1.89 | 1.86 | 1.84 | 1.82 | 1.80 | 1.78 | 1.77 |
| 25 | 1.96 | 1.92 | 1.89 | 1.87 | 1.84 | 1.82 | 1.80 | 1.78 | 1.76 | 1.75 |
| 26 | 1.94 | 1.90 | 1.87 | 1.85 | 1.82 | 1.80 | 1.78 | 1.76 | 1.74 | 1.73 |
| 27 | 1.92 | 1.88 | 1.86 | 1.84 | 1.81 | 1.79 | 1.76 | 1.74 | 1.72 | 1.71 |
| 28 | 1.91 | 1.87 | 1.84 | 1.82 | 1.79 | 1.77 | 1.75 | 1.73 | 1.70 | 1.69 |
| 29 | 1.89 | 1.85 | 1.83 | 1.81 | 1.77 | 1.75 | 1.73 | 1.71 | 1.69 | 1.67 |
| 30 | 1.88 | 1.84 | 1.81 | 1.79 | 1.76 | 1.74 | 1.72 | 1.70 | 1.67 | 1.66 |
| 35 | 1.82 | 1.79 | 1.76 | 1.74 | 1.70 | 1.68 | 1.66 | 1.63 | 1.61 | 1.60 |
| 40 | 1.78 | 1.74 | 1.72 | 1.69 | 1.66 | 1.64 | 1.61 | 1.59 | 1.56 | 1.55 |
| 50 | 1.73 | 1.69 | 1.66 | 1.63 | 1.60 | 1.58 | 1.55 | 1.52 | 1.50 | 1.48 |
| 60 | 1.69 | 1.65 | 1.62 | 1.59 | 1.56 | 1.53 | 1.51 | 1.48 | 1.45 | 1.44 |
| 70 | 1.66 | 1.62 | 1.59 | 1.57 | 1.53 | 1.50 | 1.48 | 1.45 | 1.42 | 1.40 |
| 80 | 1.64 | 1.60 | 1.57 | 1.54 | 1.51 | 1.48 | 1.45 | 1.43 | 1.39 | 1.38 |
| 90 | 1.63 | 1.59 | 1.55 | 1.53 | 1.49 | 1.46 | 1.44 | 1.41 | 1.38 | 1.36 |
| 100 | 1.62 | 1.57 | 1.54 | 1.52 | 1.48 | 1.45 | 1.42 | 1.39 | 1.36 | 1.34 |
| 120 | 1.60 | 1.55 | 1.52 | 1.50 | 1.46 | 1.43 | 1.40 | 1.37 | 1.33 | 1.32 |
| 150 | 1.58 | 1.54 | 1.50 | 1.48 | 1.44 | 1.41 | 1.38 | 1.34 | 1.31 | 1.29 |
| 200 | 1.56 | 1.52 | 1.48 | 1.46 | 1.41 | 1.39 | 1.35 | 1.32 | 1.28 | 1.26 |
| 250 | 1.55 | 1.50 | 1.47 | 1.44 | 1.40 | 1.37 | 1.34 | 1.31 | 1.27 | 1.25 |
| 300 | 1.54 | 1.50 | 1.46 | 1.43 | 1.39 | 1.36 | 1.33 | 1.30 | 1.26 | 1.23 |
| 400 | 1.53 | 1.49 | 1.45 | 1.42 | 1.38 | 1.35 | 1.32 | 1.28 | 1.24 | 1.22 |
| 500 | 1.53 | 1.48 | 1.45 | 1.42 | 1.38 | 1.35 | 1.31 | 1.28 | 1.23 | 1.21 |
| 600 | 1.52 | 1.48 | 1.44 | 1.41 | 1.37 | 1.34 | 1.31 | 1.27 | 1.23 | 1.20 |
| 750 | 1.52 | 1.47 | 1.44 | 1.41 | 1.37 | 1.34 | 1.30 | 1.26 | 1.22 | 1.20 |
| 1000 | 1.52 | 1.47 | 1.43 | 1.41 | 1.36 | 1.33 | 1.30 | 1.26 | 1.22 | 1.19 |