

UNIVERSITY OF SWAZILAND

SUPPLEMENTARY EXAMINATION PAPER 2008

TITLE OF PAPER : LINEAR STATISTICAL METHODS

COURSE CODE : ST204

TIME ALLOWED : 2 (TWO) HOURS

**REQUIRMENTS : STATISTICAL TABLES
AND CALCULATORS**

**INSTRUCTIONS : 1. THIS PAPER CONSISTS OF FIVE
QUESTIONS.
2. ANSWER ANY FOUR QUESTIONS.**

**THIS PAPER IS NOT TO BE OPENED UNTIL PERMISSION HAS BEEN
GRANTED BY THE INVIGILATOR**

QUESTION 1

1. A researcher wants to compare the effectiveness of two different teaching methods for three different class sizes. The data on the student's score on a standardized test were collected and analyzed using SPSS. The following ANOVA table is part of the output from that analysis.

Source of variation	Sum of squares	Degrees of freedom	Mean squares	F-ratio
Between treatments	220	5		
Factor <i>A</i>	120	1	120	24
Factor <i>B</i>	20	2	10	2
<i>A</i> × <i>B</i> Interaction	80	2	40	8
Within treatments	120	24	5	
Total	340	29		

- (a) What are the treatments in this experiment? How many? [4 marks]
- (b) Which one is factor *A*? Which one is factor *B*? [4 marks]
- (c) How many scores were used in the experiment? [4 marks]
- (d) Using the 1% level of significance, examine the significance of
- (i) the teaching method. [4 marks]
 - (ii) class size [4 marks]
 - (iii) the interaction between class size and the teaching method. [5 marks]

QUESTION 2

2. Five automobiles were used in an experiment designed to compare the mileage per gallon obtained by 3 competing brands of gasoline and the following data resulted.

Automobile	Gasoline		
	A	B	C
1	21	23	22
2	25	26	24
3	29	30	29
4	32	34	32
5	18	24	22

- (a) Identify the dependent variable, factor studied and factor levels. [5 marks]
- (b) Complete the computation of the ANOVA table and conduct the F test. Clearly state all the steps in the test including the conclusions. [20 marks]

QUESTION 3

3. To see whether a widely used food preservative contributes to the hyperactivity of preschool children, a dietician chose a random sample of 10 four year-olds known to be fairly hyperactive from various nursery schools and observed their behaviour 45 minutes after they had eaten measured amounts of food containing the preservative. In the table that follows, X is the amount of food consumed containing the preservative (in grams) and Y is a subjective rating of hyperactivity (on a scale of 1 to 20) based on a child's restlessness and interaction with other children.

X	36	82	45	49	21	24	58	73	85	52
Y	6	14	5	13	5	8	14	11	18	6

- (a) Find the least squares regression line. [5 marks]
- (b) Use the equation in (a) to estimate the hyperactivity rating of a child that had 65 grams of food with the preservative 45 minutes earlier. [2 marks]
- (c) Interpret the estimated values of β_0 and β_1 . [4 marks]
- (d) Find the coefficient of determination and interpret the result. [5 marks]
- (e) Compute σ^2 . [5 marks]
- (f) Test the hypothesis $H_0 : \beta_1 = 0$ against $H_1 : \beta_1 \neq 0$ at a significance level $\alpha = 0.05$ [4 marks]

QUESTION 4

4. The following table shows how many weeks six persons have worked at an automobile inspection station and the number of cars each one inspected between noon and 2 P.M. on a given day.

Number of weeks employed	Number of cars inspected
X	Y
2	13
7	21
9	23
1	14
5	15
12	21

- (a) Find the least squares regression line. [7 marks]
- (b) Compute σ^2 . [5 marks]
- (c) Test the null hypothesis $\beta_1 = 1.5$ against the alternative hypothesis $\beta < 1.5$ at the 0.05 level of significance. [3 marks]
- (d) Construct a 95% confidence interval for the slope β_1 . [5 marks]
- (e) Construct a 99% confidence interval for the mean hyperactivity rating of a four year old at one of the nursery schools 45 minutes after he or she has eaten 60 grams of food containing the preservative. [5 marks]

QUESTION 5

5. (a) What is Simple Linear Regression Model? Discuss the main purposes of fitting this model. [5 marks]
- (b) Find the point estimators of two regression coefficients using Method of Least Squares. [5 marks]
- (c) Discuss Regression Analysis and Analysis of Variance in terms of their similarities and differences. [5 marks]
- (d) Define a two-factor ANOVA Model and state its important features. [5 marks]
- (e) Suppose there is only one case for each treatment. What would be the new form of the model defined in question (b) ? Explain [5 marks]

END OF EXAMINATION

TABLE A.2 Percentiles of the *t* Distribution

Entry is $t(A; \nu)$ where $P(t(\nu) \leq t(A; \nu)) = A$



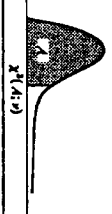
ν	A					
	.50	.70	.80	.85	.90	.95
1	0.333	0.727	1.376	1.963	3.078	6.314
2	0.289	0.617	1.061	1.386	1.886	4.303
3	0.277	0.584	0.978	1.250	1.638	3.182
4	0.271	0.569	0.941	1.190	1.533	2.776
5	0.267	0.559	0.920	1.154	1.476	2.571
6	0.265	0.553	0.906	1.134	1.440	2.447
7	0.263	0.549	0.896	1.119	1.415	2.365
8	0.262	0.546	0.889	1.108	1.397	2.306
9	0.261	0.543	0.883	1.100	1.383	2.262
10	0.260	0.542	0.879	1.095	1.372	2.228
11	0.260	0.540	0.876	1.092	1.363	2.201
12	0.259	0.539	0.873	1.088	1.356	2.179
13	0.259	0.537	0.870	1.085	1.350	2.160
14	0.258	0.536	0.868	1.082	1.345	2.145
15	0.258	0.535	0.866	1.079	1.341	2.131
16	0.258	0.535	0.865	1.071	1.337	2.120
17	0.257	0.534	0.863	1.069	1.333	2.110
18	0.257	0.534	0.862	1.067	1.330	2.101
19	0.257	0.533	0.861	1.066	1.328	2.093
20	0.257	0.533	0.860	1.064	1.325	2.086
21	0.257	0.532	0.859	1.063	1.323	2.080
22	0.256	0.532	0.858	1.061	1.321	2.074
23	0.256	0.532	0.858	1.060	1.319	2.069
24	0.256	0.531	0.857	1.059	1.318	2.064
25	0.256	0.531	0.856	1.058	1.316	2.060
26	0.256	0.531	0.856	1.058	1.315	2.056
27	0.256	0.531	0.855	1.057	1.314	2.052
28	0.256	0.530	0.855	1.056	1.313	2.048
29	0.256	0.530	0.854	1.055	1.311	2.045
30	0.256	0.530	0.854	1.055	1.310	2.042
40	0.255	0.529	0.851	1.050	1.303	2.021
60	0.254	0.527	0.848	1.045	1.296	2.001
120	0.254	0.526	0.845	1.041	1.289	1.980
∞	0.253	0.524	0.842	1.036	1.282	1.960

TABLE A.3 (continued) Percentiles of the *t* Distribution

ν	A					
	.98	.985	.99	.9925	.995	.9975
1	15.895	21.203	31.821	42.654	63.657	127.322
2	4.849	5.643	6.965	8.073	9.925	14.089
3	3.482	3.886	4.541	5.047	5.841	7.453
4	2.999	3.298	3.747	4.088	4.604	5.988
5	2.757	3.003	3.365	3.634	4.032	4.773
6	2.612	2.829	3.143	3.372	3.707	4.317
7	2.517	2.715	2.998	3.203	3.499	4.029
8	2.449	2.634	2.886	3.083	3.355	3.833
9	2.398	2.574	2.821	2.998	3.250	3.690
10	2.359	2.527	2.764	2.932	3.169	3.581
11	2.328	2.491	2.718	2.879	3.106	3.497
12	2.303	2.464	2.681	2.836	3.054	3.428
13	2.282	2.444	2.650	2.800	3.012	3.372
14	2.264	2.428	2.620	2.771	2.977	3.326
15	2.249	2.397	2.602	2.746	2.947	3.286
16	2.235	2.382	2.583	2.724	2.921	3.252
17	2.224	2.368	2.567	2.704	2.898	3.222
18	2.214	2.358	2.552	2.689	2.878	3.197
19	2.205	2.346	2.539	2.674	2.861	3.174
20	2.197	2.336	2.528	2.661	2.843	3.153
21	2.189	2.328	2.518	2.649	2.831	3.135
22	2.183	2.320	2.508	2.639	2.819	3.119
23	2.177	2.313	2.500	2.629	2.807	3.104
24	2.172	2.307	2.492	2.620	2.797	3.091
25	2.167	2.301	2.485	2.612	2.787	3.078
26	2.162	2.296	2.479	2.605	2.779	3.067
27	2.158	2.291	2.473	2.598	2.771	3.057
28	2.154	2.286	2.467	2.592	2.763	3.047
29	2.150	2.282	2.462	2.586	2.756	3.038
30	2.147	2.278	2.457	2.581	2.750	3.030
40	2.123	2.250	2.423	2.542	2.704	2.971
60	2.099	2.223	2.390	2.504	2.660	2.915
120	2.076	2.203	2.360	2.468	2.617	2.860
∞	2.054	2.170	2.326	2.432	2.576	2.807

TABLE A.3 Percentiles of the χ^2 Distribution

Entry is $\chi^2(A; v)$ where $P(\chi^2(v) \leq \chi^2(A; v)) = A$

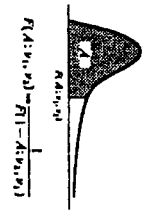


v	A									
	.005	.010	.025	.050	.100	.500	.950	.975	.990	.995
1	0.0043	0.0086	0.0175	0.0358	0.0718	1.385	3.841	4.605	5.024	5.401
2	0.0100	0.0200	0.0400	0.0778	0.1533	2.770	3.000	3.219	3.579	3.858
3	0.0777	0.1533	0.3177	0.5844	1.2125	2.366	2.746	2.947	3.219	3.437
4	0.2048	0.4048	0.7879	1.3858	2.366	1.924	2.204	2.366	2.528	2.690
5	0.4113	0.8113	1.5085	2.366	3.353	1.676	1.978	2.140	2.302	2.464
6	0.6169	1.2169	2.2041	3.353	4.751	1.501	1.801	1.963	2.125	2.287
7	0.8385	1.6385	2.8995	4.751	6.344	1.370	1.670	1.832	1.994	2.156
8	1.0998	2.1998	3.8886	6.344	8.328	1.266	1.566	1.728	1.890	2.052
9	1.3858	2.7858	5.024	8.328	10.557	1.179	1.479	1.641	1.803	1.965
10	1.6759	3.1759	6.344	10.557	13.017	1.106	1.406	1.568	1.730	1.892
11	1.9779	3.5779	7.779	13.017	15.658	1.043	1.343	1.505	1.667	1.829
12	2.2899	3.9799	9.302	15.658	18.475	0.989	1.289	1.451	1.613	1.775
13	2.6019	4.3819	10.925	18.475	21.476	0.943	1.243	1.405	1.567	1.729
14	2.9139	4.7839	12.648	21.476	24.661	0.902	1.202	1.359	1.521	1.683
15	3.2259	5.1859	14.471	24.661	28.000	0.865	1.165	1.313	1.475	1.637
16	3.5379	5.5879	16.394	28.000	31.526	0.832	1.132	1.276	1.429	1.591
17	3.8499	5.9899	18.417	31.526	35.272	0.802	1.102	1.239	1.383	1.545
18	4.1619	6.3919	20.540	35.272	39.152	0.774	1.074	1.202	1.337	1.499
19	4.4739	6.7939	22.763	39.152	43.152	0.749	1.049	1.167	1.291	1.453
20	4.7859	7.1959	25.186	43.152	47.321	0.726	1.026	1.132	1.245	1.407
21	5.0979	7.5979	27.709	47.321	51.550	0.705	1.005	1.097	1.199	1.361
22	5.4099	7.9999	30.332	51.550	55.929	0.686	0.986	1.062	1.153	1.315
23	5.7219	8.4019	33.055	55.929	60.429	0.669	0.969	1.027	1.107	1.269
24	6.0339	8.8039	35.878	60.429	65.029	0.654	0.954	0.992	1.061	1.223
25	6.3459	9.2059	38.781	65.029	69.729	0.641	0.941	0.957	1.015	1.177
26	6.6579	9.6079	41.764	69.729	74.529	0.629	0.929	0.922	0.969	1.131
27	6.9699	10.0099	44.827	74.529	79.429	0.618	0.918	0.887	0.923	1.085
28	7.2819	10.4119	47.970	79.429	84.429	0.608	0.908	0.846	0.877	1.039
29	7.5939	10.8139	51.193	84.429	89.529	0.600	0.900	0.805	0.831	0.993
30	7.9059	11.2159	54.496	89.529	94.729	0.593	0.893	0.764	0.785	0.947
31	8.2179	11.6179	57.879	94.729	100.029	0.587	0.887	0.723	0.739	0.901
32	8.5299	12.0199	61.342	100.029	105.429	0.582	0.882	0.682	0.693	0.855
33	8.8419	12.4219	64.885	105.429	110.929	0.578	0.878	0.641	0.647	0.809
34	9.1539	12.8239	68.508	110.929	116.529	0.574	0.874	0.600	0.601	0.763
35	9.4659	13.2259	72.211	116.529	122.229	0.571	0.871	0.559	0.555	0.717
36	9.7779	13.6279	76.094	122.229	128.029	0.568	0.868	0.518	0.509	0.671
37	10.0899	14.0299	79.957	128.029	133.929	0.566	0.866	0.477	0.463	0.625
38	10.4019	14.4319	83.900	133.929	140.029	0.564	0.864	0.436	0.417	0.579
39	10.7139	14.8339	87.923	140.029	146.329	0.562	0.862	0.395	0.373	0.533
40	11.0259	15.2359	92.026	146.329	152.829	0.561	0.861	0.354	0.327	0.487
41	11.3379	15.6379	96.209	152.829	159.529	0.560	0.860	0.313	0.281	0.441
42	11.6499	16.0399	100.472	159.529	166.429	0.559	0.859	0.272	0.235	0.395
43	11.9619	16.4419	104.815	166.429	173.529	0.558	0.858	0.231	0.189	0.349
44	12.2739	16.8439	109.238	173.529	180.829	0.558	0.858	0.190	0.143	0.303
45	12.5859	17.2459	113.741	180.829	188.329	0.557	0.857	0.149	0.097	0.257
46	12.8979	17.6479	118.324	188.329	196.029	0.557	0.857	0.108	0.051	0.211
47	13.2099	18.0499	122.987	196.029	203.929	0.557	0.857	0.067	0.005	0.165
48	13.5219	18.4519	127.730	203.929	212.029	0.557	0.857	0.026	0.000	0.119
49	13.8339	18.8539	132.553	212.029	220.329	0.557	0.857	0.000	0.000	0.073
50	14.1459	19.2559	137.456	220.329	228.829	0.557	0.857	0.000	0.000	0.027

Source: Biometrika table published by Frank C. M. Thompson, "Table of Percentage Points of the Chi-Square Distribution," Biometrika 27 (1941), pp. 188-96.

TABLE A.4 Percentiles of the F Distribution

Entry is $F(A; n_1, n_2)$ where $P(F(n_1, n_2) \leq F(A; n_1, n_2)) = A$



$F(A; n_1, n_2) = F | - A(n_1, n_2)$



TABLE A-4 (continued) Percentiles of the F Distribution

Den. of A	Numerator of A								
	1	2	3	4	5	6	7	8	9
1 .50	1.00	1.50	1.71	1.82	1.89	1.94	1.98	2.00	2.03
.90	39.9	49.5	51.6	52.8	53.2	53.6	53.9	54.1	54.3
.95	18.1	20.0	21.0	21.5	21.8	22.0	22.1	22.2	22.3
.975	10.1	11.0	11.5	11.7	11.8	11.9	12.0	12.0	12.1
.99	6.0	6.5	6.8	7.0	7.1	7.2	7.2	7.3	7.3
.995	4.0	4.2	4.4	4.5	4.5	4.6	4.6	4.6	4.7
.999	2.0	2.1	2.2	2.2	2.3	2.3	2.3	2.4	2.4
2 .50	0.667	1.00	1.13	1.21	1.23	1.28	1.30	1.32	1.33
.90	8.33	9.00	9.16	9.24	9.28	9.33	9.35	9.38	9.38
.95	4.5	4.8	4.9	5.0	5.0	5.0	5.0	5.0	5.0
.975	3.0	3.1	3.2	3.2	3.2	3.2	3.2	3.2	3.2
.99	2.0	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
.995	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
.999	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3 .50	0.585	0.881	1.00	1.06	1.10	1.13	1.15	1.16	1.17
.90	5.34	5.46	5.50	5.53	5.54	5.55	5.56	5.56	5.57
.95	3.0	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
.975	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
.99	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
.995	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
.999	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
4 .50	0.549	0.822	0.941	1.00	1.04	1.06	1.08	1.09	1.10
.90	4.24	4.32	4.35	4.37	4.38	4.39	4.39	4.40	4.40
.95	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
.975	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
.99	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
.995	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
.999	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
5 .50	0.528	0.799	0.907	0.965	1.00	1.02	1.04	1.05	1.06
.90	4.06	4.16	4.20	4.22	4.23	4.24	4.24	4.25	4.25
.95	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
.975	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
.99	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
.995	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
.999	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
6 .50	0.515	0.780	0.886	0.942	0.977	1.00	1.02	1.03	1.04
.90	3.78	3.86	3.90	3.92	3.93	3.94	3.94	3.95	3.95
.95	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
.975	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
.99	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
.995	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
.999	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
7 .50	0.506	0.767	0.871	0.926	0.960	0.983	1.00	1.01	1.02
.90	3.59	3.66	3.70	3.72	3.73	3.74	3.74	3.75	3.75
.95	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
.975	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
.99	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
.995	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
.999	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6

TABLE A-4 (continued) Percentiles of the F Distribution

Den. of A	Numerator of A											
	10	12	15	20	24	30	60	120	∞			
1 .50	2.04	2.07	2.09	2.12	2.13	2.15	2.17	2.18	2.20			
.90	40.2	40.7	41.2	41.7	42.0	42.3	42.8	43.1	43.3			
.95	24.0	24.2	24.4	24.6	24.7	24.8	24.9	25.0	25.0			
.975	18.0	18.1	18.2	18.3	18.3	18.4	18.4	18.4	18.4			
.99	14.0	14.0	14.1	14.1	14.1	14.1	14.1	14.1	14.1			
.995	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0			
.999	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0			
2 .50	1.34	1.36	1.38	1.40	1.40	1.41	1.43	1.43	1.44			
.90	9.41	9.42	9.43	9.44	9.44	9.45	9.46	9.46	9.46			
.95	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8			
.975	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2			
.99	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0			
.995	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3			
.999	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7			
3 .50	1.18	1.20	1.21	1.23	1.23	1.24	1.25	1.26	1.27			
.90	5.23	5.22	5.20	5.18	5.18	5.17	5.15	5.14	5.13			
.95	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2			
.975	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3			
.99	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7			
.995	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3			
.999	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0			
4 .50	1.11	1.13	1.14	1.15	1.16	1.16	1.18	1.18	1.19			
.90	3.92	3.90	3.87	3.84	3.83	3.82	3.79	3.78	3.76			
.95	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4			
.975	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8			
.99	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3			
.995	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0			
.999	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7			
5 .50	1.07	1.09	1.10	1.11	1.12	1.12	1.14	1.14	1.15			
.90	3.30	3.27	3.24	3.21	3.19	3.17	3.14	3.12	3.11			
.95	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0			
.975	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5			
.99	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1			
.995	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8			
.999	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6			
6 .50	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12	1.12			
.90	2.80	2.77	2.74	2.72	2.70	2.68	2.64	2.62	2.61			
.95	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7			
.975	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2			
.99	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9			
.995	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7			
.999	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5			
7 .50	1.03	1.04	1.05	1.07	1.07	1.08	1.09	1.10	1.10			
.90	2.70	2.67	2.63	2.59	2.58	2.56	2.52	2.49	2.47			
.95	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6			
.975	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1			
.99	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8			
.995	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6			
.999	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4			

TABLE A.4 (continued) Percentiles of the F Distribution

Den. df	Numerator df								
	1	2	3	4	5	6	7	8	9
8	0.499	0.757	0.860	0.915	0.948	0.971	0.988	1.00	1.01
10	0.499	0.757	0.860	0.915	0.948	0.971	0.988	1.00	1.01
12	0.499	0.757	0.860	0.915	0.948	0.971	0.988	1.00	1.01
15	0.499	0.757	0.860	0.915	0.948	0.971	0.988	1.00	1.01
20	0.499	0.757	0.860	0.915	0.948	0.971	0.988	1.00	1.01
24	0.499	0.757	0.860	0.915	0.948	0.971	0.988	1.00	1.01
30	0.499	0.757	0.860	0.915	0.948	0.971	0.988	1.00	1.01
40	0.499	0.757	0.860	0.915	0.948	0.971	0.988	1.00	1.01
50	0.499	0.757	0.860	0.915	0.948	0.971	0.988	1.00	1.01
60	0.499	0.757	0.860	0.915	0.948	0.971	0.988	1.00	1.01
80	0.499	0.757	0.860	0.915	0.948	0.971	0.988	1.00	1.01
100	0.499	0.757	0.860	0.915	0.948	0.971	0.988	1.00	1.01

TABLE A.4 (continued) Percentiles of the F Distribution

Den. df	Numerator df										
	10	12	15	20	24	30	40	60	120	∞	
8	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	
10	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	
12	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	
15	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	
20	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	
24	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	
30	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	
40	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	
50	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	
60	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	
80	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	
100	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	

TABLE A.3 (continued) Percentiles of the F Distribution

Den. df	Numerator df								
	1	2	3	4	5	6	7	8	9
30	0.466	0.709	0.807	0.858	0.890	0.912	0.927	0.939	0.948
.90	2.88	2.49	2.28	2.16	2.08	2.02	1.98	1.95	1.93
.95	4.17	3.52	3.22	3.05	2.95	2.87	2.81	2.77	2.75
.975	5.57	4.18	3.79	3.57	3.47	3.40	3.35	3.31	3.29
.99	7.26	5.13	4.62	4.32	4.22	4.15	4.10	4.07	4.05
.995	9.18	6.35	5.74	5.42	5.32	5.25	5.20	5.17	5.15
.999	13.1	8.77	7.95	7.62	7.53	7.47	7.42	7.38	7.36
60	0.461	0.701	0.798	0.849	0.880	0.901	0.917	0.928	0.937
.90	2.79	2.39	2.18	2.04	1.95	1.87	1.82	1.77	1.74
.95	4.00	3.15	2.76	2.53	2.43	2.35	2.30	2.26	2.24
.975	5.39	3.93	3.54	3.31	3.21	3.12	3.07	3.03	3.01
.99	7.04	4.98	4.43	4.15	4.04	3.96	3.90	3.86	3.84
.995	8.89	5.80	5.17	4.84	4.73	4.65	4.60	4.56	4.54
.999	12.0	7.77	7.17	6.81	6.70	6.62	6.57	6.53	6.51
120	0.458	0.697	0.793	0.844	0.875	0.896	0.912	0.923	0.932
.90	2.75	2.35	2.13	1.99	1.90	1.82	1.77	1.72	1.68
.95	3.92	3.07	2.68	2.45	2.35	2.27	2.22	2.18	2.16
.975	5.15	3.80	3.41	3.18	3.07	2.98	2.93	2.89	2.87
.99	6.85	4.79	4.24	3.96	3.85	3.76	3.71	3.67	3.65
.995	8.18	5.54	4.90	4.62	4.51	4.42	4.37	4.33	4.31
.999	11.4	7.32	6.72	6.35	6.24	6.15	6.10	6.06	6.04
∞	0.455	0.693	0.789	0.840	0.870	0.891	0.907	0.918	0.927
.90	2.71	2.30	2.08	1.94	1.85	1.77	1.72	1.67	1.63
.95	3.87	3.00	2.60	2.37	2.27	2.19	2.14	2.10	2.08
.975	5.02	3.69	3.12	2.79	2.67	2.58	2.53	2.49	2.47
.99	6.63	4.61	4.17	3.72	3.60	3.51	3.46	3.42	3.40
.995	7.98	5.30	4.78	4.42	4.31	4.22	4.17	4.13	4.11
.999	10.8	6.91	6.32	5.92	5.81	5.72	5.67	5.63	5.61

TABLE A.4 (continued) Percentiles of the F Distribution

Den. df	Numerator df										
	10	12	15	20	24	30	60	120	∞		
30	0.935	0.866	0.828	0.809	0.794	0.784	0.774	0.767	0.762	0.758	
.90	1.82	1.69	1.62	1.57	1.54	1.52	1.50	1.49	1.48	1.47	
.95	2.31	2.09	2.01	1.93	1.89	1.86	1.84	1.83	1.82	1.81	
.975	2.98	2.64	2.56	2.45	2.41	2.38	2.36	2.35	2.34	2.33	
.99	3.94	3.18	3.01	2.82	2.73	2.63	2.62	2.61	2.60	2.59	
.995	4.24	4.00	3.75	3.49	3.36	3.22	3.22	3.22	3.22	3.22	
.999	4.24	4.00	3.75	3.49	3.36	3.22	3.22	3.22	3.22	3.22	
60	0.945	0.856	0.827	0.807	0.792	0.782	0.772	0.765	0.760	0.756	
.90	1.71	1.66	1.60	1.54	1.51	1.48	1.46	1.45	1.44	1.43	
.95	1.99	1.92	1.84	1.75	1.70	1.65	1.63	1.62	1.61	1.60	
.975	2.27	2.17	2.06	1.94	1.88	1.82	1.80	1.79	1.78	1.77	
.99	2.63	2.50	2.35	2.20	2.12	2.03	2.02	2.01	2.00	1.99	
.995	2.90	2.74	2.57	2.39	2.29	2.19	2.18	2.17	2.16	2.15	
.999	3.14	3.12	3.08	2.83	2.69	2.53	2.53	2.53	2.53	2.53	
120	0.939	0.850	0.821	0.801	0.786	0.776	0.766	0.759	0.754	0.750	
.90	1.63	1.60	1.53	1.46	1.43	1.41	1.39	1.38	1.37	1.36	
.95	1.91	1.83	1.72	1.58	1.51	1.45	1.43	1.42	1.41	1.40	
.975	2.18	2.07	1.92	1.76	1.69	1.62	1.60	1.59	1.58	1.57	
.99	2.47	2.34	2.19	2.01	1.92	1.82	1.81	1.80	1.79	1.78	
.995	2.74	2.62	2.47	2.27	2.17	2.07	2.06	2.05	2.04	2.03	
.999	3.02	3.02	2.78	2.53	2.40	2.26	2.26	2.26	2.26	2.26	
∞	0.934	0.845	0.816	0.796	0.781	0.771	0.761	0.754	0.749	0.745	
.90	1.60	1.55	1.49	1.42	1.38	1.34	1.32	1.31	1.30	1.29	
.95	1.83	1.75	1.67	1.57	1.52	1.46	1.44	1.43	1.42	1.41	
.975	2.03	1.94	1.83	1.71	1.64	1.57	1.55	1.54	1.53	1.52	
.99	2.32	2.18	2.04	1.88	1.79	1.70	1.67	1.66	1.65	1.64	
.995	2.52	2.36	2.19	2.00	1.90	1.79	1.78	1.77	1.76	1.75	
.999	2.96	2.74	2.51	2.27	2.13	1.99	1.98	1.97	1.96	1.95	

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