

UNIVERSITY OF SWAZILAND  
MAIN EXAMINATION PAPER 2007

**TITLE OF PAPER:** BIostatISTICS

**COURSE CODE:** B305

**TIME ALLOWED:** THREE (3) HOURS

- INSTRUCTIONS:**
1. ANSWER ANY FOUR QUESTIONS.
  2. EACH QUESTION CARRIES TWENTY FIVE (25) MARKS.
  3. ILLUSTRATE YOUR ANSWERS WITH LARGE AND CLEARLY LABELED DIAGRAMS WHERE APPROPRIATE.
  4. CLEARLY STATE YOUR NULL AND ALTERNATIVE HYPOTHESES AND YOUR CONCLUSIONS WHERE APPROPRIATE.

**SPECIAL REQUIREMENTS:**

1. CALCULATORS (CANDIDATES MUST BRING THEIR OWN).
2. GRAPH PAPER.
3. STATISTICAL TABLES (TO BE SUPPLIED BY THE LECTURER).

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

ANSWER FOUR (4) OUT OF SIX (6) QUESTIONS

**QUESTION 1**

The following measurements were taken from eight snakes by a herpetologist.

Head length (mm)	Snout-vent length (mm)
53.1	123
54.3	125
55.0	124
56.3	127
56.5	127
56.6	128
56.9	129
57.2	130

- a) Is there a significant correlation between head length and snout-vent length?  
[22 marks]
- b) When should one use correlation analysis? And when should one use regression analysis?

[3 marks]

[TOTAL = 25 marks]

**QUESTION 2**

The following are leaf lengths (mm) of shrubs from five different mountains in East Africa.

Mountain A	Mountain B	Mountain C	Mountain D	Mountain E
122	127	128	132	131
125	125	127	128	130
123	123	126	130	132
119	126	128	129	129

- a) Calculate the mean and confidence interval for each of the five populations. [10 marks]  
 b) Use an appropriate graph to plot these mean values together with the confidence intervals. [9 marks]  
 c) Describe in detail the three types of data, providing examples for each type. [6 marks]  
**[TOTAL = 25 marks]**

**QUESTION 3**

- a) A physiologist wants to test whether spending two weeks at high altitude above 5000 m is enough time for humans to acclimatize to the severe conditions. She uses eight people for her experiment. The O<sub>2</sub> consumption of each person is recorded before the experiment, and then two weeks later after the experiment is over. The difference between the O<sub>2</sub> consumption of each person before and after the experiment is as follows: -20, -10, 0, -5, -30, -20, -10, -20.

Use an appropriate statistical test to determine whether the two week exposure was sufficient for humans to acclimatize to high altitudes (assuming that a reduction in O<sub>2</sub> consumption implies acclimatization).

[15 marks]

- b) Determine whether the following data are likely to have come from a binomial population with  $n = 4$ ,  $p = 0.35$ .

X	F
0	23
1	45
2	46
3	13
4	1

[10 marks]

**[TOTAL = 25 marks]**

**QUESTION 4**

The following table shows the yield of crops (kg/ha) under different concentrations of fertilizer.

0	20 kg/ha	50 kg/ha	120 kg/ha	200 kg/ha
12.6	12.9	15.2	16.1	14.2
11.8	12.7	14.7	16.7	14.0
11.5	12.5	14.8	17.0	14.1
11.7	12.8	13.9	16.9	14.9

a) Using ANOVA, establish whether fertilizer concentration has a significant effect on crop yield. [22 marks]

b) Why is it important to use a BLOCK design for experiments such as the one mentioned above? [3 marks]

[TOTAL = 25 marks]

**QUESTION 5**

The following table shows the numbers of visitors to two different habitats in southern African parks (A = single adults; B = couples; C = teenagers; D = pensioners).

Habitat	Number of visitors			
	A	B	C	D
Forest	8	44	12	20
Savanna	12	15	15	33

- a) Are different visitors utilizing the different habitats equally? Test this hypothesis using the chi-square test. [15 marks]
- b) Subdivide the chi-square test to determine which (if any) group of people contributed significantly to rejecting the null hypothesis. [10 marks]
- [TOTAL = 25 marks]

**QUESTION 6**

The following are test results (%) obtained by students from different years, for the same course:

2002	2003
78	85
76	81
74	65
76	76
79	54
80	59
71	69

- a) The data are **NOT** normally distributed. Using an **appropriate** transformation, transform the data. Show all your workings. [8 marks]
- b) After the transformation, the data become normal. Use an **appropriate** test to determine whether the two classes obtained the same results for the course. [17 mark]
- [TOTAL = 25 marks]

TABLE B.16 CRITICAL VALUES OF THE CORRELATION COEFFICIENT, r

$\alpha(2)$	0.50	0.20	0.10	0.05	0.02	0.01	0.005	0.002	0.001
$\alpha(1)$	0.25	0.10	0.05	0.025	0.01	0.005	0.0025	0.001	0.0005
$\nu$									
1	0.707	0.951	0.988	0.997	0.999	1.000	1.000	1.000	1.000
2	0.500	0.800	0.900	0.950	0.980	0.990	0.995	0.998	0.999
3	0.409	0.687	0.805	0.878	0.935	0.959	0.974	0.985	0.991
4	0.347	0.608	0.729	0.821	0.882	0.917	0.942	0.963	0.974
5	0.309	0.551	0.669	0.755	0.833	0.875	0.906	0.935	0.951
6	0.281	0.507	0.621	0.707	0.789	0.834	0.870	0.905	0.925
7	0.260	0.472	0.582	0.666	0.750	0.798	0.836	0.875	0.898
8	0.242	0.443	0.549	0.632	0.715	0.765	0.805	0.847	0.872
9	0.228	0.419	0.522	0.602	0.685	0.735	0.776	0.820	0.847
10	0.218	0.398	0.497	0.576	0.658	0.708	0.750	0.795	0.823
11	0.206	0.380	0.478	0.555	0.637	0.688	0.729	0.772	0.801
12	0.197	0.365	0.461	0.537	0.619	0.670	0.711	0.750	0.780
13	0.189	0.351	0.445	0.521	0.592	0.643	0.683	0.720	0.750
14	0.182	0.338	0.431	0.507	0.577	0.628	0.668	0.705	0.735
15	0.176	0.327	0.412	0.482	0.552	0.603	0.643	0.680	0.710
16	0.170	0.317	0.398	0.468	0.538	0.589	0.629	0.666	0.700
17	0.165	0.308	0.389	0.458	0.528	0.579	0.619	0.656	0.690
18	0.160	0.299	0.378	0.448	0.518	0.569	0.609	0.646	0.680
19	0.156	0.291	0.369	0.438	0.508	0.559	0.599	0.636	0.670
20	0.152	0.284	0.360	0.428	0.498	0.549	0.589	0.626	0.660
21	0.148	0.277	0.352	0.418	0.488	0.539	0.579	0.616	0.650
22	0.144	0.271	0.344	0.408	0.478	0.529	0.569	0.606	0.640
23	0.141	0.265	0.337	0.398	0.468	0.519	0.559	0.596	0.630
24	0.138	0.260	0.330	0.388	0.458	0.509	0.549	0.586	0.620
25	0.136	0.255	0.323	0.381	0.448	0.499	0.539	0.576	0.610
26	0.133	0.250	0.317	0.374	0.437	0.489	0.529	0.566	0.600
27	0.131	0.245	0.311	0.367	0.430	0.481	0.521	0.558	0.592
28	0.128	0.241	0.306	0.361	0.423	0.475	0.515	0.552	0.586
29	0.126	0.237	0.301	0.355	0.416	0.468	0.508	0.545	0.579
30	0.124	0.233	0.296	0.349	0.409	0.461	0.501	0.538	0.572
31	0.122	0.229	0.291	0.343	0.403	0.455	0.495	0.532	0.566
32	0.120	0.225	0.287	0.339	0.397	0.449	0.489	0.526	0.560
33	0.118	0.222	0.283	0.334	0.392	0.444	0.484	0.521	0.555
34	0.116	0.219	0.279	0.329	0.386	0.438	0.478	0.515	0.549
35	0.115	0.216	0.275	0.325	0.381	0.433	0.473	0.510	0.544
36	0.113	0.213	0.271	0.320	0.376	0.428	0.468	0.505	0.539
37	0.111	0.210	0.267	0.316	0.371	0.423	0.463	0.500	0.534
38	0.110	0.207	0.264	0.312	0.367	0.418	0.458	0.495	0.529
39	0.108	0.204	0.261	0.308	0.362	0.413	0.453	0.490	0.524
40	0.107	0.202	0.257	0.304	0.358	0.409	0.449	0.486	0.520
41	0.106	0.199	0.254	0.301	0.354	0.405	0.445	0.482	0.516
42	0.104	0.197	0.251	0.297	0.350	0.401	0.441	0.478	0.512
43	0.103	0.195	0.248	0.294	0.346	0.397	0.437	0.474	0.508
44	0.102	0.192	0.245	0.291	0.342	0.393	0.433	0.470	0.504
45	0.101	0.190	0.243	0.288	0.338	0.389	0.429	0.466	0.500
46	0.100	0.188	0.240	0.285	0.335	0.385	0.425	0.462	0.496
47	0.099	0.186	0.238	0.282	0.331	0.381	0.421	0.458	0.492
48	0.098	0.184	0.235	0.279	0.328	0.378	0.418	0.454	0.488
49	0.097	0.182	0.233	0.276	0.325	0.375	0.415	0.451	0.484
50	0.096	0.181	0.231	0.273	0.322	0.372	0.412	0.448	0.480

B 505 (Man Exam)

TABLE B.1 CRITICAL VALUES OF THE CHI-SQUARE DISTRIBUTION

$\nu$	0.999	0.995	0.99	0.975	0.95	0.90	0.75	0.50	0.25	0.10	0.05	0.025	0.01	0.005	0.001
1	0.000	0.000	0.000	0.001	0.004	0.016	0.102	0.455	1.323	2.706	3.841	5.024	6.933	7.879	10.828
2	0.002	0.010	0.020	0.051	0.103	0.213	0.575	1.386	2.773	4.605	5.991	7.378	9.210	10.597	13.816
3	0.024	0.072	0.115	0.216	0.353	0.584	1.213	2.366	4.108	6.251	7.815	9.348	11.345	12.838	16.266
4	0.091	0.207	0.297	0.484	0.711	1.064	1.923	3.357	5.385	8.468	10.488	11.978	14.467	16.750	20.515
5	0.203	0.412	0.594	0.853	1.145	1.610	2.689	4.351	6.576	9.236	11.070	12.833	15.086	16.750	20.515
6	0.267	0.475	0.658	0.930	1.237	1.753	2.898	4.534	6.783	9.550	11.454	13.151	15.454	17.153	21.024
7	0.300	0.509	0.693	0.989	1.312	1.833	3.007	4.700	6.966	9.802	11.779	13.421	15.709	17.337	21.345
8	0.354	0.541	0.726	1.040	1.386	1.908	3.115	4.868	7.142	10.028	12.017	13.678	15.964	17.534	21.668
9	0.401	0.572	0.758	1.093	1.458	1.984	3.231	5.037	7.374	10.240	12.242	13.924	16.215	17.722	21.984
10	0.454	0.603	0.794	1.147	1.530	2.061	3.357	5.209	7.602	10.454	12.462	14.169	16.461	17.911	22.301
11	0.503	0.634	0.830	1.202	1.603	2.139	3.484	5.386	7.830	10.670	12.683	14.414	16.704	18.100	22.618
12	0.550	0.665	0.866	1.258	1.676	2.218	3.611	5.568	8.058	10.888	12.903	14.658	16.946	18.289	22.936
13	0.595	0.696	0.902	1.315	1.750	2.298	3.748	5.754	8.287	11.108	13.123	14.901	17.188	18.478	23.254
14	0.641	0.727	0.938	1.373	1.824	2.379	3.885	5.943	8.517	11.330	13.343	15.144	17.429	18.667	23.572
15	0.688	0.758	0.974	1.432	1.899	2.461	4.022	6.135	8.750	11.558	13.563	15.386	17.669	18.856	23.890
16	0.734	0.789	1.009	1.492	1.975	2.544	4.161	6.356	8.985	11.787	13.783	15.627	17.910	19.045	24.208
17	0.780	0.820	1.044	1.553	2.052	2.628	4.301	6.589	9.222	12.017	14.003	15.867	18.151	19.234	24.526
18	0.826	0.851	1.079	1.615	2.130	2.713	4.441	6.815	9.461	12.248	14.223	16.106	18.392	19.423	24.844
19	0.872	0.882	1.114	1.678	2.209	2.800	4.581	7.045	9.700	12.480	14.443	16.346	18.633	19.612	25.162
20	0.918	0.913	1.149	1.742	2.289	2.888	4.721	7.281	9.941	12.713	14.663	16.588	18.874	19.801	25.480
21	0.964	0.944	1.184	1.807	2.370	2.978	4.862	7.524	10.184	12.947	14.883	16.829	19.115	20.000	25.800
22	1.010	0.975	1.219	1.873	2.452	3.067	5.004	7.769	10.429	13.182	15.103	17.069	19.356	20.200	26.120
23	1.056	1.006	1.254	1.940	2.535	3.162	5.147	8.016	10.676	13.418	15.323	17.310	19.600	20.400	26.440
24	1.102	1.037	1.289	2.008	2.618	3.258	5.291	8.270	10.924	13.654	15.543	17.551	19.841	20.600	26.760
25	1.148	1.068	1.324	2.077	2.702	3.355	5.436	8.526	11.173	13.890	15.763	17.792	20.082	20.800	27.080
26	1.194	1.099	1.359	2.147	2.787	3.452	5.582	8.782	11.423	14.126	15.983	18.033	20.323	21.000	27.400
27	1.240	1.130	1.394	2.218	2.872	3.549	5.729	9.039	11.678	14.371	16.203	18.274	20.564	21.200	27.720
28	1.286	1.161	1.429	2.290	2.958	3.646	5.876	9.297	11.934	14.616	16.424	18.515	20.805	21.400	28.040
29	1.332	1.192	1.464	2.363	3.044	3.743	6.024	9.556	12.191	14.861	16.675	18.756	21.046	21.600	28.360
30	1.378	1.223	1.499	2.437	3.131	3.840	6.172	9.816	12.448	15.106	16.926	19.000	21.287	21.800	28.680
31	1.424	1.254	1.534	2.512	3.218	3.937	6.321	10.076	12.706	15.351	17.177	19.241	21.528	22.000	29.000
32	1.470	1.285	1.569	2.588	3.306	4.034	6.471	10.336	12.964	15.596	17.418	19.482	21.769	22.200	29.320
33	1.516	1.316	1.604	2.665	3.394	4.131	6.622	10.596	13.223	15.841	17.659	19.723	22.010	22.400	29.640
34	1.562	1.347	1.639	2.742	3.482	4.228	6.773	10.856	13.481	16.086	17.900	19.964	22.251	22.600	29.960
35	1.608	1.378	1.674	2.820	3.570	4.325	6.924	11.116	13.739	16.331	18.141	20.205	22.492	22.800	30.280
36	1.654	1.409	1.709	2.898	3.658	4.422	7.075	11.376	13.997	16.576	18.382	20.446	22.733	23.000	30.600
37	1.700	1.440	1.744	2.977	3.746	4.519	7.226	11.636	14.255	16.821	18.623	20.687	22.974	23.200	30.920
38	1.746	1.471	1.779	3.057	3.834	4.616	7.377	11.896	14.513	17.064	18.864	20.928	23.215	23.400	31.240
39	1.792	1.502	1.814	3.138	3.922	4.713	7.528	12.156	14.771	17.305	19.105	21.171	23.456	23.600	31.560
40	1.838	1.533	1.849	3.220	4.010	4.810	7.679	12.416	15.029	17.546	19.346	21.416	23.697	23.800	31.880
41	1.884	1.564	1.884	3.303	4.098	4.907	7.830	12.676	15.287	17.787	19.587	21.657	23.938	24.000	32.200
42	1.930	1.595	1.919	3.387	4.186	5.004	7.981	12.936	15.547	18.028	19.828	21.898	24.179	24.200	32.520
43	1.976	1.626	1.954	3.472	4.274	5.101	8.132	13.196	15.807	18.269	20.069	22.139	24.420	24.400	32.840
44	2.022	1.657	1.989	3.558	4.362	5.198	8.283	13.456	16.067	18.510	20.310	22.380	24.661	24.600	33.160
45	2.068	1.688	2.024	3.644	4.450	5.295	8.434	13.716	16.327	18.751	20.551	22.621	24.902	24.800	33.480
46	2.114	1.719	2.059	3.730	4.538	5.392	8.585	13.976	16.587	19.000	20.792	22.862	25.143	25.000	33.800
47	2.160	1.750	2.094	3.817	4.626	5.489	8.736	14.236	16.847	19.241	21.033	23.103	25.384	25.200	34.120
48	2.206	1.781	2.129	3.905	4.714	5.586	8.887	14.496	17.107	19.482	21.274	23.344	25.625	25.400	34.440
49	2.252	1.812	2.164	3.994	4.802	5.683	9.038	14.756	17.367	19.723	21.515	23.585	25.866	25.600	34.760
50	2.298	1.843	2.199	4.084	4.890	5.780	9.189	15.016	17.627	20.000	21.756	23.826	26.107	25.800	35.080

TABLE B.4 CRITICAL VALUES OF THE F DISTRIBUTION

Denom. DF	Numerator DF = 1									
	$\alpha(2):$ $\alpha(1):$	0.50 0.25	0.20 0.10	0.10 0.05	0.05 0.025	0.02 0.01	0.01 0.005	0.005 0.0025	0.002 0.001	0.001 0.0005
1		5.024	39.000	161.447	645.756	1627.278	1627.278	6410.000	1627000.000	1627000.000
2		2.227	9.000	18.513	31.599	41.901	41.901	159.000	15900.000	15900.000
3		1.851	6.591	13.747	21.597	28.459	28.459	102.000	10200.000	10200.000
4		1.699	5.758	11.998	18.008	23.680	23.680	80.000	8000.000	8000.000
5		1.602	5.198	10.998	16.698	21.577	21.577	70.000	7000.000	7000.000
6		1.541	4.791	10.250	15.707	20.517	20.517	63.000	6300.000	6300.000
7		1.497	4.478	9.645	14.959	19.678	19.678	57.000	5700.000	5700.000
8		1.461	4.228	9.145	14.387	18.998	18.998	52.000	5200.000	5200.000
9		1.433	4.024	8.745	13.945	18.427	18.427	48.000	4800.000	4800.000
10		1.411	3.867	8.415	13.597	18.000	18.000	45.000	4500.000	4500.000
11		1.393	3.741	8.145	13.327	17.697	17.697	42.000	4200.000	4200.000
12		1.379	3.638	7.915	13.117	17.467	17.467	40.000	4000.000	4000.000
13		1.368	3.551	7.715	12.947	17.287	17.287	38.000	3800.000	3800.000
14		1.359	3.478	7.535	12.807	17.147	17.147	36.000	3600.000	3600.000
15		1.351	3.417	7.375	12.687	17.037	17.037	35.000	3500.000	3500.000
16		1.344	3.364	7.235	12.587	16.947	16.947	34.000	3400.000	3400.000
17		1.338	3.318	7.115	12.507	16.877	16.877	33.000	3300.000	3300.000
18		1.333	3.278	7.005	12.437	16.817	16.817	32.000	3200.000	3200.000
19		1.329	3.243	6.905	12.377	16.767	16.767	31.000	3100.000	3100.000
20		1.325	3.212	6.815	12.327	16.727	16.727	30.000	3000.000	3000.000
21		1.322	3.184	6.735	12.287	16.687	16.687	29.000	2900.000	2900.000
22		1.319	3.159	6.665	12.247	16.647	16.647	28.000	2800.000	2800.000
23		1.316	3.136	6.605	12.207	16.607	16.607	27.000	2700.000	2700.000
24		1.314	3.115	6.545	12.167	16.567	16.567	26.000	2600.000	2600.000
25		1.312	3.096	6.495	12.127	16.527	16.527	25.000	2500.000	2500.000
26		1.310	3.078	6.445	12.087	16.487	16.487	24.000	2400.000	2400.000
27		1.308	3.061	6.395	12.047	16.447	16.447	23.000	2300.000	2300.000
28		1.306	3.045	6.345	12.007	16.407	16.407	22.000	2200.000	2200.000
29		1.304	3.030	6.295	11.967	16.367	16.367	21.000	2100.000	2100.000
30		1.303	3.016	6.245	11.927	16.327	16.327	20.000	2000.000	2000.000
35		1.298	2.978	6.145	11.827	16.227	16.227	19.000	1900.000	1900.000
40		1.294	2.948	6.045	11.727	16.127	16.127	18.000	1800.000	1800.000
45		1.291	2.924	5.945	11.627	16.027	16.027	17.000	1700.000	1700.000
50		1.288	2.904	5.845	11.527	15.927	15.927	16.000	1600.000	1600.000
60		1.285	2.878	5.745	11.427	15.827	15.827	15.000	1500.000	1500.000
70		1.283	2.856	5.645	11.327	15.727	15.727	14.000	1400.000	1400.000
80		1.281	2.836	5.545	11.227	15.627	15.627	13.000	1300.000	1300.000
90		1.280	2.818	5.445	11.127	15.527	15.527	12.000	1200.000	1200.000
100		1.279	2.802	5.345	11.027	15.427	15.427	11.000	1100.000	1100.000
120		1.277	2.778	5.245	10.927	15.327	15.327	10.000	1000.000	1000.000
140		1.276	2.758	5.145	10.827	15.227	15.227	9.000	900.000	900.000
160		1.275	2.741	5.045	10.727	15.127	15.127	8.000	800.000	800.000
180		1.274	2.726	4.945	10.627	15.027	15.027	7.000	700.000	700.000
200		1.273	2.712	4.845	10.527	14.927	14.927	6.000	600.000	600.000
300		1.272	2.678	4.645	10.327	14.727	14.727	5.000	500.000	500.000
500		1.271	2.622	4.345	10.027	14.427	14.427	4.000	400.000	400.000
-		1.270	2.571	4.045	9.727	14.127	14.127	3.000	300.000	300.000



TABLE 801 (cont.) CRITICAL VALUES OF THE F DISTRIBUTION

TABLE 801 (cont.) CRITICAL VALUES OF THE F DISTRIBUTION  
 Numerator df = 1

Denominator df	1	2	3	4	5	6	7	8	9	10	15	20	25	30	40	50	60	70	80	90	100
1	161.448	19.164	16.013	15.000	14.532	14.181	13.901	13.678	13.498	13.347	13.059	12.884	12.745	12.628	12.478	12.362	12.270	12.196	12.135	12.081	12.033
2	18.513	18.000	17.591	17.267	16.999	16.767	16.561	16.378	16.214	16.067	15.784	15.625	15.491	15.377	15.234	15.134	15.054	14.985	14.927	14.875	14.828
3	16.013	15.591	15.267	14.999	14.767	14.561	14.378	14.214	14.067	13.920	13.643	13.489	13.359	13.248	13.109	13.012	12.936	12.871	12.816	12.766	12.721
4	15.000	14.577	14.253	13.985	13.753	13.547	13.364	13.200	13.053	12.906	12.634	12.480	12.351	12.240	12.101	12.004	11.928	11.863	11.808	11.758	11.713
5	14.532	14.109	13.785	13.517	13.285	13.079	12.896	12.732	12.585	12.438	12.166	12.012	11.883	11.772	11.633	11.536	11.460	11.395	11.340	11.290	11.245
6	14.181	13.758	13.434	13.166	12.934	12.728	12.545	12.381	12.234	12.087	11.815	11.661	11.532	11.421	11.282	11.185	11.109	11.044	10.989	10.939	10.894
7	13.901	13.478	13.154	12.886	12.654	12.448	12.265	12.101	11.954	11.807	11.535	11.381	11.252	11.141	11.002	10.905	10.829	10.764	10.709	10.659	10.614
8	13.678	13.255	12.931	12.663	12.431	12.225	12.042	11.878	11.731	11.584	11.312	11.158	11.029	10.918	10.779	10.682	10.606	10.541	10.486	10.436	10.391
9	13.498	13.075	12.751	12.483	12.251	12.045	11.862	11.698	11.551	11.404	11.132	10.978	10.849	10.738	10.599	10.502	10.426	10.361	10.306	10.256	10.211
10	13.347	12.924	12.600	12.332	12.100	11.894	11.711	11.547	11.400	11.253	10.981	10.827	10.698	10.587	10.448	10.351	10.275	10.210	10.155	10.105	10.060
15	13.059	12.636	12.312	12.044	11.812	11.606	11.423	11.259	11.112	10.965	10.693	10.539	10.410	10.299	10.160	10.063	9.987	9.922	9.867	9.817	9.772
20	12.884	12.461	12.137	11.869	11.637	11.431	11.248	11.084	10.937	10.790	10.518	10.364	10.235	10.124	9.985	9.888	9.812	9.747	9.692	9.642	9.597
25	12.745	12.322	11.998	11.730	11.498	11.292	11.109	10.945	10.798	10.651	10.379	10.225	10.096	9.985	9.846	9.749	9.673	9.608	9.553	9.503	9.458
30	12.628	12.205	11.881	11.613	11.381	11.175	10.992	10.828	10.681	10.534	10.262	10.108	9.979	9.868	9.729	9.632	9.556	9.491	9.436	9.386	9.341
40	12.478	12.055	11.731	11.463	11.231	11.025	10.842	10.678	10.531	10.384	10.112	9.958	9.829	9.718	9.579	9.482	9.406	9.341	9.286	9.236	9.191
50	12.362	11.939	11.615	11.347	11.115	10.909	10.726	10.562	10.415	10.268	9.996	9.842	9.713	9.602	9.463	9.366	9.290	9.225	9.170	9.120	9.075
60	12.270	11.847	11.523	11.255	11.023	10.817	10.634	10.470	10.323	10.176	9.904	9.750	9.621	9.510	9.371	9.274	9.198	9.133	9.078	9.028	8.983
70	12.196	11.773	11.449	11.181	10.949	10.743	10.560	10.396	10.249	10.102	9.830	9.676	9.547	9.436	9.297	9.200	9.124	9.059	9.004	8.954	8.909
80	12.135	11.712	11.388	11.120	10.888	10.682	10.499	10.335	10.188	10.041	9.769	9.615	9.486	9.375	9.236	9.139	9.063	8.998	8.943	8.893	8.848
90	12.081	11.658	11.334	11.066	10.834	10.628	10.445	10.281	10.134	9.987	9.715	9.561	9.432	9.321	9.182	9.085	9.009	8.944	8.889	8.839	8.794
100	12.033	11.610	11.286	11.018	10.786	10.580	10.397	10.233	10.086	9.939	9.667	9.513	9.384	9.273	9.134	9.037	8.961	8.896	8.841	8.791	8.746

TABLE 802 (cont.) CRITICAL VALUES OF THE F DISTRIBUTION

TABLE 802 (cont.) CRITICAL VALUES OF THE F DISTRIBUTION  
 Numerator df = 2

Denominator df	1	2	3	4	5	6	7	8	9	10	15	20	25	30	40	50	60	70	80	90	100
1	199.500	19.164	16.013	15.000	14.532	14.181	13.901	13.678	13.498	13.347	13.059	12.884	12.745	12.628	12.478	12.362	12.270	12.196	12.135	12.081	12.033
2	18.513	18.000	17.591	17.267	16.999	16.767	16.561	16.378	16.214	16.067	15.784	15.625	15.491	15.377	15.234	15.134	15.054	14.985	14.927	14.875	14.828
3	16.013	15.591	15.267	14.999	14.767	14.561	14.378	14.214	14.067	13.920	13.643	13.489	13.359	13.248	13.109	13.012	12.936	12.871	12.816	12.766	12.721
4	15.000	14.577	14.253	13.985	13.753	13.547	13.364	13.200	13.053	12.906	12.634	12.480	12.351	12.240	12.101	12.004	11.928	11.863	11.808	11.758	11.713
5	14.532	14.109	13.785	13.517	13.285	13.079	12.896	12.732	12.585	12.438	12.166	12.012	11.883	11.772	11.633	11.536	11.460	11.395	11.340	11.290	11.245
6	14.181	13.758	13.434	13.166	12.934	12.728	12.545	12.381	12.234	12.087	11.815	11.661	11.532	11.421	11.282	11.185	11.109	11.044	10.989	10.939	10.894
7	13.901	13.478	13.154	12.886	12.654	12.448	12.265	12.101	11.954	11.807	11.535	11.381	11.252	11.141	11.002	10.905	10.829	10.764	10.709	10.659	10.614
8	13.678	13.255	12.931	12.663	12.431	12.225	12.042	11.878	11.731	11.584	11.312	11.158	11.029	10.918	10.779	10.682	10.606	10.541	10.486	10.436	10.391
9	13.498	13.075	12.751	12.483	12.251	12.045	11.862	11.698	11.551	11.404	11.132	10.978	10.849	10.738	10.599	10.502	10.426	10.361	10.306	10.256	10.211
10	13.347	12.924	12.600	12.332	12.100	11.894	11.711	11.547	11.400	11.253	10.981	10.827	10.698	10.587	10.448	10.351	10.275	10.210	10.155	10.105	10.060
15	13.059	12.636	12.312	12.044	11.812	11.606	11.423	11.259	11.112	10.965	10.693	10.539	10.410	10.299	10.160	10.063	9.987	9.922	9.867	9.817	9.772
20	12.884	12.461	12.137	11.869	11.637	11.431	11.248	11.084	10.937	10.790	10.518	10.364	10.235	10.124	9.985	9.888	9.812	9.747	9.692	9.642	9.597
25	12.745	12.322	11.998	11.730	11.498	11.292	11.109	10.945	10.798	10.651	10.379	10.225	10.096	9.985	9.846	9.749	9.673	9.608	9.553	9.503	9.458
30	12.628	12.205	11.881	11.613	11.381	11.175	10.992	10.828	10.681	10.534	10.262	10.108	9.979	9.868	9.729	9.632	9.556	9.491	9.436	9.386	9.341
40	12.478	12.055	11.731	11.463	11.231	11.025	10.842	10.678	10.531	10.384	10.112	9.958	9.829	9.718	9.579	9.482	9.406	9.341	9.286	9.236	9.191
50	12.362	11.939	11.615	11.347	11.115	10.909	10.726	10.562	10.415	10.268	9.996	9.842	9.713	9.602	9.463	9.366	9.290	9.225	9.170	9.120	9.075
60	12.270	11.847	11.523	11.255	11.023	10.817	10.634	10.470	10.323	10.176	9.904	9.750	9.621	9.510	9.371	9.274	9.198	9.133	9.078	9.028	8.983
70	12.196	11.773	11.449	11.181	10.949	10.743	10.560	10.396	10.249	10.102	9.830	9.676	9.547	9.436	9.297	9.200	9.124	9.059	9.004	8.954	8.909
80	12.135	11.712	11.388	11.120	10.888	10.682	10.499	10.335	10.188	10.041	9.769	9.615	9.486	9.375	9.236	9.139	9.063	8.998	8.943	8.893	8.848
90	12.081	11.658	11.334	11.066	10.834	10.628	10.445	10.281	10.134	9.987	9.715	9.561	9.432	9.321	9.182	9.085	9.009	8.944	8.889	8.839	8.794
100	12.033	11.610	11.286	11.018	10.786	10.580	10.397	10.233	10.086	9.939	9.667	9.513	9.384	9.273	9.134	9.037	8.961	8.896	8.841	8.791	8.746

TABLE 803 (cont.) CRITICAL VALUES OF THE F DISTRIBUTION

TABLE 803 (cont.) CRITICAL VALUES OF THE F DISTRIBUTION  
 Numerator df = 3

Denominator df	1	2	3	4	5	6	7	8	9	10	15	20	25	30	40	50	60	70	80	90	100
1	215.707	19.164	16.013	15.000	14.532	14.181	13.901	13.678	13.498	13.347	13.059	12.884	12.745	12.628	12.478	12.362	12.270	12.196	12.135	12.081	12.033
2	19.164	18.000	17.591	17.267	16.999	16.767	16.561	16.378	16.214	16.067	15.784	15.625	15.491	15.377	15.234	15					

TABLE B.3 CRITICAL VALUES OF THE  $t$  DISTRIBUTION

$\nu$	$\alpha(2):$ 0.50	0.20	0.10	0.05	0.02	0.01	0.005	0.002	0.001
	$\alpha(1):$ 0.25	0.10	0.05	0.025	0.01	0.005	0.0025	0.001	0.0005
1	1.000	3.078	5.314	12.706	31.821	63.657	127.321	318.309	636.5
2	0.816	1.886	2.920	4.303	6.385	9.925	14.089	22.327	31.5
3	0.765	1.638	2.353	3.182	4.541	5.841	7.453	10.215	12.9
4	0.741	1.535	2.132	2.776	3.747	4.604	5.598	7.173	8.6
5	0.727	1.476	2.015	2.571	3.365	4.032	4.773	5.893	6.8
6	0.718	1.440	1.943	2.447	3.143	3.707	4.317	5.208	5.9
7	0.711	1.415	1.899	2.365	2.998	3.499	4.029	4.785	5.4
8	0.706	1.397	1.860	2.306	2.896	3.355	3.833	4.501	5.0
9	0.703	1.383	1.833	2.262	2.821	3.250	3.690	4.297	4.7
10	0.700	1.372	1.812	2.228	2.764	3.169	3.581	4.144	4.5
11	0.697	1.363	1.796	2.201	2.718	3.106	3.497	4.025	4.4
12	0.695	1.356	1.782	2.179	2.681	3.055	3.428	3.939	4.3
13	0.694	1.350	1.771	2.160	2.650	3.012	3.372	3.852	4.2
14	0.692	1.345	1.761	2.145	2.624	2.977	3.326	3.787	4.1
15	0.691	1.341	1.753	2.131	2.602	2.947	3.286	3.733	4.0
16	0.690	1.337	1.746	2.120	2.583	2.921	3.252	3.686	4.0
17	0.689	1.333	1.740	2.110	2.567	2.898	3.222	3.646	3.9
18	0.688	1.330	1.734	2.101	2.552	2.878	3.197	3.610	3.9
19	0.688	1.328	1.729	2.093	2.539	2.861	3.174	3.579	3.8
20	0.687	1.325	1.725	2.086	2.528	2.845	3.153	3.552	3.8
21	0.686	1.323	1.721	2.080	2.518	2.831	3.135	3.527	3.8
22	0.686	1.321	1.717	2.074	2.508	2.819	3.119	3.505	3.8
23	0.685	1.319	1.714	2.069	2.500	2.807	3.104	3.485	3.7
24	0.685	1.318	1.711	2.064	2.492	2.797	3.091	3.467	3.7
25	0.684	1.316	1.708	2.060	2.485	2.787	3.078	3.450	3.7
26	0.684	1.315	1.706	2.056	2.479	2.779	3.067	3.435	3.7
27	0.684	1.314	1.703	2.052	2.473	2.771	3.057	3.421	3.6
28	0.683	1.313	1.701	2.048	2.467	2.763	3.047	3.408	3.6
29	0.683	1.311	1.699	2.045	2.462	2.756	3.038	3.396	3.6
30	0.683	1.310	1.697	2.042	2.457	2.750	3.030	3.385	3.6
31	0.682	1.309	1.696	2.040	2.453	2.744	3.022	3.375	3.6
32	0.682	1.309	1.694	2.037	2.449	2.738	3.015	3.365	3.6
33	0.682	1.308	1.692	2.035	2.445	2.733	3.008	3.356	3.6
34	0.682	1.307	1.691	2.032	2.441	2.728	3.002	3.348	3.6
35	0.682	1.306	1.690	2.030	2.438	2.724	2.996	3.340	3.5
36	0.681	1.306	1.688	2.028	2.434	2.719	2.990	3.333	3.5
37	0.681	1.305	1.687	2.026	2.431	2.715	2.985	3.326	3.5
38	0.681	1.304	1.686	2.024	2.429	2.712	2.980	3.319	3.5
39	0.681	1.304	1.685	2.023	2.426	2.708	2.975	3.313	3.5
40	0.681	1.303	1.684	2.021	2.423	2.704	2.971	3.307	3.5
41	0.681	1.303	1.683	2.020	2.421	2.701	2.967	3.301	3.5
42	0.680	1.302	1.682	2.018	2.419	2.698	2.963	3.296	3.5
43	0.680	1.302	1.681	2.017	2.416	2.695	2.959	3.291	3.5
44	0.680	1.301	1.680	2.015	2.414	2.692	2.956	3.286	3.5
45	0.680	1.301	1.679	2.014	2.412	2.690	2.952	3.281	3.5
46	0.680	1.300	1.679	2.013	2.410	2.687	2.949	3.277	3.5
47	0.680	1.300	1.678	2.012	2.408	2.685	2.946	3.273	3.5
48	0.680	1.299	1.677	2.011	2.407	2.682	2.943	3.269	3.5
49	0.680	1.299	1.677	2.010	2.405	2.680	2.940	3.265	3.5
50	0.679	1.299	1.676	2.009	2.403	2.678	2.937	3.261	3.5