

UNIVERSITY OF SWAZILAND

SUPPLEMENTARY EXAMINATION PAPER 2005

TITLE OF PAPER : CATEGORICAL DATA ANALYSIS

COURSE CODE : ST 481

TIME ALLOWED : TWO (2) HOURS

REQUIREMENTS : CALCULATOR AND STATISTICAL TABLES

INSTRUCTIONS : ANSWER QUESTION ONE AND ANY OTHER TWO QUESTIONS

Question 1

In the Annual Education Statistics Survey of 1999 it was found that 90586 boys and 85484 girls are enrolled in government-aided primary schools. Government-aided Secondary/High schools had enrolled 15815 boys and 14387 girls.

Is there any relationship between gender and Level of class attended? What is the extent of the any relationship that may exist?

(25 Marks)

Question 2

The Annual Transport and Communications Survey in 2003 tabulated the number of vehicle accidents by type of accident and time of accidents. The data are given in the table below. The Road Safety Council wants to know from you, as a statistician/researcher, if the time of accidents (a.m. & p.m.) is related to the three categories of types of accidents? Analyse and advise appropriately.

Types of accidents are categorized into three, namely:

- A. Nose to tail, side, head on collision & rollover;
- B. Obstacle, pedestrian, domestic animal & wild animal;
- C. Other.

Time of Accident	Type of Accident			Total
	A	B	C	
a.m.	1448	435	472	2355
p.m.	2312	1019	676	4007
Total	3760	1454	1148	6362

(25 Marks)

Question 3

The Physicians' Health Study was a clinical trial performed in the United States of America in the late 1980's and early 1990's. It involved physician subjects over the age of 40 who were divided into three groups according to their smoking history: current smokers, past smokers and those who have never smoked. Each subject was assigned randomly to one of two groups. One group of physicians took a small dose of aspirin daily; physicians in the second group took a placebo instead. These physicians were observed over a period of several years; for each subject a record was kept of whether he had a heart attack during the period under study. The table below gives data for physicians who were current smokers;

	Placebo	Aspirin
Had heart attack	37	21
Did not have heart attack	1188	1192

Derive a model, with estimates, that best describes the association between these two variables for the physicians who are current smokers.

(25 Marks)

Question 4

Given the following table with a set of models with values of G^2 (likelihood Ratio Criterion) and p -value which relate to;

- Defendant's race **D** : *W* (White), *B* (Black) = Z variable
- Victim's race **V** : *W* (White), *B* (Black) = Y variable
- Death Penalty **P** : *Y* (yes), *N* (No) = X variable

Model	G^2	p -value
(D,V,P)	137.9	0.001
(DV,P)	8.1	0.04
(VP,DV)	1.9	0.39
(DP,VP,DV)	0.70	0.40
(DVP)	0	---

- a) Select two models that provide the best fit for the data and state the reasons for your choice. (2 Marks)
- b) From the two models select the best model and derive its log-linear model and give reasons for selecting it. (8 Marks)
- c) If $n_{111}=19$, $n_{112}=0$, $n_{121}=11$, $n_{122}=6$, $n_{211}=132$, $n_{212}=9$, $n_{221}=52$, and $n_{222}=97$, for the best model chosen in b) calculate \hat{u} , $\hat{u}_{D(1)}$ and $\hat{u}_{DV(11)}$.

(15 Marks)

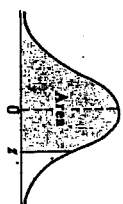
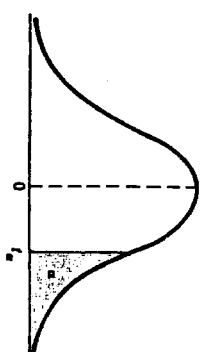


TABLE A.4
Areas Under the Normal Curve

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
-1.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
-1.3	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
-1.2	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
-1.1	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
-1.0	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007
-0.9	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
-0.8	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009
-0.7	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010
-0.6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
-0.5	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
-0.4	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013
-0.3	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014
-0.2	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015
-0.1	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016
0.0	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017
0.1	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018
0.2	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019
0.3	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020
0.4	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021
0.5	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
0.6	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023
0.7	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024
0.8	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
0.9	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026
1.0	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027
1.1	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
1.2	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029
1.3	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030
1.4	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031
1.5	0.0032	0.0032	0.0032	0.0032	0.0032	0.0032	0.0032	0.0032	0.0032	0.0032
1.6	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033
1.7	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034
1.8	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035
1.9	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036
2.0	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037
2.1	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038
2.2	0.0039	0.0039	0.0039	0.0039	0.0039	0.0039	0.0039	0.0039	0.0039	0.0039
2.3	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040
2.4	0.0041	0.0041	0.0041	0.0041	0.0041	0.0041	0.0041	0.0041	0.0041	0.0041
2.5	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042
2.6	0.0043	0.0043	0.0043	0.0043	0.0043	0.0043	0.0043	0.0043	0.0043	0.0043
2.7	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044
2.8	0.0045	0.0045	0.0045	0.0045	0.0045	0.0045	0.0045	0.0045	0.0045	0.0045
2.9	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046
3.0	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047
3.1	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048
3.2	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049
3.3	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050
3.4	0.0051	0.0051	0.0051	0.0051	0.0051	0.0051	0.0051	0.0051	0.0051	0.0051

TABLE A.5*
Critical Values of the t Distribution



v	alpha				
	0.10	0.05	0.025	0.01	0.005
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
Inf.	1.282	1.645	1.960	2.326	2.576

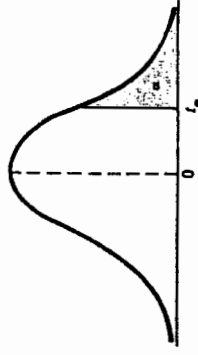
*Table A.5 is taken from Table IV of R. A. Fisher, *Statistical Methods for Research Workers*, Oliver & Boyd Ltd., Edinburgh, by permission of the author and publishers.

TABLE A.4
Areas Under the Normal Curve

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
-3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002
-3.3	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
-3.2	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005
-3.1	0.0010	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0008
-3.0	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0011	0.0011	0.0010
-2.9	0.0019	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0015	0.0014	0.0014
-2.8	0.0025	0.0024	0.0023	0.0022	0.0022	0.0021	0.0021	0.0021	0.0020	0.0020
-2.7	0.0031	0.0030	0.0029	0.0028	0.0028	0.0027	0.0027	0.0027	0.0026	0.0026
-2.6	0.0038	0.0037	0.0036	0.0035	0.0035	0.0034	0.0034	0.0034	0.0033	0.0033
-2.5	0.0044	0.0043	0.0042	0.0041	0.0041	0.0040	0.0040	0.0040	0.0039	0.0039
-2.4	0.0050	0.0049	0.0048	0.0047	0.0046	0.0046	0.0045	0.0045	0.0044	0.0044
-2.3	0.0055	0.0054	0.0053	0.0052	0.0052	0.0051	0.0051	0.0051	0.0050	0.0050
-2.2	0.0060	0.0059	0.0058	0.0057	0.0057	0.0056	0.0056	0.0056	0.0055	0.0055
-2.1	0.0065	0.0064	0.0063	0.0062	0.0062	0.0061	0.0061	0.0061	0.0060	0.0060
-2.0	0.0070	0.0069	0.0068	0.0067	0.0067	0.0066	0.0066	0.0066	0.0065	0.0065
-1.9	0.0075	0.0074	0.0073	0.0072	0.0072	0.0071	0.0071	0.0071	0.0070	0.0070
-1.8	0.0080	0.0079	0.0078	0.0077	0.0077	0.0076	0.0076	0.0076	0.0075	0.0075
-1.7	0.0085	0.0084	0.0083	0.0082	0.0082	0.0081	0.0081	0.0081	0.0080	0.0080
-1.6	0.0090	0.0089	0.0088	0.0087	0.0087	0.0086	0.0086	0.0086	0.0085	0.0085
-1.5	0.0095	0.0094	0.0093	0.0092	0.0092	0.0091	0.0091	0.0091	0.0090	0.0090
-1.4	0.0100	0.0099	0.0098	0.0097	0.0097	0.0096	0.0096	0.0096	0.0095	0.0095
-1.3	0.0105	0.0104	0.0103	0.0102	0.0102	0.0101	0.0101	0.0101	0.0100	0.0100
-1.2	0.0110	0.0109	0.0108	0.0107	0.0107	0.0106	0.0106	0.0106	0.0105	0.0105
-1.1	0.0115	0.0114	0.0113	0.0112	0.0112	0.0111	0.0111	0.0111	0.0110	0.0110
-1.0	0.0120	0.0119	0.0118	0.0117	0.0117	0.0116	0.0116	0.0116	0.0115	0.0115
-0.9	0.0125	0.0124	0.0123	0.0122	0.0122	0.0121	0.0121	0.0121	0.0120	0.0120
-0.8	0.0130	0.0129	0.0128	0.0127	0.0127	0.0126	0.0126	0.0126	0.0125	0.0125
-0.7	0.0135	0.0134	0.0133	0.0132	0.0132	0.0131	0.0131	0.0131	0.0130	0.0130
-0.6	0.0140	0.0139	0.0138	0.0137	0.0137	0.0136	0.0136	0.0136	0.0135	0.0135
-0.5	0.0145	0.0144	0.0143	0.0142	0.0142	0.0141	0.0141	0.0141	0.0140	0.0140
-0.4	0.0150	0.0149	0.0148	0.0147	0.0147	0.0146	0.0146	0.0146	0.0145	0.0145
-0.3	0.0155	0.0154	0.0153	0.0152	0.0152	0.0151	0.0151	0.0151	0.0150	0.0150
-0.2	0.0160	0.0159	0.0158	0.0157	0.0157	0.0156	0.0156	0.0156	0.0155	0.0155
-0.1	0.0165	0.0164	0.0163	0.0162	0.0162	0.0161	0.0161	0.0161	0.0160	0.0160
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6481	0.6518
0.4	0.6554	0.6591	0.6628	0.6665	0.6702	0.6738	0.6774	0.6811	0.6847	0.6884
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7824	0.7854
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8666	0.8688	0.8709	0.8729	0.8749	0.8768	0.8787	0.8805	0.8823
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9278	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9874	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9903	0.9906	0.9908	0.9911	0.9913	0.9915
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9944	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9958	0.9959	0.9960	0.9961	0.9962	0.9964
2.7	0.9964	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973
2.8	0.9974	0.9975	0.9976	0.9977	0.9978	0.9979	0.9980	0.9981	0.9982	0.9983
2.9	0.9984	0.9985	0.9986	0.9987	0.9988	0.9989	0.9990	0.9991	0.9992	0.9993
3.0	0.9994	0.9995	0.9996	0.9997	0.9998	0.9999	0.9999	0.9999	0.9999	0.9999
3.1	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999
3.2	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999
3.3	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999
3.4	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999



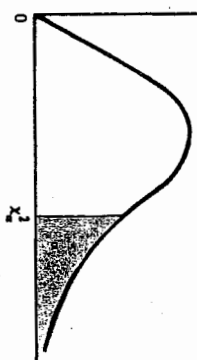
TABLE A.5*
Critical Values of the t Distribution



v	α				
	0.10	0.05	0.025	0.01	0.005
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
inf.	1.282	1.645	1.960	2.326	2.576

*Table A.5 is taken from Table IV of R. A. Fisher, *Statistical Methods for Research Workers*, Oliver & Boyd Ltd., Edinburgh, by permission of the author and publishers.

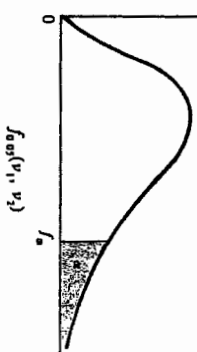
TABLE A.6*
Critical Values of the Chi-Square Distribution



v	α									
	0.995	0.99	0.975	0.95	0.05	0.025	0.01	0.005		
1	0.004393	0.01157	0.01982	0.03939	3.841	5.024	6.635	7.879		
2	0.01000	0.02010	0.05066	0.103	5.991	7.378	9.210	10.597		
3	0.0717	0.115	0.216	0.352	7.815	9.348	11.345	12.838		
4	0.207	0.297	0.484	0.711	9.488	11.143	13.277	14.860		
5	0.412	0.554	0.831	1.145	11.070	12.832	15.086	16.750		
6	0.676	0.872	1.237	1.635	12.592	14.449	16.812	18.548		
7	0.989	1.239	1.690	2.167	14.067	16.013	18.475	20.278		
8	1.344	1.646	2.180	2.733	15.507	17.535	20.090	21.955		
9	1.735	2.088	2.700	3.325	16.919	19.023	21.666	23.589		
10	2.156	2.558	3.247	3.940	18.307	20.483	23.209	25.188		
11	2.603	3.053	3.816	4.575	19.675	21.920	24.725	26.757		
12	3.074	3.571	4.404	5.226	21.026	23.337	26.217	28.300		
13	3.565	4.107	5.009	5.892	22.362	24.736	27.688	29.819		
14	4.075	4.660	5.629	6.571	23.685	26.119	29.141	31.319		
15	4.601	5.229	6.262	7.261	24.996	27.488	30.578	32.801		
16	5.142	5.812	6.908	7.962	26.296	28.845	32.000	34.267		
17	5.697	6.408	7.564	8.672	27.587	30.191	33.409	35.718		
18	6.265	7.015	8.231	9.390	28.869	31.526	34.805	37.156		
19	6.844	7.633	8.907	10.117	30.144	32.852	36.191	38.582		
20	7.434	8.260	9.591	10.851	31.410	34.170	37.566	39.997		
21	8.034	8.897	10.283	11.591	32.671	35.479	38.932	41.401		
22	8.643	9.542	10.982	12.338	33.924	36.781	40.289	42.796		
23	9.260	10.196	11.689	13.091	35.172	38.076	41.638	44.181		
24	9.886	10.856	12.401	13.848	36.415	39.364	42.980	45.558		
25	10.520	11.524	13.120	14.611	37.652	40.646	44.314	46.928		
26	11.160	12.198	13.844	15.379	38.885	41.923	45.642	48.290		
27	11.808	12.879	14.573	16.151	40.113	43.194	46.963	49.645		
28	12.461	13.565	15.308	16.928	41.337	44.461	48.278	50.993		
29	13.121	14.256	16.047	17.708	42.557	45.722	49.588	52.336		
30	13.787	14.953	16.791	18.493	43.773	46.979	50.892	53.672		

*Abridged from Table 8 of *Biometrika Tables for Statisticians*, Vol. 1, by permission of E. S. Pearson and the Biometrika Trustees.

TABLE A.7*
Critical Values of the F Distribution



v ₂	v ₁								
	1	2	3	4	5	6	7	8	9
1	161.4	199.4	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	4.74	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	2.80	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

*Reproduced from Table 18 of *Biometrika Tables for Statisticians*, Vol. 1, by permission of E. S. Pearson and the Biometrika Trustees.

TABLE A.7 (continued)
Critical Values of the F Distribution
 $f_{\alpha}(v_1, v_2)$

v_2	v_1										
	10	12	15	20	24	30	40	60	120	∞	
1	241.9	243.9	245.9	248.0	249.1	250.1	251.1	252.2	253.3	254.3	
2	19.40	19.41	19.43	19.45	19.46	19.46	19.47	19.48	19.49	19.50	
3	8.79	8.74	8.70	8.66	8.64	8.62	8.59	8.57	8.55	8.53	
4	5.96	5.91	5.86	5.80	5.77	5.75	5.72	5.69	5.66	5.63	
5	4.74	4.68	4.62	4.56	4.53	4.50	4.46	4.43	4.40	4.36	
6	4.06	4.00	3.94	3.87	3.84	3.81	3.77	3.74	3.70	3.67	
7	3.64	3.57	3.51	3.44	3.41	3.38	3.34	3.30	3.27	3.23	
8	3.35	3.28	3.22	3.15	3.12	3.08	3.04	3.01	2.97	2.93	
9	3.14	3.07	3.01	2.94	2.90	2.86	2.83	2.79	2.75	2.71	
10	2.98	2.91	2.85	2.77	2.74	2.70	2.66	2.62	2.58	2.54	
11	2.85	2.79	2.72	2.65	2.61	2.57	2.53	2.49	2.45	2.40	
12	2.75	2.69	2.62	2.54	2.51	2.47	2.43	2.38	2.34	2.30	
13	2.67	2.60	2.53	2.46	2.42	2.38	2.34	2.30	2.25	2.21	
14	2.60	2.53	2.46	2.39	2.35	2.31	2.27	2.22	2.18	2.13	
15	2.54	2.48	2.40	2.33	2.29	2.25	2.20	2.16	2.11	2.07	
16	2.49	2.42	2.35	2.28	2.24	2.19	2.15	2.11	2.06	2.01	
17	2.45	2.38	2.31	2.23	2.19	2.15	2.10	2.06	2.01	1.96	
18	2.41	2.34	2.27	2.19	2.15	2.11	2.06	2.02	1.97	1.92	
19	2.38	2.31	2.23	2.16	2.11	2.07	2.03	1.98	1.93	1.88	
20	2.35	2.28	2.20	2.12	2.08	2.04	1.99	1.95	1.90	1.84	
21	2.32	2.25	2.18	2.10	2.05	2.01	1.96	1.92	1.87	1.81	
22	2.30	2.23	2.15	2.07	2.03	1.98	1.94	1.89	1.84	1.78	
23	2.27	2.20	2.13	2.05	2.01	1.96	1.91	1.86	1.81	1.76	
24	2.25	2.18	2.11	2.03	1.98	1.94	1.89	1.84	1.79	1.73	
25	2.24	2.16	2.09	2.01	1.96	1.92	1.87	1.82	1.77	1.71	
26	2.22	2.15	2.07	1.99	1.95	1.90	1.85	1.80	1.75	1.69	
27	2.20	2.13	2.06	1.97	1.93	1.88	1.84	1.79	1.73	1.65	
28	2.19	2.12	2.04	1.96	1.91	1.87	1.82	1.77	1.71	1.65	
29	2.18	2.10	2.03	1.94	1.90	1.85	1.81	1.75	1.70	1.64	
30	2.16	2.09	2.01	1.93	1.89	1.84	1.79	1.74	1.68	1.62	
40	2.08	2.00	1.92	1.84	1.79	1.74	1.69	1.64	1.58	1.51	
60	1.99	1.92	1.84	1.75	1.70	1.65	1.59	1.53	1.47	1.39	
120	1.91	1.83	1.75	1.66	1.61	1.55	1.50	1.43	1.35	1.25	
∞	1.83	1.75	1.67	1.57	1.52	1.46	1.39	1.32	1.22	1.00	

TABLE A.7 (continued)
Critical Values of the F Distribution
 $f_{\alpha}(v_1, v_2)$

v_2	v_1								
	1	2	3	4	5	6	7	8	9
1	4052	4099.5	5403	5625	5764	5859	5928	5981	6022
2	98.50	99.00	99.17	99.25	99.30	99.33	99.36	99.37	99.39
3	34.12	30.82	29.46	28.71	28.24	27.91	27.67	27.49	27.35
4	21.20	18.00	16.69	15.98	15.52	15.21	14.98	14.80	14.66
5	16.26	13.27	12.06	11.39	10.97	10.67	10.46	10.29	10.16
6	13.75	10.92	9.78	9.15	8.75	8.47	8.26	8.10	7.98
7	12.25	9.55	8.45	7.85	7.46	7.19	6.99	6.84	6.72
8	11.26	8.65	7.59	7.01	6.63	6.37	6.18	6.03	5.91
9	10.56	8.02	6.99	6.42	6.06	5.80	5.61	5.47	5.35
10	10.04	7.56	6.55	5.99	5.64	5.39	5.20	5.06	4.94
11	9.65	7.21	6.22	5.67	5.32	5.07	4.89	4.74	4.63
12	9.33	6.93	5.95	5.41	5.06	4.82	4.64	4.50	4.39
13	9.07	6.70	5.74	5.21	4.86	4.62	4.44	4.30	4.19
14	8.86	6.51	5.56	5.04	4.69	4.46	4.28	4.14	4.03
15	8.68	6.36	5.42	4.89	4.56	4.32	4.14	4.00	3.89
16	8.53	6.23	5.29	4.77	4.44	4.20	4.03	3.89	3.78
17	8.40	6.11	5.18	4.67	4.34	4.10	3.93	3.79	3.68
18	8.29	6.01	5.09	4.58	4.25	4.01	3.84	3.71	3.60
19	8.18	5.93	5.01	4.50	4.17	3.94	3.77	3.63	3.52
20	8.10	5.85	4.94	4.43	4.10	3.87	3.70	3.56	3.46
21	8.02	5.78	4.87	4.37	4.04	3.81	3.64	3.51	3.40
22	7.95	5.72	4.82	4.31	3.99	3.76	3.59	3.45	3.35
23	7.88	5.66	4.76	4.26	3.94	3.71	3.54	3.41	3.30
24	7.82	5.61	4.72	4.22	3.90	3.67	3.50	3.36	3.26
25	7.77	5.57	4.68	4.18	3.85	3.63	3.46	3.32	3.22
26	7.72	5.53	4.64	4.14	3.82	3.59	3.42	3.29	3.18
27	7.68	5.49	4.60	4.11	3.78	3.56	3.39	3.26	3.15
28	7.64	5.45	4.57	4.07	3.75	3.53	3.36	3.23	3.12
29	7.60	5.42	4.54	4.04	3.73	3.50	3.33	3.20	3.09
30	7.56	5.39	4.51	4.02	3.70	3.47	3.30	3.17	3.07
40	7.31	5.18	4.31	3.83	3.51	3.29	3.12	2.99	2.89
60	7.08	4.98	4.13	3.65	3.34	3.12	2.95	2.82	2.72
120	6.85	4.79	3.95	3.48	3.17	2.96	2.79	2.66	2.56
∞	6.63	4.61	3.78	3.32	3.02	2.80	2.64	2.51	2.41

TABLE A.7 (continued)
Critical Values of the F Distribution
 $f_{\alpha}(v_1, v_2)$

v_2	v_1												
	10	12	15	20	24	30	40	60	120	∞			
1	6056	6106	6157	6209	6235	6261	6287	6313	6339	6366	6392	6418	
2	99.40	99.42	99.43	99.45	99.46	99.47	99.48	99.49	99.50	99.51	99.52	99.53	
3	27.22	27.05	26.87	26.69	26.60	26.50	26.41	26.32	26.22	26.13	26.04	25.95	
4	14.55	14.37	14.20	14.02	13.93	13.84	13.75	13.65	13.56	13.46	13.37	13.28	
5	10.05	9.89	9.72	9.55	9.47	9.38	9.29	9.20	9.11	9.02	8.93	8.84	
6	7.87	7.72	7.56	7.40	7.31	7.23	7.14	7.06	6.97	6.88	6.80	6.71	
7	6.62	6.47	6.31	6.16	6.07	5.99	5.91	5.82	5.74	5.65	5.57	5.48	
8	5.81	5.67	5.52	5.36	5.28	5.20	5.12	5.03	4.95	4.86	4.78	4.69	
9	5.26	5.11	4.96	4.81	4.73	4.65	4.57	4.48	4.40	4.31	4.23	4.14	
10	4.85	4.71	4.56	4.41	4.33	4.25	4.17	4.08	4.00	3.91	3.83	3.74	
11	4.54	4.40	4.25	4.10	4.02	3.94	3.86	3.78	3.69	3.60	3.52	3.43	
12	4.30	4.16	4.01	3.86	3.78	3.70	3.62	3.54	3.45	3.36	3.28	3.19	
13	4.10	3.96	3.82	3.66	3.59	3.51	3.43	3.34	3.25	3.17	3.08	3.00	
14	3.94	3.80	3.66	3.51	3.43	3.35	3.27	3.18	3.09	3.00	2.92	2.83	
15	3.80	3.67	3.52	3.37	3.29	3.21	3.13	3.05	2.96	2.87	2.78	2.70	
16	3.69	3.55	3.41	3.26	3.18	3.10	3.02	2.93	2.84	2.75	2.66	2.57	
17	3.59	3.46	3.31	3.16	3.08	3.00	2.92	2.83	2.75	2.65	2.56	2.47	
18	3.51	3.37	3.23	3.08	3.00	2.92	2.84	2.75	2.66	2.57	2.48	2.39	
19	3.43	3.30	3.15	3.00	2.92	2.84	2.76	2.67	2.58	2.49	2.40	2.31	
20	3.37	3.23	3.09	2.94	2.86	2.78	2.69	2.61	2.52	2.42	2.33	2.24	
21	3.31	3.17	3.03	2.88	2.80	2.72	2.64	2.55	2.46	2.36	2.27	2.18	
22	3.26	3.12	2.98	2.83	2.75	2.67	2.58	2.50	2.40	2.31	2.22	2.13	
23	3.21	3.07	2.93	2.78	2.70	2.62	2.54	2.45	2.35	2.26	2.17	2.08	
24	3.17	3.03	2.89	2.74	2.66	2.58	2.49	2.40	2.31	2.21	2.12	2.03	
25	3.13	2.99	2.85	2.70	2.62	2.54	2.45	2.36	2.27	2.17	2.08	1.99	
26	3.09	2.96	2.81	2.66	2.58	2.50	2.42	2.33	2.23	2.13	2.04	1.95	
27	3.06	2.93	2.78	2.63	2.55	2.47	2.38	2.29	2.20	2.10	2.01	1.92	
28	3.03	2.90	2.75	2.60	2.52	2.44	2.35	2.26	2.17	2.06	1.97	1.88	
29	3.00	2.87	2.73	2.57	2.49	2.41	2.33	2.23	2.14	2.03	1.94	1.85	
30	2.98	2.84	2.70	2.55	2.47	2.39	2.30	2.21	2.11	2.01	1.92	1.83	
40	2.80	2.66	2.52	2.37	2.29	2.20	2.11	2.02	1.92	1.80	1.71	1.60	
60	2.63	2.50	2.35	2.20	2.12	2.03	1.94	1.84	1.73	1.60	1.50	1.38	
120	2.47	2.34	2.19	2.03	1.95	1.86	1.76	1.66	1.53	1.38	1.28	1.16	
∞	2.32	2.18	2.04	1.88	1.79	1.70	1.59	1.47	1.32	1.16	1.06	0.94	