UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Pertama
Sidang Akademik 1998/99

Ogos/September 1998

FMS 161.4 - Matematik dan Statistik untuk Farmasi

Masa: (3 jam)

Kertas ini mengandungi **ENAM (6)** soalan dan 26 muka surat yang bertaip.

Jawab **LIMA (5)** soalan sahaja.

Semua soalan mesti dijawab di dalam Bahasa Malaysia.

I. (A) Ɍ

Tinktur Beladona	40 mL
Eliksir Fenobarbital	140 mL
Alkohol USP	qs
Sirap Tolu qs ad.	360 mL

Sekiranya Tinktur Beladona mengandungi 67% v/v etanol dan Eliksir Fenobarbital mengandungi 15% v/v etanol, berapa banyak Alkohol USP yang mengandungi 95% v/v etanol patut digunakan supaya kepekatan etanol di dalam sediaan tersebut ialah 20% v/v.

(7 markah)

(B) Selesaikan:

(i) $\int \left(x\sqrt{1-x^2} \right) dx$

(ii) $\int \left(\sqrt{x+1} - \sqrt{x} \right) dx$

(iii) $\int \dfrac{x}{\left(3x^2 + 7 \right)^3} \, dx$

(3 markah)

.....3/-

(C) Kajian telah dijalankan untuk mengkaji kesan agen hipoglisemia, drug terhadap paras glukosa darah (mg/dl). Kesan drug X telah dibandingkan dengan agen hipoglisemia piawai iaitu glibenklamid. Jumlah sampel (n) bagi setiap drug ialah 20 orang. Keputusan yang diperolehi adalah seperti berikut:

Kumpulan Glibenklamid:

67, 89, 78, 87, 86, 100, 75, 103, 110, 88
98, 94, 116, 88, 102, 85, 58, 61, 92, 76

Kumpulan Drug X:

87, 86, 91, 99, 83, 95, 84, 83, 92, 94
79, 94, 96, 83, 92, 88, 92, 82, 84, 90

(i)   Hitung min, sisihan piawai dan ralat piawai bagi setiap kumpulan.

(ii)   Bincangkan taburan data bagi setiap kumpulan dan kaitkan dengan sisihan piawai masing-masing.

(iii)   Hitung kesahan min bagi setiap kumpulan.

(iv)   Bincangkan kepentingan sisihan piawai dan ralat piawai di dalam statistik.

(v)   Lakarkan keputusan di atas (min setiap kumpulan serta sisihan piawainya) dalam bentuk grafik.

(10 markah)

.....4/-

II. **(A)** Suatu kajian dikendalikan untuk membandingkan dua drug anti-hipertensif. Dua puluh (20) pesakit diberikan drug A dan dua puluh (20) yang lain diberikan drug B.

Bagi drug A, 5 pesakit mencapai kesan positif manakala bagi drug B, 14 mencapai kesan positif. Adakah perbezaan itu benar secara statistik?

(10 markah)

(B) Terangkan apakah yang dimaksudkan oleh ralat "Type I" dan "Type II".

(5 markah)

(C) Apabila drug C disuntik secara ekstravaskular, proses penyerapan drug menyebabkan suatu kepekatan puncak dicapai selepas masa tertentu. Jika kepekatan drug C (mg/ml) selepas masa t jam diberikan oleh fungsi berikut:

$$C(t) = 0.15 \, (e^{-0.18t} - e^{-1.2t})$$

Hitungkan:

(i) kepekatan awal drug dan kepekatan drug selepas 3 jam.

(ii) masa puncak drug.

(iii) had C(t)
$t \to \infty$

(iv) Lakaran fungsi C(t)

(5 markah)

III. **(A)** Ujian klinikal telah dijalankan ke atas pesakit yang:

(i) mengalami sekurang-kurangnya dua perulangan ulser duodenal.

(ii) sedang mengalami keredaan dan;

(iii) menunjukkan ujian positif kehadiran bakteria H. pylori yang biasa ditemui dalam duodenum manusia.

Subjek kajian telah dibahagikan kepada dua kumpulan secara rawak. Satu kumpulan menerima ubat ulser yang sering digunakan dan satu kumpulan lagi menerima ubat ulser yang serupa bersama-sama sejenis antibiotik. Pesakit diperhatikan selama satu tahun dan penentuan dibuat sama ada ulser berulang (ya/tidak) dalam tempoh 12 bulan tersebut. Keputusan ditunjukkan di dalam jadual di bawah:

RAWATAN	PERULANGAN DALAM TEMPOH PEMERHATIAN		TOTAL
	YA	TIDAK	
Ubat ulser dan antibiotik	9	99	108
Ubat ulser	89	15	104
Total	98	114	212

(i) Tentukan sama ada perkiraan nisbah ods atau risiko relatif sesuai untuk kajian di atas? Berikan penjelasan.

(ii) Kirakan insiden kumulatif perulangan ulser untuk setiap kumpulan pesakit.

(iii) Kirakan risiko relatif perulangan ulser.

(iv) Keputusan akhir kajian menunjukkan terapi kombinasi mampu mengurangkan risiko perulangan ulser. Adakah anda setuju dengan kenyataan tersebut? Jelaskan.

(13 markah)

...6/-

(B) Mengikut keperluan piawai, tinktur "A" patut mengandungi 1:3333 alkaloid. Sekiranya 250 mL tinktur "A" telah disediakan dan didapati kandungan alkaloidnya ialah 0.035% w/v, berapa banyak pelarut harus digunakan untuk mencairkan tinktur itu supaya ia akan memenuhi keperluan piawai?

(7 markah)

IV. **(A)** Kadar nadi normal lelaki dan wanita dibandingkan. Berikut ialah keputusan yang diperolehi daripada 6 orang lelaki dan 6 orang wanita.

Wanita	Lelaki
62	70
60	72
69	73
70	75
71	79
72	79

Adakah kadar nadi normal lelaki dan wanita itu berbeza secara statistik?

(10 markah)

(B) Komen tentang rekabentuk kajian yang digunakan di atas.

(5 markah)

(C) Cari had untuk fungsi berikut:

(i) $\displaystyle\lim_{x \to 1} \frac{x^{\frac{1}{2}} - x^{\frac{1}{4}}}{x - 1}$

(ii) $\displaystyle\lim_{x \to \infty} \ln \frac{(x^2 - 1)^3}{(x^2 + 1)}$

(iii) $\displaystyle\lim_{x \to \infty} x \ln x^2$

(3 markah)

(D) Terbitan untuk suatu fungsi f(x) didapati bersamaan dengan dua kali lebih besar fungsi f(x) iaitu f(x) = 2 f(x). Jika f(x) = 4 apabila x = 2, selesaikan fungsi f(x).

(2 markah)

.....7/-

V. **(A)** Tulis nota ringkas mengenai topik-topik berikut dan sertakan contoh-contoh yang sesuai:

      (i)   kaedah persampelan berstrata.

      (ii)   skala pengukuran.

(12 markah)

(B) Dapatkan perbezaan berikut:

      (i) $\ln \sqrt{\dfrac{x-1}{x^2+1}}$

      (ii) $x \ln (x^2 + 1)$

(2 markah)

(C) HCl BP (36% w/w) mempunyai nilai ketumpatan 1.18 g/mL. Berapa ml asid pekat itu perlu digunakan untuk menyediakan 200 mL suatu larutan 5 % w/v HCl?

(6 markah)

VI. **(A)** Apakah ciri-ciri penting yang terdapat dalam kajian klinikal rawak. Buatkan perbandingan rekabentuk kajian ini dengan kajian kes kontrol dan kajian kohort.

(10 markah)

(B) Bincangkan perkara-perkara yang boleh mempengaruhi kesahihan dan kebolehpercayaan sesuatu kajian klinikal.

(5 markah)

(C)   Berikut adalah statistik penting ("vital statistics") untuk negara XYZ bagi tahun 1990.

Jumlah populasi pada pertengahan tahun	80,000
Jumlah populasi yang berumur 45 tahun dan ke atas	20,000
Jumlah bayi yang hidup selepas dilahirkan	2,000
Kematian fetus (yang dilaporkan)	32
Kematian maternal	1
Kematian total	648
Kematian di bawah umur 1 tahun	42
Kematian individu 45 tahun dan ke atas	300
disebabkan sakit jantung	98
disebabkan kanser	60
disebabkan strok	48
disebabkan oleh punca lain	94

Berdasarkan maklumat di atas, kirakan indeks kesihatan berikut (gunakan nilai pemalar x 1000 atau x 100,000).

(i)   Kadar kematian spesifik dari segi umur bagi individu berumur 45 tahun dan ke atas.

(ii)   Kadar kematian spesifik dari segi punca dan umur bagi individu yang berumur 45 tahun dan ke atas bagi masalah:

(a)   penyakit jantung.

(b)   kanser.

(5 markah)

FORMULA

1. Median $(m) = b + c \times \dfrac{d}{f}$

2. $u_1 = Ax_1 + B$

3. $\bar{x} = \dfrac{1}{A}(\bar{u} - B)$

4. $S_x^2 = \dfrac{1}{A^2} S_u^2$

5. $S_u^2 = \dfrac{\Sigma ui^2 fi - n\bar{u}^2}{n - 1}$

6. Trimean $= \dfrac{\text{kuartil atas} + (2 \times \text{median}) + \text{kuartil bawah}}{4}$

7. **Ujian-t**

   $t = \dfrac{\bar{x} - \mu_o}{S/\sqrt{n}}$

   $s = \sqrt{\dfrac{x^2 - \dfrac{(x)^2}{n}}{n - 1}}$

   $t = \dfrac{\bar{x}_1 - \bar{x}_2}{S\sqrt{1/n_1 + 1/n_2}}$

   $s = \sqrt{\dfrac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2}}$

   $t = \dfrac{\bar{D}}{S/\sqrt{n}}$

   $s = \sqrt{\dfrac{\Sigma D^2 - \dfrac{(\Sigma D)^2}{n}}{n - 1}}$

TABLE X Critical values of F_{max}

ν	2	3	4	5	6	7	8	9	10	11	12
2	39.0	87.5	142.	202.	266.	333.	403.	475.	550.	626.	704.
	199.	448.	729.	1036.	1362.	1705.	2063.	2432.	2813.	3204.	3605.
3	15.4	27.8	39.2	50.7	62.0	72.9	83.5	93.9	104.	114.	124.
	47.5	85.	120.	151.	184.	21(6)	24(9)	28(1)	31(0)	33(7)	36(1)
4	9.60	15.5	20.6	25.2	29.5	33.6	37.5	41.1	44.6	48.0	51.4
	23.2	37.	49.	59.	69.	79.	89.	97.	106.	113.	120.
5	7.15	10.8	13.7	16.3	18.7	20.8	22.9	24.7	26.5	28.2	29.9
	14.9	22.	28.	33.	38.	42.	46.	50.	54.	57.	60.
6	5.82	8.38	10.4	12.1	13.7	15.0	16.3	17.5	18.6	19.7	20.7
	11.1	15.5	19.1	22.	25.	27.	30.	32.	34.	36.	37.
7	4.99	6.94	8.44	9.70	10.8	11.8	12.7	13.5	14.3	15.1	15.8
	8.89	12.1	14.5	16.5	18.4	20.	22.	23.	24.	26.	27.
8	4.43	6.00	7.18	8.12	9.03	9.78	10.5	11.1	11.7	12.2	12.7
	7.50	9.9	11.7	13.2	14.5	15.8	16.9	17.9	18.9	19.8	21.
9	4.03	5.34	6.31	7.11	7.80	8.41	8.95	9.45	9.91	10.3	10.7
	6.54	8.5	9.9	11.1	12.1	13.1	13.9	14.7	15.3	16.0	16.6
10	3.72	4.85	5.67	6.34	6.92	7.42	7.87	8.28	8.66	9.01	9.34
	5.85	7.4	8.6	9.6	10.4	11.1	11.8	12.4	12.9	13.4	13.9
12	3.28	4.16	4.79	5.30	5.72	6.09	6.42	6.72	7.00	7.25	7.48
	4.91	6.1	6.9	7.6	8.2	8.7	9.1	9.5	9.9	10.2	10.6
15	2.86	3.54	4.01	4.37	4.68	4.95	5.19	5.40	5.59	5.77	5.93
	4.07	4.9	5.5	6.0	6.4	6.7	7.1	7.3	7.5	7.8	8.0
20	2.46	2.95	3.29	3.54	3.76	3.94	4.10	4.24	4.37	4.49	4.59
	3.32	3.8	4.3	4.6	4.9	5.1	5.3	5.5	5.6	5.8	5.9
30	2.07	2.40	2.61	2.78	2.91	3.02	3.12	3.21	3.29	3.36	3.39
	2.63	3.0	3.3	3.4	3.6	3.7	3.8	3.9	4.0	4.1	4.2
60	1.67	1.85	1.96	2.04	2.11	2.17	2.22	2.26	2.30	2.33	2.36
	1.96	2.2	2.3	2.4	2.4	2.5	2.5	2.6	2.6	2.7	2.7
∞	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

From H. A. David, *Biometrika*, 39, 422-4. Reprinted by permission of the Biometrika trustees.

8. **Ujian Wilcoxon** (independent samples)

$$U = n_1 \, n_2 + \frac{n_2(n_2 + 1)}{2} - \Sigma_R$$

$$U' = n_1 \, n_2 - U$$

9. **Ujian Sign**

$$P \, (s \geq k) = 1 - P \, (s \geq k-1)$$

10. **ANOVA** (1-way)

$$SS_{Total} = \Sigma X^2 - \frac{(\Sigma X)^2}{n_T}$$

$$SS_{Treatments} = \frac{(\Sigma X_A)^2}{n_A} + \frac{(\Sigma X_B)^2}{n_B} \, \ldots\ldots \, - \frac{(\Sigma X)^2}{n_T}$$

$$SS_{Error} = SS_{Total} - SS_{Treatments}$$

$$d.f. \, (Total) = (n_T - 1)$$

$$d.f. \, (Treatment) = (k - 1)$$

$$d.f. \, (Error) = (n_1 + n_2 \, \ldots\ldots + n_k - k)$$

$$HSD = \frac{q\sqrt{MS_{error}}}{\sqrt{n}}$$

$$n_{nm} = \frac{2 \, n_1 n_2}{n_1 + n_2}$$

11. **Ujian Kruskal-Wallis**

$$H = \frac{12}{N(N + 1)} \left(\frac{R_1^2}{n_1} + \frac{R_2^2}{n_2} + \ldots + \frac{R_k^2}{n_k} \right) - 3 (N + 1)$$

$$N = n_1 + n_2 + \ldots + n_k$$

$$d.f. = k - 1$$

Ujian perbandingan berganda:

$$\Delta R = Z_{(\alpha/k \ (k-1))} \sqrt{\frac{N(N + 1)}{12} \left(\frac{1}{n_1} + \frac{1}{n_j} \right)}$$

12. **Ujian Friedman**

$$Q = \frac{12}{n_k (k + 1)} (R_1^2 + R_2^2 + \ldots + R_k^2) - 3 n (k + 1)$$

$$d.f. = k - 1$$

Ujian perbandingan berganda:

$$\Delta R = Z_{(\alpha/k \ (k-1))} \sqrt{\frac{b \ k \ (K + 1)}{6}}$$

13. **Formula Sturges**

$$k = 1 + 3.3 \log_{10} n$$

14. **Ujian Korelasi**

$$R = \frac{n \Sigma xy - \Sigma x \, \Sigma y}{\sqrt{n \, \Sigma x^2 - (\Sigma x)^2} \; \sqrt{n \, \Sigma y^2 - (\Sigma y)^2}}$$

15. **Analisis Regresi**

$$y = mx + c$$

$$m = \frac{\Sigma xy - \dfrac{\Sigma x \Sigma y}{n}}{\Sigma x^2 - \dfrac{(\Sigma x)^2}{n}}$$

$$c = \frac{\Sigma y - m(\Sigma x)}{n}$$

$$SS_E = \Sigma y^2 - m \, \Sigma xy - \frac{(\Sigma y)^2}{n} + \frac{m \, \Sigma x \Sigma y}{n}$$

$$S_{yx} = \sqrt{\frac{SS_E}{n-2}}$$

16. $$\chi^2 = \frac{N(AD - BC)^2}{(A+B)(C+D)(A+C)(B+D)}$$

17. $$99\% \; CI \; \mu = \bar{X} \pm \left(t \times \frac{s}{\sqrt{n}} \right)$$

18. $$99\% \; CI \; \mu = \bar{X} \pm \left(z \times \frac{s}{\sqrt{n}} \right)$$

19. $$Z = \frac{\bar{x} - \mu}{\sigma/\sqrt{n}}$$

20. $$\chi^2 = \Sigma \frac{(O-E)^2}{E}$$

.....14/-

TABLE IV Normal curve areas

Z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.0359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0753
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2257	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2517	.2549
0.7	.2580	.2611	.2642	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2995	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990
3.1	.49903									
3.2	.49931									
3.3	.49952									
3.4	.49966									
3.5	.49977									
3.6	.49984									
3.7	.49989									
3.8	.49993									
3.9	.49995									
4.0	.50000									

TABLE III   Critical values of t

For any given df, the table shows the values of t corresponding to various levels of probability. Obtained t is significant at a given level if it is equal to or greater than the value shown in the table.

df	Level of significance for one-tailed test					
	.10	.05	.025	.01	.005	.0005
	Level of significance for two-tailed test					
	.20	.10	.05	.02	.01	.001
1	3.078	6.314	12.706	31.821	63.657	636.619
2	1.886	2.920	4.303	6.965	9.925	31.598
3	1.638	2.353	3.182	4.541	5.841	12.941
4	1.533	2.132	2.776	3.747	4.604	8.610
5	1.476	2.015	2.571	3.365	4.032	6.859
6	1.440	1.943	2.447	3.143	707	5.959
7	1.415	1.895	2.365	2.998	3.499	5.405
8	1.397	1.860	2.306	2.896	3.355	5.041
9	1.383	1.833	2.262	2.821	3.250	4.781
10	1.372	1.812	2.228	2.764	3.169	4.587
11	1.363	1.796	2.201	2.718	3.106	4.437
12	1.356	1.782	2.179	2.681	3.055	4.318
13	1.350	1.771	2.160	2.650	3.012	4.221
14	1.345	1.761	2.145	2.624	2.977	4.140
15	1.341	1.753	2.131	2.602	2.947	4.073
16	1.337	1.746	2.120	2.583	2.921	4.015
17	1.333	1.740	2.110	2.567	2.898	3.965
18	1.330	1.734	2.101	2.552	2.878	3.922
19	1.328	1.729	2.093	2.539	2.861	3.883
20	1.325	1.725	2.086	2.528	2.845	3.850
21	1.323	1.721	2.080	2.518	2.831	3.819
22	1.321	1.717	2.074	2.508	2.819	3.792
23	1.319	1.714	2.069	2.500	2.807	3.767
24	1.318	1.711	2.064	2.492	2.797	3.745
25	1.316	1.708	2.060	2.485	2.787	3.725
26	1.315	1.706	2.056	2.479	2.779	3.707
27	1.314	1.703	2.052	2.473	2.771	3.690
28	1.313	1.701	2.048	2.467	2.763	3.674
29	1.311	1.699	2.045	2.462	2.756	3.659
30	1.310	1.697	2.042	2.457	2.750	3.646
40	1.303	1.684	2.021	2.423	2.704	3.551
60	1.296	1.671	2.000	2.390	2.660	3.460
120	1.289	1.658	1.980	2.358	2.617	3.373
∞	1.282	1.645	1.960	2.326	2.576	3.291

TABLE IX Critical values of U

n_1	n_2	0.10	0.05	0.025	0.01	0.005	0.001	n_1	n_2	0.10	0.05	0.025	0.01	0.005	0.001
3	2	6	-	-	-	-	-	10	5	37	39	42	44	46	49
	3	8	9	-	-	-	-		6	43	46	49	52	54	57
4	2	8	-	-	-	-	-		7	49	53	56	59	61	65
	3	11	12	-	-	-	-		8	56	60	63	67	69	74
	4	13	15	16	-	-	-		9	62	66	70	74	77	82
5	2	9	10	-	-	-	-	10	10	68	73	77	81	84	90
	3	13	14	15	-	-	-	11	1	11	-	-	-	-	-
	4	16	18	19	20	-	-		2	19	21	22	-	-	-
	5	20	21	23	24	25	-		3	26	28	30	32	33	-
6	2	11	12	-	-	-	-		4	33	36	38	40	42	44
6	3	15	16	17	-	-	-	11	5	40	43	46	48	50	53
	4	19	21	22	23	24	-		6	47	50	53	57	59	62
	5	23	25	27	28	29	-		7	54	58	61	65	67	71
	6	27	29	31	33	34	-		8	61	65	69	73	75	80
7	2	13	14	-	-	-	-		9	68	72	76	81	83	89
7	3	17	19	20	21	-	-	11	10	74	79	84	88	92	98
	4	22	24	25	27	28	-		11	81	87	91	96	100	106
	5	27	29	30	32	34	-	12	1	12	-	-	-	-	-
	6	31	34	36	38	39	42		2	20	22	23	-	-	-
	7	36	38	41	43	45	48		3	28	31	32	34	35	-
8	2	14	15	16	-	-	-	12	4	36	39	41	43	45	48
	3	19	21	22	24	-	-		5	43	47	49	52	54	58
	4	25	27	28	30	31	-		6	51	55	58	61	63	68
	5	30	32	34	36	38	40		7	58	63	66	70	72	77
	6	35	38	40	42	44	47		8	66	70	74	79	81	87
8	7	40	43	46	49	50	54	12	9	73	78	82	87	90	96
	8	45	49	51	55	57	60		10	81	86	91	96	99	106
9	1	9	-	-	-	-	-		11	88	94	99	104	108	115
	2	16	17	18	-	-	-		12	95	102	107	113	117	124
	3	22	23	25	26	27	-	13	1	13	-	-	-	-	-
9	4	27	30	32	33	35	-	13	2	22	24	25	26	-	-
	5	33	36	38	40	42	44		3	30	33	35	37	38	-
	6	39	42	44	47	49	52		4	39	42	44	47	49	51
	7	45	48	51	54	56	60		5	47	50	53	56	58	62
	8	50	54	57	61	63	67		6	55	59	62	66	68	73
9	9	56	60	64	67	70	74	13	7	63	67	71	75	78	83
10	1	10	-	-	-	-	-		8	71	76	80	84	87	93
	2	17	19	20	-	-	-		9	79	84	89	94	97	103
	3	24	26	27	29	30	-		10	87	93	97	103	106	113
	4	30	33	35	37	38	40		11	95	101	106	112	116	123

TABLE IX (continued)

n_1	n_2	0.10	0.05	0.025	0.01	0.005	0.001	n_1	n_2	0.10	0.05	0.025	0.01	0.005	0.001
13	12	103	109	115	121	125	133	16	10	106	112	118	124	129	137
	13	111	118	124	130	135	143		11	115	122	129	135	140	149
14	1	14	-	-	-	-	-		12	125	132	139	146	151	161
	2	24	25	27	28	-	-		13	134	143	149	157	163	173
	3	32	35	37	40	41	-		14	144	153	160	168	174	185
14	4	41	45	47	50	52	55	16	15	154	163	170	179	185	197
	5	50	54	57	60	63	67		16	163	173	181	190	196	208
	6	59	63	67	71	73	78	17	1	17	-	-	-	-	-
	7	67	72	76	81	83	89		2	28	31	32	34	-	-
	8	76	81	86	90	94	100		3	39	42	45	47	49	51
14	9	85	90	95	100	104	111	17	4	50	53	57	60	62	66
	10	93	99	104	110	114	121		5	60	65	68	72	75	80
	11	102	108	114	120	124	132		6	71	76	80	84	87	93
	12	110	117	123	130	134	143		7	81	86	91	96	100	106
	13	119	126	132	139	144	153		8	91	97	102	108	112	119
14	14	127	135	141	149	154	164	17	9	101	108	114	120	124	132
15	1	15	-	-	-	-	-		10	112	119	125	132	136	145
	2	25	27	29	30	-	-		11	122	130	136	143	148	158
	3	35	38	40	42	43	-		12	132	140	147	155	160	170
	4	44	48	50	53	55	59		13	142	151	158	166	172	183
15	5	53	57	61	64	67	71	17	14	153	161	169	178	184	195
	6	63	67	71	75	78	83		15	163	172	180	189	195	208
	7	72	77	81	86	89	95		16	173	183	191	201	207	220
	8	81	87	91	96	100	106		17	183	193	202	212	219	232
	9	90	96	101	107	111	118	18	1	18	-	-	-	-	-
15	10	99	106	111	117	121	129		2	30	32	34	36	-	-
	11	108	115	121	128	132	141		3	41	45	47	50	52	54
	12	117	125	131	138	143	152		4	52	56	60	63	66	69
	13	127	134	141	148	153	163		5	63	68	72	76	79	84
	14	136	144	151	159	164	174		6	74	80	84	89	92	98
15	15	145	153	161	169	174	185	18	7	85	91	96	102	105	112
16	1	16	-	-	-	-	-		8	96	103	108	114	118	126
	2	27	29	31	32	-	-		9	107	114	120	126	131	139
	3	37	40	42	45	46	-		10	118	125	132	139	143	153
	4	47	50	53	57	59	62		11	129	137	143	151	156	166
16	5	57	61	65	68	71	75	18	12	139	148	155	163	169	179
	6	67	71	75	80	83	88		13	150	159	167	175	181	192
	7	76	82	86	91	94	101		14	161	170	178	187	194	206
	8	86	92	97	102	106	113		15	172	182	190	200	206	219
	9	96	102	107	113	117	125		16	182	193	202	212	218	232

(FMS 161)

TABLE IX (*continued*)

n_1	n_2	0.10	0.05	0.025	0.01	0.005	0.001
18	17	193	204	213	224	231	245
	18	204	215	225	236	243	258
19	1	18	19	-	-	-	-
	2	31	34	36	37	38	-
	3	43	47	50	53	54	57
19	4	55	59	63	67	69	73
	5	67	72	76	80	83	88
	6	78	84	89	94	97	103
	7	90	96	101	107	111	118
	8	101	108	114	120	124	132
19	9	113	120	126	133	138	146
	10	124	132	138	146	151	161
	11	136	144	151	159	164	175
	12	147	156	163	172	177	188
	13	158	167	175	184	190	202
19	14	169	179	188	197	203	216
	15	181	191	200	210	216	230
	16	192	203	212	222	230	244
	17	203	214	224	235	242	257
	18	214	226	236	248	255	271
19	19	226	238	248	260	268	284
20	1	19	20	-	-	-	-
	2	33	36	38	39	40	-
	3	45	49	52	55	57	60
	4	58	62	66	70	72	77
20	5	70	75	80	84	87	93
	6	82	88	93	98	102	108
	7	94	101	106	112	116	124
	8	106	113	119	126	130	139
	9	118	126	132	140	144	154
20	10	130	138	145	153	158	168
	11	142	151	158	167	172	183
	12	154	163	171	180	186	198
	13	166	176	184	193	200	212
	14	178	188	197	207	213	226
20	15	190	200	210	220	227	241
	16	201	213	222	233	241	255
	17	213	225	235	247	254	270
	18	225	237	248	260	268	284
	19	237	250	261	273	281	298
	20	249	262	273	286	295	312

From D. B. Owen, *Handbook of Statistical Tables*. Reading,
MA: Addison-Wesley, 1962. Reprinted by permission.

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TABLE XIII   Table of q (0.05 level)

d.f. \ k	2	3	4	5	6	7	8	9	10	11
5	3.64	4.60	5.22	5.67	6.03	6.33	6.58	6.80	6.99	7.17
6	3.46	4.34	4.90	5.30	5.63	5.90	6.12	6.32	6.49	6.65
7	3.34	4.16	4.68	5.06	5.36	5.61	5.82	6.00	6.16	6.30
8	3.26	4.04	4.53	4.89	5.17	5.40	5.60	5.77	5.92	6.05
9	3.20	3.95	4.41	4.76	5.02	5.24	5.43	5.59	5.74	5.87
10	3.15	3.88	4.33	4.65	4.91	5.12	5.30	5.46	5.60	5.72
11	3.11	3.82	4.26	4.57	4.82	5.03	5.20	5.35	5.49	5.61
12	3.08	3.77	4.20	4.51	4.75	4.95	5.12	5.27	5.39	5.51
13	3.06	3.73	4.15	4.45	4.69	4.88	5.05	5.19	5.32	5.43
14	3.03	3.70	4.11	4.41	4.64	4.83	4.99	5.13	5.25	5.36
15	3.01	3.67	4.08	4.37	4.59	4.78	4.94	5.08	5.20	5.31
16	3.00	3.65	4.05	4.33	4.56	4.74	4.90	5.03	5.15	5.26
17	2.98	3.63	4.02	4.30	4.52	4.71	4.86	4.99	5.11	5.21
18	2.97	3.61	4.00	4.28	4.49	4.67	4.82	4.96	5.07	5.17
19	2.96	3.59	3.98	4.25	4.47	4.65	4.79	4.92	5.04	5.14
20	2.95	3.58	3.96	4.23	4.45	4.62	4.77	4.90	5.01	5.11
24	2.92	3.53	3.90	4.17	4.37	4.54	4.68	4.81	4.92	5.01
30	2.89	3.49	3.85	4.10	4.30	4.46	4.60	4.72	4.82	4.92
40	2.86	3.44	3.79	4.04	4.23	4.39	4.52	4.63	4.73	4.82
60	2.83	3.40	3.74	3.98	4.16	4.31	4.44	4.55	4.65	4.73
120	2.80	3.36	3.68	3.92	4.10	4.24	4.36	4.47	4.56	4.64
∞	2.77	3.31	3.63	3.86	4.03	4.17	4.29	4.39	4.47	4.55

From H.L. Harker in *Annals of Mathematical Statistics*, 31 (1960): 1122-1147. Reprinted by permission of the publishers, The Institute of Mathematical Statistics.

TABLE V   Chi square

Column headings indicate probability of chance

deviation between O and E.

P D.F.	0.25	0.10	0.05	0.025	0.01	0.005
1.	1.323	2.706	3.841	5.024	6.635	7.879
2.	2.773	4.605	5.991	7.378	9.210	10.597
3.	4.108	6.251	7.815	9.348	11.345	12.838
4.	5.385	7.779	9.488	11.143	13.277	14.860
5.	6.626	9.236	11.071	12.833	15.086	16.750
6.	7.841	10.645	12.592	14.449	16.812	18.548
7.	9.037	12.017	14.067	16.013	18.475	20.278
8.	10.219	13.362	15.507	17.535	20.090	21.955
9.	11.389	14.684	16.919	19.023	21.666	23.589
10.	12.549	15.987	18.307	20.483	23.209	25.188
11.	13.701	17.275	19.675	21.920	24.725	26.757
12.	14.845	18.549	21.026	23.337	26.217	28.299
13.	15.984	19.812	22.362	24.736	27.688	29.819
14.	17.117	21.064	23.685	26.119	29.141	31.319
15.	18.245	22.307	24.996	27.488	30.578	32.801

Adapted from table of χ^2 appearing in *Handbook of Statistical Tables* by D. B. Owen, Addison-Wesley, 1962, p. 50. Reprinted by permission of the U.S. Atomic Energy Commission.

TABLE VII Critical Values of F

The obtained F is significant at a given level if it is equal to or greater than the value shown in the table. 0.05 (light row) and 0.01 (dark row) points for the distribution of F

Each cell shows the 0.05 point (upper/light) and the 0.01 point (lower/dark).

Degrees of freedom for greater mean square

lesser \ greater	1	2	3	4	5	6	7	8	9	10	11	12	14	16	20	24	30	40	50	75	100	200	500	∞
1	161 / 4052	200 / 4999	216 / 5403	225 / 5625	230 / 5764	234 / 5859	237 / 5928	239 / 5981	241 / 6022	242 / 6056	243 / 6082	244 / 6106	245 / 6142	246 / 6169	248 / 6208	249 / 6234	250 / 6258	251 / 6286	252 / 6302	253 / 6323	253 / 6334	254 / 6352	254 / 6361	254 / 6366
2	18.51 / 98.49	19.00 / 99.01	19.16 / 99.17	19.25 / 99.25	19.30 / 99.30	19.33 / 99.33	19.36 / 99.34	19.37 / 99.36	19.38 / 99.38	19.39 / 99.40	19.40 / 99.41	19.41 / 99.42	19.42 / 99.43	19.43 / 99.44	19.44 / 99.45	19.45 / 99.46	19.46 / 99.47	19.47 / 99.48	19.47 / 99.48	19.48 / 99.49	19.49 / 99.49	19.49 / 99.49	19.50 / 99.50	19.50 / 99.50
3	10.13 / 34.12	9.55 / 30.81	9.28 / 29.46	9.12 / 28.71	9.01 / 28.24	8.94 / 27.91	8.88 / 27.67	8.84 / 27.49	8.81 / 27.34	8.78 / 27.23	8.76 / 27.13	8.74 / 27.05	8.71 / 26.92	8.69 / 26.83	8.66 / 26.69	8.64 / 26.60	8.62 / 26.50	8.60 / 26.41	8.58 / 26.30	8.57 / 26.27	8.56 / 26.23	8.54 / 26.18	8.54 / 26.14	8.53 / 26.12
4	7.71 / 21.20	6.94 / 18.00	6.59 / 16.69	6.39 / 15.98	6.26 / 15.52	6.16 / 15.21	6.09 / 14.98	6.04 / 14.80	6.00 / 14.66	5.96 / 14.54	5.93 / 14.45	5.91 / 14.37	5.87 / 14.24	5.84 / 14.15	5.80 / 14.02	5.77 / 13.93	5.74 / 13.83	5.71 / 13.74	5.70 / 13.69	5.68 / 13.61	5.66 / 13.57	5.65 / 13.52	5.64 / 13.48	5.63 / 13.46
5	6.61 / 16.26	5.79 / 13.27	5.41 / 12.06	5.19 / 11.39	5.05 / 10.97	4.95 / 10.67	4.88 / 10.45	4.82 / 10.27	4.78 / 10.15	4.74 / 10.05	4.70 / 9.96	4.68 / 9.89	4.64 / 9.77	4.60 / 9.68	4.56 / 9.55	4.53 / 9.47	4.50 / 9.38	4.46 / 9.29	4.44 / 9.24	4.42 / 9.17	4.40 / 9.13	4.38 / 9.07	4.37 / 9.04	4.36 / 9.02
6	5.99 / 13.74	5.14 / 10.92	4.76 / 9.78	4.53 / 9.15	4.39 / 8.75	4.28 / 8.47	4.21 / 8.26	4.15 / 8.10	4.10 / 7.98	4.06 / 7.87	4.03 / 7.79	4.00 / 7.72	3.96 / 7.60	3.92 / 7.52	3.87 / 7.39	3.84 / 7.31	3.81 / 7.23	3.77 / 7.14	3.75 / 7.09	3.72 / 7.02	3.71 / 6.99	3.69 / 6.94	3.68 / 6.90	3.67 / 6.88
7	5.59 / 12.25	4.74 / 9.55	4.35 / 8.45	4.12 / 7.85	3.97 / 7.46	3.87 / 7.19	3.79 / 7.00	3.73 / 6.84	3.68 / 6.71	3.63 / 6.62	3.60 / 6.54	3.57 / 6.47	3.52 / 6.35	3.49 / 6.27	3.44 / 6.15	3.41 / 6.07	3.38 / 5.98	3.34 / 5.90	3.32 / 5.85	3.29 / 5.78	3.28 / 5.75	3.25 / 5.70	3.24 / 5.67	3.23 / 5.65
8	5.32 / 11.26	4.46 / 8.65	4.07 / 7.59	3.84 / 7.01	3.69 / 6.63	3.58 / 6.37	3.50 / 6.19	3.44 / 6.03	3.39 / 5.91	3.34 / 5.82	3.31 / 5.74	3.28 / 5.67	3.23 / 5.56	3.20 / 5.48	3.15 / 5.36	3.12 / 5.28	3.08 / 5.20	3.05 / 5.11	3.03 / 5.06	3.00 / 5.00	2.98 / 4.96	2.96 / 4.91	2.94 / 4.88	2.93 / 4.86
9	5.12 / 10.56	4.26 / 8.02	3.86 / 6.99	3.63 / 6.42	3.48 / 6.06	3.37 / 5.80	3.29 / 5.62	3.23 / 5.47	3.18 / 5.35	3.13 / 5.26	3.10 / 5.18	3.07 / 5.11	3.02 / 5.00	2.98 / 4.92	2.93 / 4.80	2.90 / 4.73	2.86 / 4.64	2.82 / 4.56	2.80 / 4.51	2.77 / 4.45	2.76 / 4.41	2.73 / 4.36	2.72 / 4.33	2.71 / 4.31
10	4.96 / 10.04	4.10 / 7.56	3.71 / 6.55	3.48 / 5.99	3.33 / 5.64	3.22 / 5.39	3.14 / 5.21	3.07 / 5.06	3.02 / 4.95	2.97 / 4.85	2.94 / 4.78	2.91 / 4.71	2.86 / 4.60	2.82 / 4.52	2.77 / 4.41	2.74 / 4.33	2.70 / 4.25	2.67 / 4.17	2.64 / 4.12	2.61 / 4.05	2.59 / 4.01	2.56 / 3.96	2.55 / 3.93	2.54 / 3.91
11	4.84 / 9.65	3.98 / 7.20	3.59 / 6.22	3.36 / 5.67	3.20 / 5.32	3.09 / 5.07	3.01 / 4.88	2.95 / 4.74	2.90 / 4.63	2.86 / 4.54	2.82 / 4.46	2.79 / 4.40	2.74 / 4.29	2.70 / 4.21	2.65 / 4.10	2.61 / 4.02	2.57 / 3.94	2.53 / 3.86	2.50 / 3.80	2.47 / 3.74	2.45 / 3.70	2.42 / 3.66	2.41 / 3.62	2.40 / 3.60
12	4.75 / 9.33	3.88 / 6.93	3.49 / 5.95	3.26 / 5.41	3.11 / 5.06	3.00 / 4.82	2.92 / 4.65	2.85 / 4.50	2.80 / 4.39	2.76 / 4.30	2.72 / 4.22	2.69 / 4.16	2.64 / 4.05	2.60 / 3.98	2.54 / 3.86	2.50 / 3.78	2.46 / 3.70	2.42 / 3.61	2.40 / 3.56	2.36 / 3.49	2.35 / 3.46	2.32 / 3.41	2.31 / 3.38	2.30 / 3.36
13	4.67 / 9.07	3.80 / 6.70	3.41 / 5.74	3.18 / 5.20	3.02 / 4.86	2.92 / 4.62	2.84 / 4.44	2.77 / 4.30	2.72 / 4.19	2.67 / 4.10	2.63 / 4.02	2.60 / 3.96	2.55 / 3.85	2.51 / 3.78	2.46 / 3.67	2.42 / 3.59	2.38 / 3.51	2.34 / 3.42	2.32 / 3.37	2.28 / 3.30	2.26 / 3.27	2.24 / 3.21	2.22 / 3.18	2.21 / 3.16
14	4.60 / 8.86	3.74 / 6.51	3.34 / 5.56	3.11 / 5.03	2.96 / 4.69	2.85 / 4.46	2.77 / 4.28	2.70 / 4.14	2.65 / 4.03	2.60 / 3.94	2.56 / 3.86	2.53 / 3.80	2.48 / 3.70	2.44 / 3.62	2.39 / 3.51	2.35 / 3.43	2.31 / 3.34	2.27 / 3.26	2.24 / 3.21	2.21 / 3.14	2.19 / 3.11	2.16 / 3.06	2.14 / 3.02	2.13 / 3.00
15	4.54 / 8.68	3.68 / 6.36	3.29 / 5.42	3.06 / 4.89	2.90 / 4.56	2.79 / 4.32	2.70 / 4.14	2.64 / 4.00	2.59 / 3.89	2.55 / 3.80	2.51 / 3.73	2.48 / 3.67	2.43 / 3.56	2.39 / 3.48	2.33 / 3.36	2.29 / 3.29	2.25 / 3.20	2.21 / 3.12	2.18 / 3.07	2.15 / 3.00	2.12 / 2.97	2.10 / 2.92	2.08 / 2.89	2.07 / 2.87

Degrees of freedom for lesser mean square

TABLE VII (continued)

0.05 (light row) and 0.01 (dark row) points for the distribution of F

Each cell shows the 0.05 value (light row, upper) and the 0.01 value (dark row, lower).

Degrees of freedom for greater mean square

df (lesser)	1	2	3	4	5	6	7	8	9	10	11	12	14	16	20	24	30	40	50	75	100	200	500	∞
16	4.49 / 8.53	3.63 / 6.23	3.24 / 5.29	3.01 / 4.77	2.85 / 4.44	2.74 / 4.20	2.66 / 4.03	2.59 / 3.89	2.54 / 3.78	2.49 / 3.69	2.45 / 3.61	2.42 / 3.55	2.37 / 3.45	2.33 / 3.37	2.28 / 3.25	2.24 / 3.18	2.20 / 3.10	2.16 / 3.01	2.13 / 2.96	2.09 / 2.89	2.07 / 2.86	2.04 / 2.80	2.02 / 2.77	2.01 / 2.75
17	4.45 / 8.40	3.59 / 6.11	3.20 / 5.18	2.96 / 4.67	2.81 / 4.34	2.70 / 4.10	2.62 / 3.93	2.55 / 3.79	2.50 / 3.68	2.45 / 3.59	2.41 / 3.52	2.38 / 3.45	2.33 / 3.35	2.29 / 3.27	2.23 / 3.16	2.19 / 3.08	2.15 / 3.00	2.11 / 2.92	2.08 / 2.86	2.04 / 2.79	2.02 / 2.76	1.99 / 2.70	1.97 / 2.67	1.96 / 2.65
18	4.41 / 8.28	3.55 / 6.01	3.16 / 5.09	2.93 / 4.58	2.77 / 4.25	2.66 / 4.01	2.58 / 3.85	2.51 / 3.71	2.46 / 3.60	2.41 / 3.51	2.37 / 3.44	2.34 / 3.37	2.29 / 3.27	2.25 / 3.19	2.19 / 3.07	2.15 / 3.00	2.11 / 2.91	2.07 / 2.83	2.04 / 2.78	2.00 / 2.71	1.98 / 2.68	1.95 / 2.62	1.93 / 2.59	1.92 / 2.57
19	4.38 / 8.18	3.52 / 5.93	3.13 / 5.01	2.90 / 4.50	2.74 / 4.17	2.63 / 3.94	2.55 / 3.77	2.48 / 3.63	2.43 / 3.52	2.38 / 3.43	2.34 / 3.36	2.31 / 3.30	2.26 / 3.19	2.21 / 3.12	2.15 / 3.00	2.11 / 2.92	2.07 / 2.84	2.02 / 2.76	2.00 / 2.70	1.96 / 2.63	1.94 / 2.60	1.91 / 2.54	1.90 / 2.51	1.88 / 2.49
20	4.35 / 8.10	3.49 / 5.85	3.10 / 4.94	2.87 / 4.43	2.71 / 4.10	2.60 / 3.87	2.52 / 3.71	2.45 / 3.56	2.40 / 3.45	2.35 / 3.37	2.31 / 3.30	2.28 / 3.23	2.23 / 3.13	2.18 / 3.05	2.12 / 2.94	2.08 / 2.86	2.04 / 2.77	1.99 / 2.69	1.96 / 2.63	1.92 / 2.56	1.90 / 2.53	1.87 / 2.47	1.85 / 2.44	1.84 / 2.42
21	4.32 / 8.02	3.47 / 5.78	3.07 / 4.87	2.84 / 4.37	2.68 / 4.04	2.57 / 3.81	2.49 / 3.65	2.42 / 3.51	2.37 / 3.40	2.32 / 3.31	2.28 / 3.24	2.25 / 3.17	2.20 / 3.07	2.15 / 2.99	2.09 / 2.88	2.05 / 2.80	2.00 / 2.72	1.96 / 2.63	1.93 / 2.58	1.89 / 2.51	1.87 / 2.47	1.84 / 2.42	1.82 / 2.38	1.81 / 2.36
22	4.30 / 7.94	3.44 / 5.72	3.05 / 4.82	2.82 / 4.31	2.66 / 3.99	2.55 / 3.76	2.47 / 3.59	2.40 / 3.45	2.35 / 3.35	2.30 / 3.26	2.26 / 3.18	2.23 / 3.12	2.18 / 3.02	2.13 / 2.94	2.07 / 2.83	2.03 / 2.75	1.98 / 2.67	1.93 / 2.58	1.91 / 2.53	1.87 / 2.46	1.84 / 2.42	1.81 / 2.37	1.80 / 2.33	1.78 / 2.31
23	4.28 / 7.88	3.42 / 5.66	3.03 / 4.76	2.80 / 4.26	2.64 / 3.94	2.53 / 3.71	2.45 / 3.54	2.38 / 3.41	2.32 / 3.30	2.28 / 3.21	2.24 / 3.14	2.20 / 3.07	2.14 / 2.97	2.10 / 2.89	2.04 / 2.78	2.00 / 2.70	1.96 / 2.62	1.91 / 2.53	1.88 / 2.48	1.84 / 2.41	1.82 / 2.37	1.79 / 2.32	1.77 / 2.28	1.76 / 2.26
24	4.26 / 7.82	3.40 / 5.61	3.01 / 4.72	2.78 / 4.22	2.62 / 3.90	2.51 / 3.67	2.43 / 3.50	2.36 / 3.36	2.30 / 3.25	2.26 / 3.17	2.22 / 3.09	2.18 / 3.03	2.13 / 2.93	2.09 / 2.85	2.02 / 2.74	1.98 / 2.66	1.94 / 2.58	1.89 / 2.49	1.86 / 2.44	1.82 / 2.36	1.80 / 2.33	1.76 / 2.27	1.74 / 2.23	1.73 / 2.21
25	4.24 / 7.77	3.38 / 5.57	2.99 / 4.68	2.76 / 4.18	2.60 / 3.86	2.49 / 3.63	2.41 / 3.46	2.34 / 3.32	2.28 / 3.21	2.24 / 3.13	2.20 / 3.05	2.16 / 2.99	2.11 / 2.89	2.06 / 2.81	2.00 / 2.70	1.96 / 2.62	1.92 / 2.54	1.87 / 2.45	1.84 / 2.40	1.80 / 2.32	1.77 / 2.29	1.74 / 2.23	1.72 / 2.19	1.71 / 2.17
26	4.22 / 7.72	3.37 / 5.53	2.98 / 4.64	2.74 / 4.14	2.59 / 3.82	2.47 / 3.59	2.39 / 3.42	2.32 / 3.29	2.27 / 3.17	2.22 / 3.09	2.18 / 3.02	2.15 / 2.96	2.10 / 2.86	2.05 / 2.77	1.99 / 2.66	1.95 / 2.58	1.90 / 2.50	1.85 / 2.41	1.82 / 2.36	1.78 / 2.28	1.76 / 2.25	1.72 / 2.19	1.70 / 2.15	1.69 / 2.13
27	4.21 / 7.68	3.35 / 5.49	2.96 / 4.60	2.73 / 4.11	2.57 / 3.79	2.46 / 3.56	2.37 / 3.39	2.30 / 3.26	2.25 / 3.14	2.20 / 3.06	2.16 / 2.98	2.13 / 2.93	2.08 / 2.83	2.03 / 2.74	1.97 / 2.63	1.93 / 2.55	1.88 / 2.47	1.84 / 2.38	1.80 / 2.33	1.76 / 2.25	1.74 / 2.21	1.71 / 2.16	1.68 / 2.12	1.67 / 2.10
28	4.20 / 7.64	3.34 / 5.45	2.95 / 4.57	2.71 / 4.07	2.56 / 3.76	2.44 / 3.53	2.36 / 3.36	2.29 / 3.23	2.24 / 3.11	2.19 / 3.03	2.15 / 2.95	2.12 / 2.90	2.06 / 2.80	2.02 / 2.71	1.96 / 2.60	1.91 / 2.52	1.87 / 2.44	1.81 / 2.35	1.78 / 2.30	1.75 / 2.22	1.72 / 2.18	1.69 / 2.13	1.67 / 2.09	1.65 / 2.06
29	4.18 / 7.60	3.33 / 5.42	2.93 / 4.54	2.70 / 4.04	2.54 / 3.73	2.43 / 3.50	2.35 / 3.33	2.28 / 3.20	2.22 / 3.08	2.18 / 3.00	2.14 / 2.92	2.10 / 2.87	2.05 / 2.77	2.00 / 2.68	1.94 / 2.57	1.90 / 2.49	1.85 / 2.41	1.80 / 2.32	1.77 / 2.27	1.73 / 2.19	1.71 / 2.15	1.68 / 2.10	1.65 / 2.06	1.64 / 2.03
30	4.17 / 7.56	3.32 / 5.39	2.92 / 4.51	2.69 / 4.02	2.53 / 3.70	2.42 / 3.47	2.34 / 3.30	2.27 / 3.17	2.21 / 3.06	2.16 / 2.98	2.12 / 2.90	2.09 / 2.84	2.04 / 2.74	1.99 / 2.66	1.93 / 2.55	1.89 / 2.47	1.84 / 2.38	1.79 / 2.29	1.76 / 2.24	1.72 / 2.16	1.69 / 2.13	1.66 / 2.07	1.64 / 2.03	1.62 / 2.01

Degrees of freedom for lesser mean square

TABLE VII (continued)

0.05 (light row) and 0.01 (dark row) points for the distribution of F

Degrees of freedom for greater mean square

Lesser df	1	2	3	4	5	6	7	8	9	10	11	12	14	16	20	24	30	40	50	75	100	200	500	∞
32	4.15/7.50	3.30/5.34	2.90/4.46	2.67/3.97	2.51/3.66	2.40/3.42	2.32/3.25	2.25/3.12	2.19/3.01	2.14/2.94	2.10/2.86	2.07/2.80	2.02/2.70	1.97/2.62	1.91/2.51	1.86/2.42	1.82/2.34	1.76/2.25	1.74/2.20	1.69/2.12	1.67/2.08	1.64/2.02	1.61/1.98	1.59/1.96
34	4.13/7.44	3.28/5.29	2.88/4.42	2.65/3.93	2.49/3.61	2.38/3.38	2.30/3.21	2.23/3.08	2.17/2.97	2.12/2.89	2.08/2.82	2.05/2.76	2.00/2.66	1.95/2.58	1.89/2.47	1.84/2.38	1.80/2.30	1.74/2.21	1.71/2.15	1.67/2.08	1.64/2.04	1.61/1.98	1.59/1.94	1.57/1.91
36	4.11/7.39	3.26/5.25	2.86/4.38	2.63/3.89	2.48/3.58	2.36/3.35	2.28/3.18	2.21/3.04	2.15/2.94	2.10/2.86	2.06/2.78	2.03/2.72	1.98/2.62	1.93/2.54	1.87/2.43	1.82/2.35	1.78/2.26	1.72/2.17	1.69/2.12	1.65/2.04	1.62/2.00	1.59/1.94	1.56/1.90	1.55/1.87
38	4.10/7.35	3.25/5.21	2.85/4.34	2.62/3.86	2.46/3.54	2.35/3.32	2.26/3.15	2.19/3.02	2.14/2.91	2.09/2.82	2.05/2.75	2.02/2.69	1.96/2.59	1.92/2.51	1.85/2.40	1.80/2.32	1.76/2.22	1.71/2.14	1.67/2.08	1.63/2.00	1.60/1.97	1.57/1.90	1.54/1.86	1.53/1.84
40	4.08/7.31	3.23/5.18	2.84/4.31	2.61/3.83	2.45/3.51	2.34/3.29	2.25/3.12	2.18/2.99	2.12/2.88	2.07/2.80	2.04/2.73	2.00/2.66	1.95/2.56	1.90/2.49	1.84/2.37	1.79/2.29	1.74/2.20	1.69/2.11	1.66/2.05	1.61/1.97	1.59/1.94	1.55/1.88	1.53/1.84	1.51/1.81
42	4.07/7.27	3.22/5.15	2.83/4.29	2.59/3.80	2.44/3.49	2.32/3.26	2.24/3.10	2.17/2.96	2.11/2.86	2.06/2.77	2.02/2.70	1.99/2.64	1.94/2.54	1.89/2.46	1.82/2.35	1.78/2.26	1.73/2.17	1.68/2.08	1.64/2.02	1.60/1.94	1.57/1.91	1.54/1.85	1.51/1.80	1.49/1.78
44	4.06/7.24	3.21/5.12	2.82/4.26	2.58/3.78	2.43/3.46	2.31/3.24	2.23/3.07	2.16/2.94	2.10/2.84	2.05/2.75	2.01/2.68	1.98/2.62	1.92/2.52	1.88/2.44	1.81/2.32	1.76/2.24	1.72/2.15	1.66/2.06	1.63/2.00	1.58/1.92	1.56/1.88	1.52/1.82	1.50/1.78	1.48/1.75
46	4.05/7.21	3.20/5.10	2.81/4.24	2.57/3.76	2.42/3.44	2.30/3.22	2.22/3.05	2.14/2.92	2.09/2.82	2.04/2.73	2.00/2.66	1.97/2.60	1.91/2.50	1.87/2.42	1.80/2.30	1.75/2.22	1.71/2.13	1.65/2.04	1.62/1.98	1.57/1.90	1.54/1.86	1.51/1.80	1.48/1.76	1.46/1.72
48	4.04/7.19	3.19/5.08	2.80/4.22	2.56/3.74	2.41/3.42	2.30/3.20	2.21/3.04	2.14/2.90	2.08/2.80	2.03/2.71	1.99/2.64	1.96/2.58	1.90/2.48	1.86/2.40	1.79/2.28	1.74/2.20	1.70/2.11	1.64/2.02	1.61/1.96	1.56/1.88	1.53/1.84	1.50/1.78	1.47/1.73	1.45/1.70
50	4.03/7.17	3.18/5.06	2.79/4.20	2.56/3.72	2.40/3.41	2.29/3.18	2.20/3.02	2.13/2.88	2.07/2.78	2.02/2.70	1.98/2.62	1.95/2.56	1.90/2.46	1.85/2.39	1.78/2.26	1.74/2.18	1.69/2.10	1.63/2.00	1.60/1.94	1.55/1.86	1.52/1.82	1.48/1.76	1.46/1.71	1.44/1.68
55	4.02/7.12	3.17/5.01	2.78/4.16	2.54/3.68	2.38/3.37	2.27/3.15	2.18/2.98	2.11/2.85	2.05/2.75	2.00/2.66	1.97/2.59	1.93/2.53	1.88/2.43	1.83/2.35	1.76/2.23	1.72/2.15	1.67/2.06	1.61/1.96	1.58/1.90	1.52/1.82	1.50/1.78	1.46/1.71	1.43/1.66	1.41/1.64
60	4.00/7.08	3.15/4.98	2.76/4.13	2.52/3.65	2.37/3.34	2.25/3.12	2.17/2.95	2.10/2.82	2.04/2.72	1.99/2.63	1.95/2.56	1.92/2.50	1.86/2.40	1.81/2.32	1.75/2.20	1.70/2.12	1.65/2.03	1.59/1.93	1.56/1.87	1.50/1.79	1.48/1.74	1.44/1.68	1.41/1.63	1.39/1.60
65	3.99/7.04	3.14/4.95	2.75/4.10	2.51/3.62	2.36/3.31	2.24/3.09	2.15/2.93	2.08/2.79	2.02/2.70	1.98/2.61	1.94/2.54	1.90/2.47	1.85/2.37	1.80/2.30	1.73/2.18	1.68/2.09	1.63/2.00	1.57/1.90	1.54/1.84	1.49/1.76	1.46/1.71	1.42/1.64	1.39/1.60	1.37/1.56
70	3.98/7.01	3.13/4.92	2.74/4.08	2.50/3.60	2.35/3.29	2.23/3.07	2.14/2.91	2.07/2.77	2.01/2.67	1.97/2.59	1.93/2.51	1.89/2.45	1.84/2.35	1.79/2.28	1.72/2.15	1.67/2.07	1.62/1.98	1.56/1.88	1.53/1.82	1.47/1.74	1.45/1.69	1.40/1.62	1.37/1.56	1.35/1.53
80	3.96/6.96	3.11/4.88	2.72/4.04	2.48/3.56	2.33/3.25	2.21/3.04	2.12/2.87	2.05/2.74	1.99/2.64	1.95/2.55	1.91/2.48	1.88/2.41	1.82/2.32	1.77/2.24	1.70/2.11	1.65/2.03	1.60/1.94	1.54/1.84	1.51/1.78	1.45/1.70	1.42/1.65	1.38/1.57	1.35/1.52	1.32/1.49

Degrees of freedom for lesser mean square

TABLE VII (continued)

0.05 (light row) and 0.01 (dark row) points for the distribution of F

Degrees of freedom for greater mean square

Degrees of freedom for lesser mean square	1	2	3	4	5	6	7	8	9	10	11	12	14	16	20	24	30	40	50	75	100	200	500	∞
100	3.94 / 6.90	3.09 / 4.82	2.70 / 3.98	2.46 / 3.51	2.30 / 3.20	2.19 / 2.99	2.10 / 2.82	2.03 / 2.69	1.97 / 2.59	1.92 / 2.51	1.88 / 2.43	1.85 / 2.36	1.79 / 2.26	1.75 / 2.19	1.68 / 2.06	1.63 / 1.98	1.57 / 1.89	1.51 / 1.79	1.48 / 1.73	1.42 / 1.64	1.39 / 1.59	1.34 / 1.51	1.30 / 1.46	1.28 / 1.43
125	3.92 / 6.84	3.07 / 4.78	2.68 / 3.94	2.44 / 3.47	2.29 / 3.17	2.17 / 2.95	2.08 / 2.79	2.01 / 2.65	1.95 / 2.56	1.90 / 2.47	1.86 / 2.40	1.83 / 2.33	1.77 / 2.23	1.72 / 2.15	1.65 / 2.03	1.60 / 1.94	1.55 / 1.85	1.49 / 1.75	1.45 / 1.68	1.39 / 1.59	1.36 / 1.54	1.31 / 1.46	1.27 / 1.40	1.25 / 1.37
150	3.91 / 6.81	3.06 / 4.75	2.67 / 3.91	2.43 / 3.44	2.27 / 3.13	2.16 / 2.92	2.07 / 2.76	2.00 / 2.62	1.94 / 2.53	1.89 / 2.44	1.85 / 2.37	1.82 / 2.30	1.76 / 2.20	1.71 / 2.12	1.64 / 2.00	1.59 / 1.91	1.54 / 1.83	1.47 / 1.72	1.44 / 1.66	1.37 / 1.56	1.34 / 1.51	1.29 / 1.43	1.25 / 1.37	1.22 / 1.33
200	3.89 / 6.76	3.04 / 4.71	2.65 / 3.88	2.41 / 3.41	2.26 / 3.11	2.14 / 2.90	2.05 / 2.73	1.98 / 2.60	1.92 / 2.50	1.87 / 2.41	1.83 / 2.34	1.80 / 2.28	1.74 / 2.17	1.69 / 2.09	1.62 / 1.97	1.57 / 1.88	1.52 / 1.79	1.45 / 1.69	1.42 / 1.62	1.35 / 1.53	1.32 / 1.48	1.26 / 1.39	1.22 / 1.33	1.19 / 1.28
400	3.86 / 6.70	3.02 / 4.66	2.62 / 3.83	2.39 / 3.36	2.23 / 3.06	2.12 / 2.85	2.03 / 2.69	1.96 / 2.55	1.90 / 2.46	1.85 / 2.37	1.81 / 2.29	1.78 / 2.23	1.72 / 2.12	1.67 / 2.04	1.60 / 1.92	1.54 / 1.84	1.49 / 1.74	1.42 / 1.64	1.38 / 1.57	1.32 / 1.47	1.28 / 1.42	1.22 / 1.32	1.16 / 1.24	1.13 / 1.19
1000	3.85 / 6.66	3.00 / 4.62	2.61 / 3.80	2.38 / 3.34	2.22 / 3.04	2.10 / 2.82	2.02 / 2.66	1.95 / 2.53	1.89 / 2.43	1.84 / 2.34	1.80 / 2.26	1.76 / 2.20	1.70 / 2.09	1.65 / 2.01	1.58 / 1.89	1.53 / 1.81	1.47 / 1.71	1.41 / 1.61	1.36 / 1.54	1.30 / 1.44	1.26 / 1.38	1.19 / 1.28	1.13 / 1.19	1.08 / 1.11
∞	3.84 / 6.64	2.99 / 4.60	2.60 / 3.78	2.37 / 3.32	2.21 / 3.02	2.09 / 2.80	2.01 / 2.64	1.94 / 2.51	1.88 / 2.41	1.83 / 2.32	1.79 / 2.24	1.75 / 2.18	1.69 / 2.07	1.64 / 1.99	1.57 / 1.87	1.52 / 1.79	1.46 / 1.69	1.40 / 1.59	1.35 / 1.52	1.28 / 1.41	1.24 / 1.36	1.17 / 1.25	1.11 / 1.15	1.00 / 1.00

TABLE FOR WILCOXON SIGNED RANK TEST

n	c	P (W ≥ c)	n	c	P (W ≥ c)	n	c	P (W ≥ c)	n	c	P (W ≥ c)
1	1	.500	8	32	.012	12	58	.010	16	88	.011
2	3	.250		28	.027		50	.026		76	.025
3	6	.125		24	.055		44	.046		64	.052
4	10	.062		20	.096		34	.102		52	.096
	8	.125									
			9	39	.010	13	65	.011	17	97	.010
5	15	.031		33	.027		57	.024		83	.025
	13	.062		29	.049		49	.047		71	.049
	11	.094		23	.102		39	.095		55	.103
6	21	.016	10	45	.010	14	73	.010	18	105	.010
	19	.031		39	.024		63	.025		91	.024
	17	.047		33	.053		53	.052		77	.049
	13	.109		27	.097		43	.097		61	.098
7	28	.096	11	52	.009	15	80	.011	19	114	.010
	24	.023		44	.027		70	.024		96	.025
	20	.055		38	.051		60	.047		82	.052
	16	.109		30	.013		46	.104		66	.098
									20	124	.010
										106	.024
										90	.049
										70	.101

THE CORRELATION COEFFICIENT

Values of the correlation Coefficient for Different Levels of Significance (2 tail)

d.f.	.1	.05	.02	.01	.001
1.	.98769	.99692	.999507	.999877	.9999988
2.	.90000	.95000	.98000	.990000	.99900
3.	.8054	.8783	.93433	.91873	.99116
4.	.7293	.8114	.8822	.91720	.97406
5.	.6694	.7545	.8329	.8745	.95074
6.	.6215	.7067	.7887	.8343	.92493
7.	.5822	.6664	.7498	.7977	.8982
8.	.5494	.6319	.7155	.7646	.8721
9.	.5214	.6021	.6851	.7348	.8471
10.	.4973	.5760	.6581	.7079	.8233
11.	.4762	.5529	.6339	.6835	.8010
12.	.4575	.5324	.6120	.6614	.7800
13.	.4409	.5139	.5923	.6411	.7603
14.	.4259	.4973	.5742	.6226	.7420
15.	.4124	.4821	.5577	.6055	.7246

d.f. = degrees of freedom

000000000