SULIT

POLITEKNIK MALAYSIA

BAHAGIAN PEPERIKSAAN DAN PENILAIAN
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI
KEMENTERIAN PENDIDIKAN MALAYSIA

JABATAN KEJURUTERAAN MEKANIKAL

PEPERIKSAAN AKHIR

SESI 1 2018/2019

BBM3033 : PROBABILITY & STATISTICS FOR ENGINEERING TECHNOLOGY

TARIKH : 07 JANUARI 2019
MASA : 9.00 PAGI – 12.00 PETANG

Kertas ini mengandungi **SEBELAS (11)** halaman bercetak.

Struktur (4 soalan)

Dokumen sokongan yang disertakan : Kertas Graf, Formula dan Jadual Statistik

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JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN

(CLO yang tertera hanya sebagai rujukan)

INSTRUCTION:

Answer **ALL** questions.

ARAHAN:

*Jawab **SEMUA** soalan.*

QUESTION 1

SOALAN 1

CLO1
C1

a) In a study, a life span of 100 halogen lamps manufactured by a factory is recorded in **Table 1a**.

*Dalam satu kajian, jangka hayat 100 lampu halogen yang dibuat oleh sebuah kilang direkodkan dalam **Jadual 1a**.*

Table 1a / *Jadual 1a*

Life span (days)	Frequency
1 – 10	12
11 – 20	16
21 – 30	24
31 – 40	27
41 – 50	11
51 – 60	10

(i) State the mode class and the median class.

Nyatakan kelas mod dan kelas median.

[2 marks]

[*2 markah*]

(ii) Find the class boundary, midpoint and cumulative frequency for the data.

Cari sempadan kelas, titik tengah dan kekerapan kumulatif bagi data tersebut.

[3 marks]

[*3 markah*]

CLO1
C3

b) **Table 1b** shows the information on the amounts of electric bills (RM) for a sample of 50 families during August 2018.

Jadual 1b *menunjukkan maklumat jumlah bil elektrik (RM) untuk sampel 50 buah keluarga sepanjang bulan Ogos 2018.*

Table 1b / *Jadual 1b*

Amount of bills (RM)	Number of families
1 – 20	5
21 – 40	16
41 – 60	11
61 – 80	10
81 – 100	8

Calculate the mean and mode.

Kirakan min dan mod.

[5 marks]

[*5 markah*]

CLO2
C4

c) **Table 1c** shows the frequency distribution table of the time spent in a week by 50 students in preparing for their final examination.

Jadual 1c *menunjukkan jadual taburan kekerapan bagi masa yang diperuntukkan dalam seminggu oleh 50 orang pelajar dalam membuat persediaan bagi peperiksaan akhir mereka.*

Table 1c/ *Jadual 1c*

Time (hours)	**Number of students**
5 – 9	2
10 – 14	4
15 – 19	7
20 – 24	9
25 – 29	12
30 – 34	11
34 – 39	4
40 – 44	1

(i) Construct the cumulative frequency table. Hence, draw the ogive.
Bina jadual kekerapan kumulatif. Seterusnya, bina ogif.

[7 marks]
[*7 markah*]

(ii) Based on the ogive in (i), find:
Berdasarkan ogif dalam (i), cari:

a. the median and interquartile range for the time spent in a week by 50 students in preparing for their final examination,
median dan julat antara kuartil bagi masa yang diperuntukkan dalam seminggu oleh 50 orang pelajar dalam membuat persediaan bagi peperiksaan akhir mereka,

[4 marks]
[*4 markah*]

b. the value of x if 40% of the students spent less than x hours in a week preparing for their final examination,
nilai x jika 40% pelajar memperuntukkan kurang daripada x jam dalam seminggu untuk membuat persediaan bagi peperiksaan akhir mereka,

[2 marks]
[*2 markah*]

c. the percentage number of students who spent more than 36 hours in a week preparing for their final examination.
peratusan bilangan pelajar yang memperuntukkan masa melebihi 36 jam dalam seminggu untuk membuat persediaan bagi peperiksaan akhir mereka.

[2 marks]
[*2 markah*]

QUESTION 2

SOALAN 2

CLO1
C2

a) Given that the letters of the word 'PROBABILITY' is jumbled up and then is arranged in a row.
Diberi huruf-huruf dalam perkataan 'PROBABILITY' dicampur adukkan dan kemudian disusun dalam satu baris.

(i) Identify the number of arrangements can be formed in a line?
Kenal pasti bilangan susunan boleh dibentuk dalam satu baris?

[2 marks]
[*2 markah*]

(ii) Identify the number of arrangements can be formed if the first letter is "O"?
Kenal pasti bilangan susunan boleh dibentuk dalam satu baris jika huruf yang pertama adalah "O"?

[3 marks]
[*3 markah*]

CLO2
C2

b) A survey reports that 10% of Malaysia citizens own computers. 200 people are randomly selected to identify whether they own a computer or not.
Satu kajian melaporkan bahawa 10% rakyat Malaysia memiliki komputer. 200 orang telah dipilih secara rawak bagi mengenal pasti sama ada mereka memiliki komputer atau tidak.

(i) Calculate the mean, variance and standard deviation of the people who owns a computer?
Kirakan min, varians dan sisihan piawai bagi orang yang memiliki komputer?

[5 marks]
[*5 markah*]

(ii) Calculate the probability that 10 or more people own a computer.
Hitungkan kebarangkalian 10 atau lebih orang memiliki komputer.

[5 marks]
[*5 markah*]

CLO2
C4

c) The Malaysia Automobile Association reports that the average time taken to respond to an emergency call is 25 minutes. Assume the variable is approximately normal distributed and the standard deviation of the population is 4.5 minutes. Find the probability of how many calls will be responded:
Persatuan Automobil Malaysia melaporkan bahawa purata masa yang di ambil untuk menjawab satu panggilan kecemasan adalah 25 minit. Andaikan pemboleh ubah adalah dianggarkan tertabur secara normal dan sisihan piawai bagi populasi adalah 4.5 minit. Cari kebarangkalian bilangan panggilan akan dijawab:

(i) between 15 and 20 minutes
di antara 15 minit hingga 20 minit

[7 marks]
[*7 markah*]

(ii) less than 12 minutes
kurang daripada 12 minit

[3 marks]
[*3 markah*]

QUESTION 3

SOALAN 3

CLO1
C2

a) A sample of 12 adults which randomly selected were asked how much (in RM) they usually spend on books for general reading per year. Assume that such expenses for all adults who buy books for general reading have an approximately normal distributed.

Sampel 12 orang dewasa yang dipilih secara rawak telah ditanya berapa banyak (dalam RM) yang mereka biasa peruntukkan untuk membeli buku untuk bacaan umum dalam setahun. Anggapkan bahawa perbelanjaan untuk semua orang dewasa yang membeli buku untuk bacaan umum adalah dianggarkan tertabur secara normal.

540.30	420.50	723.00	145.20
925.40	101.10	239.60	109.70

(i) Find the best point estimate for the population mean.

Cari titik anggaran terbaik bagi min populasi.

[3 marks]

[*3 markah*]

(ii) Hence, construct a 98% confidence interval for the population mean.

Seterusnya, bina selang keyakinan 98% bagi min populasi.

[10 marks]

[*10 markah*]

(iii) Calculate the maximum error of estimation for part (ii).

Kira ralat maksimum bagi penganggaran bagi bahagian (ii).

[2 marks]

[*2 markah*]

CLO1
C3

b) A random sample of 51 airline passengers at the Kuala Lumpur International Airport (KLIA) shows the mean times spent for waiting in line to check in at the tickets counter was 31 minutes with the standard deviation of 7 minutes. Assume that such waiting times for all passengers are normally distributed.
Sampel rawak daripada 51 orang penumpang syarikat penerbangan di Lapangan Terbang Antarabangsa Kuala Lumpur (KLIA) menunjukkan bahawa min masa yang di ambil untuk menunggu di barisan untuk daftar masuk di kaunter tiket adalah 31 minit dengan sisihan piawai 7 minit. Anggapkan bahawa waktu menunggu bagi semua penumpang tertabur secara normal.

(i) Construct a 99% confidence interval for the mean times spend for waiting in line by all passengers in the airport.
Bina selang keyakinan 99% untuk min masa yang di ambil untuk menunggu di barisan bagi semua penumpang di lapangan terbang tersebut.

[4 marks]
[*4 markah*]

(ii) Construct a 99% confidence interval for the standard deviation time spend for waiting in line by all passengers in the airport.
Bina selang keyakinan 99% untuk sisihan paiwai masa yang di ambil untuk menunggu di barisan bagi semua penumpang di lapangan terbang tersebut.

[6 marks]
[*6 markah*]

QUESTION 4

SOALAN 4

CLO1
C1

a) Using the z-table, find the critical values for $\alpha = 0.05$ (two tailed test) and $\alpha = 0.01$(Left-tailed test), then draw a diagram to indicate both significance values.

Dengan menggunakan jadual z, cari nilai kritikal bagi $\alpha = 0.05$ *(ujian dua-hujung) dan* $\alpha = 0.01$ *(ujian satu-hujung, kiri), kemudian lukis gambar rajah untuk menunjukkan kedua-dua nilai keertian.*

[5 marks]

[*5 markah*]

CLO2
C3

b) The **Table 4a** shows the observed pollution indexes of air samples in two areas of a city. Test the hypothesis that the mean pollution indexes are the same for the two areas. (Use $\alpha = 0.05$)

Jadual 4a *menunjukkan indeks pencemaran yang dicerap dalam sampel udara di dua kawasan sebuah bandar. Uji hipotesis bahawa min indeks pencemaran adalah sama untuk kedua-dua kawasan.(Gunakan* $\alpha = 0.05$*)*

[10 marks]

[*10 markah*]

Table 4a/ *Jadual 4a*

Area A/ *Kawasan A*		Area B/ *Kawasan B*	
2.92	4.69	1.84	3.44
1.88	4.86	0.95	3.69
5.35	5.81	4.26	4.95
3.81	5.55	3.18	4.47

CLO2
C5

c) The average systolic blood pressure of a normal male is normally to be about 129. Measurements of systolic blood pressure on a sample of 12 adult males from a community whose dietary habits are suspected of causing high blood pressure are listed below: (Use: $\alpha = 0.01$)

Min tekanan darah sistolik bagi lelaki normal kebiasaannya sekitar 129. Pengukuran tekanan darah sistolik ke atas sampel 12 orang dewasa lelaki dari komuniti tabiat pemakanan disyaki menyebabkan tekanan darah tinggi disenaraikan di bawah: (Gunakan: $\alpha = 0.01$)

115 134 131 143 130 154 119 137 155 130 110 138

Table 4b/ *Jadual 4b*

T-Test

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Blood Pressure	12	133.000	13.94144	4.0245

One-Sample Test

	Test Value = 129					
					98% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Blood Pressure	.9939	11	.3416	4.0000	-6.9390	14.9390

(i) State the null and alternative hypotheses that the average systolic blood pressure of the community is more than 129?
Nyatakan hipotesis nol dan hipotesis alternatif bahawa min tekanan darah sistolik bagi komuniti adalah lebih daripada 129?

[2 marks]
[*2 markah*]

(ii) Based on the SPSS output on Table 4b, prove that the test statistic is t = 0.9939 and state your conclusion based on the significance value?

Berdasarkan hasil data SPSS dalam Jadual 4b, buktikan ujian statistik adalah t = 0.9939 dan nyatakan kesimpulan anda berdasarkan nilai signifikan .

[8 marks]

[*8 markah*]

SOALAN TAMAT

FORMULA SHEET FOR PROBABILITY & STATISTICS FOR ENGINEERING TECHNOLOGY

DESCRIPTIVE STATISTICS

Ungrouped Data

Mean, $\overline{X} = \frac{\sum X}{n}$

Population Variance, $\sigma^2 = \frac{\sum (X-\mu)^2}{N}$

Sample Variance, $s^2 = \frac{\sum (X-\overline{X})^2}{n-1}$

Or

$$s^2 = \frac{\sum X^2 - \left[\frac{(\sum X)^2}{n}\right]}{n-1}$$

Population Standard Deviation, $\sigma = \sqrt{\sigma^2}$

Sample Standard Deviation, $s = \sqrt{s^2}$

Grouped Data

Mean, $\overline{X} = \frac{\sum f.X_m}{n}$

Population Variance, $\sigma^2 = \frac{\sum f(X-\mu)^2}{N}$

Sample Variance, $s^2 = \frac{\sum f(X-\overline{X})^2}{n-1}$

Or

$$s^2 = \frac{\sum fX_m{}^2 - \left[\frac{(\sum fX_m)^2}{n}\right]}{n-1}$$

Median, $M = L_M + \left(\frac{\frac{N}{2} - F}{f_M}\right) C$

Mode, $M_o = L_{M_o} + \left(\frac{d_1}{d_1 + d_2}\right) C$

PROBABILITY & STATISTICS

Addition Rule (mutually exclusive events),
$P(A \cup B) = P(A) + P(B)$

Addition Rule (events not mutually exclusive),
$P(A \cup B) = P(A) + P(B) - P(A \cap B)$

Multiplication Rule (Independent event),
$P(A \cap B) = P(A) \cdot P(B)$

Multiplication Rule(dependent event),
$P(A \cap B) = P(A).P(B \mid A)$

Conditional Probability, $P(B \mid A) = \frac{P(A \cap B)}{P(A)}$

Conditional Probability, $P(B \mid A) = \frac{P(A \cap B)}{P(A)}$

Complementary events, $P(\overline{A}) = 1 - P(A)$

Permutation Rule, ${}_nP_r = \frac{n!}{(n-r)!}$

Combination Rule, ${}_nC_r = \frac{n!}{(n-r)!r!}$

Mean for a probability distribution,

$$\mu = \sum [X \cdot P(X)]$$

Variance and standard deviation for a probability distribution.

$$\sigma^2 = \sum [X^2 . P(X)] - \mu^2$$

$$\sigma = \sqrt{\sum [X^2 . P(X)] - \mu^2}$$

Expectation, $E(X) = \sum [X . P(X)]$

Binomial probability,

$$P(X) = \frac{n!}{(n-X)!X!} \cdot p^x \cdot q^{n-x}$$

Mean for binomial distribution, $\mu = np$

Variance and standard deviation for the binomial distribution, $\sigma^2 = npq \quad \sigma = \sqrt{npq}$

Normal distribution

Standard score, $z = \frac{X - \mu}{\sigma}$ or $\frac{X - \overline{X}}{s}$

Mean of sample mean, $\mu_{\overline{X}} = \mu$

Standard error of the means, $\sigma_{\overline{x}} = \frac{\sigma}{\sqrt{n}}$

Central limit theorem formula, $z = \frac{X - \mu}{\sigma / \sqrt{n}}$

SAMPLING AND ESTIMATION

z confidence interval for means,

$$\overline{X} - z_{\alpha/2}\left(\frac{\sigma}{\sqrt{n}}\right) < \mu < \overline{X} + z_{\alpha/2}\left(\frac{\sigma}{\sqrt{n}}\right)$$

t confidence interval for means,

$$\overline{X} - t_{\alpha/2}\left(\frac{s}{\sqrt{n}}\right) < \mu < \overline{X} + t_{\alpha/2}\left(\frac{s}{\sqrt{n}}\right)$$

Sample size for means, $n = \left(\frac{z_{\alpha/2} \cdot \sigma}{E}\right)^2$, where E is the maximum error of estimate.

Confidence interval for a proportion,

$$\hat{p} - \left(z_{\alpha/2}\right)\sqrt{\frac{\hat{p}\hat{q}}{n}} < p < \hat{p} + \left(z_{\alpha/2}\right)\sqrt{\frac{\hat{p}\hat{q}}{n}}$$

Sample size for proportion, $n = \hat{p}\hat{q}\left(\frac{z_{\alpha/2}}{E}\right)^2$ where is the maximum error of estimate.

Confidence interval for variance,

$$\frac{(n-1)s^2}{\chi^2_{right}} < \sigma^2 < \frac{(n-1)s^2}{\chi^2_{left}}$$

Confidence interval for standard deviation,

$$\sqrt{\frac{(n-1)s^2}{\chi^2_{right}}} < \sigma < \sqrt{\frac{(n-1)s^2}{\chi^2_{left}}}$$

HYPOTHESIS TESTING

Test for the population mean

z test, $z = \dfrac{X - \mu}{\sigma/\sqrt{n}}$, variance known

z test, $z = \dfrac{X - \mu}{s/\sqrt{n}}$, variance unknown

t test, $z = \dfrac{X - \mu}{s/\sqrt{n}}$,small sample

Test for two population mean

Variances known:

Test statistics, $z = \dfrac{(\overline{x_1} - \overline{x_2}) - (\mu_1 - \mu_2)}{\sqrt{\dfrac{\sigma_1^2}{n_1} + \dfrac{\sigma_2^2}{n_2}}}$ for

Variances unknown for large samples:

Test statistics, $z = \dfrac{(\overline{x_1} - \overline{x_2}) - (\mu_1 - \mu_2)}{\sqrt{\dfrac{s_1^2}{n_1} + \dfrac{s_2^2}{n_2}}}$ for

Variances unknown for small samples:

Test statistics, $t = \dfrac{(\overline{x_1} - \overline{x_2}) - (\mu_1 - \mu_2)}{\sqrt{s_{p^2}\left(\dfrac{1}{n_1} + \dfrac{1}{n_2}\right)}}$ for small

$$S_{P^2} = \frac{(n_1 - 1){S_1}^2 + (n_2 - 1){S_2}^2}{n_1 + n_2 - 2}$$

Table B–1 The Standard Normal Distribution

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	.4990	.4991	.4991	.4991	.4992	.4992	.4992	.4992	.4993	.4993
3.2	.4993	.4993	.4994	.4994	.4994	.4994	.4994	.4995	.4995	.4995
3.3	.4995	.4995	.4995	.4996	.4996	.4996	.4996	.4996	.4996	.4997
3.4	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4998

For z values greater than 3.49, use 0.4999.

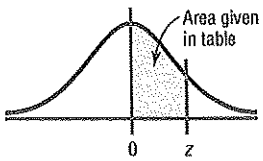

Table F The *t* Distribution

d.f.	Confidence intervals	80%	90%	95%	98%	99%
	One tail, α	0.10	0.05	0.025	0.01	0.005
	Two tails, α	0.20	0.10	0.05	0.02	0.01
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
30		1.310	1.697	2.042	2.457	2.750
32		1.309	1.694	2.037	2.449	2.738
34		1.307	1.691	2.032	2.441	2.728
36		1.306	1.688	2.028	2.434	2.719
38		1.304	1.686	2.024	2.429	2.712
40		1.303	1.684	2.021	2.423	2.704
45		1.301	1.679	2.014	2.412	2.690
50		1.299	1.676	2.009	2.403	2.678
55		1.297	1.673	2.004	2.396	2.668
60		1.296	1.671	2.000	2.390	2.660
65		1.295	1.669	1.997	2.385	2.654
70		1.294	1.667	1.994	2.381	2.648
75		1.293	1.665	1.992	2.377	2.643
80		1.292	1.664	1.990	2.374	2.639
90		1.291	1.662	1.987	2.368	2.632
100		1.290	1.660	1.984	2.364	2.626
500		1.283	1.648	1.965	2.334	2.586
1000		1.282	1.646	1.962	2.330	2.581
$(z)\ \infty$		1.282[a]	1.645[b]	1.960	2.326[c]	2.576[d]

[a] This value has been rounded to 1.28 in the textbook.
[b] This value has been rounded to 1.65 in the textbook.
[c] This value has been rounded to 2.33 in the textbook.
[d] This value has been rounded to 2.58 in the textbook.

Source: Adapted from W. H. Beyer, *Handbook of Tables for Probability and Statistics,* 2nd ed., CRC Press, Boca Raton, Fla., 1986. Reprinted with permission.

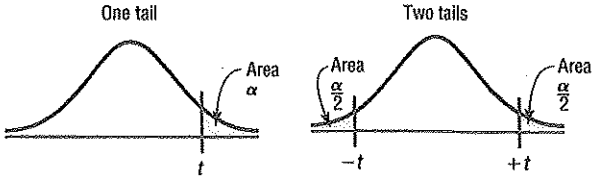

Table G The Chi-Square Distribution

Degrees of freedom	α									
	0.995	0.99	0.975	0.95	0.90	0.10	0.05	0.025	0.01	0.005
1	—	—	0.001	0.004	0.016	2.706	3.841	5.024	6.635	7.879
2	0.010	0.020	0.051	0.103	0.211	4.605	5.991	7.378	9.210	10.597
3	0.072	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.345	12.838
4	0.207	0.297	0.484	0.711	1.064	7.779	9.488	11.143	13.277	14.860
5	0.412	0.554	0.831	1.145	1.610	9.236	11.071	12.833	15.086	16.750
6	0.676	0.872	1.237	1.635	2.204	10.645	12.592	14.449	16.812	18.548
7	0.989	1.239	1.690	2.167	2.833	12.017	14.067	16.013	18.475	20.278
8	1.344	1.646	2.180	2.733	3.490	13.362	15.507	17.535	20.090	21.955
9	1.735	2.088	2.700	3.325	4.168	14.684	16.919	19.023	21.666	23.589
10	2.156	2.558	3.247	3.940	4.865	15.987	18.307	20.483	23.209	25.188
11	2.603	3.053	3.816	4.575	5.578	17.275	19.675	21.920	24.725	26.757
12	3.074	3.571	4.404	5.226	6.304	18.549	21.026	23.337	26.217	28.299
13	3.565	4.107	5.009	5.892	7.042	19.812	22.362	24.736	27.688	29.819
14	4.075	4.660	5.629	6.571	7.790	21.064	23.685	26.119	29.141	31.319
15	4.601	5.229	6.262	7.261	8.547	22.307	24.996	27.488	30.578	32.801
16	5.142	5.812	6.908	7.962	9.312	23.542	26.296	28.845	32.000	34.267
17	5.697	6.408	7.564	8.672	10.085	24.769	27.587	30.191	33.409	35.718
18	6.265	7.015	8.231	9.390	10.865	25.989	28.869	31.526	34.805	37.156
19	6.844	7.633	8.907	10.117	11.651	27.204	30.144	32.852	36.191	38.582
20	7.434	8.260	9.591	10.851	12.443	28.412	31.410	34.170	37.566	39.997
21	8.034	8.897	10.283	11.591	13.240	29.615	32.671	35.479	38.932	41.401
22	8.643	9.542	10.982	12.338	14.042	30.813	33.924	36.781	40.289	42.796
23	9.262	10.196	11.689	13.091	14.848	32.007	35.172	38.076	41.638	44.181
24	9.886	10.856	12.401	13.848	15.659	33.196	36.415	39.364	42.980	45.559
25	10.520	11.524	13.120	14.611	16.473	34.382	37.652	40.646	44.314	46.928
26	11.160	12.198	13.844	15.379	17.292	35.563	38.885	41.923	45.642	48.290
27	11.808	12.879	14.573	16.151	18.114	36.741	40.113	43.194	46.963	49.645
28	12.461	13.565	15.308	16.928	18.939	37.916	41.337	44.461	48.278	50.993
29	13.121	14.257	16.047	17.708	19.768	39.087	42.557	45.722	49.588	52.336
30	13.787	14.954	16.791	18.493	20.599	40.256	43.773	46.979	50.892	53.672
40	20.707	22.164	24.433	26.509	29.051	51.805	55.758	59.342	63.691	66.766
50	27.991	29.707	32.357	34.764	37.689	63.167	67.505	71.420	76.154	79.490
60	35.534	37.485	40.482	43.188	46.459	74.397	79.082	83.298	88.379	91.952
70	43.275	45.442	48.758	51.739	55.329	85.527	90.531	95.023	100.425	104.215
80	51.172	53.540	57.153	60.391	64.278	96.578	101.879	106.629	112.329	116.321
90	59.196	61.754	65.647	69.126	73.291	107.565	113.145	118.136	124.116	128.299
100	67.328	70.065	74.222	77.929	82.358	118.498	124.342	129.561	135.807	140.169

Source: Donald B. Owen, *Handbook of Statistics Tables,* The Chi-Square Distribution Table, © 1962 by Addison-Wesley Publishing Company, Inc. Copyright renewal © 1990. Reprinted by permission of Pearson Education, Inc.