SULIT

KEMENTERIAN PENDIDIKAN TINGGI
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI

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

JABATAN MATEMATIK, SAINS DAN KOMPUTER

PEPERIKSAAN AKHIR

SESI I : 2024/2025

BBM30093: PROBABILITY AND STATISTICS FOR ENGINEERING TECHNOLOGY

TARIKH : 07 JANUARI 2025
MASA : 9.00 PAGI – 12.00 TENGAH HARI (3 JAM)

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

Struktur (4 soalan)

Dokumen sokongan yang disertakan : Kertas Graf, Formula, Jadual

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JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN

(CLO yang tertera hanya sebagai rujukan)

INSTRUCTION:

This section consists of **FOUR (4)** structured questions. Answer **ALL** questions.

ARAHAN:

*Bahagian ini mengandungi **EMPAT (4)** soalan berstruktur. Jawab **SEMUA** soalan.*

QUESTION 1

SOALAN 1

CLO1 (a) Statistics is a branch of mathematics that deals with collection, analysis, interpretation, presentation, and organization of data.

Statistik adalah satu cabang matematik yang merangkumi proses pengumpulan, analisis, tafsiran, persembahan, dan pengorganisasian data.

(i) Explain the difference between descriptive statistics and inferential statistics.

Jelaskan perbezaan antara statistik deskriptif dan statistik inferensi.

[2 marks]

[2 *markah*]

(ii) Explain the differences between a population and a sample in statistics with examples for each difference.

Jelaskan perbezaan antara populasi dan sampel dalam statistik dengan memberikan contoh bagi setiap satu.

[3 marks]

[3 *markah*]

CLO1 (b) An electrical company received 30 complaints concerning installation during February 2024. The data from the 25 complaints represent the number of days between the receipt of the complaint and the resolution of the complaint are given as follows:

Sebuah syarikat elektrik menerima 30 aduan mengenai pemasangan sepanjang bulan Februari 2024. Data daripada 25 aduan mewakili bilangan hari antara penerimaan aduan dan penyelesaian aduan adalah seperti berikut:

50	5	35	17	31	27	15	2	12	46
33	27	11	19	16	15	29	35	31	26
15	12	14	32	29					

(i) From the above data, construct a cumulative frequency distribution table.
Berdasarkan data di atas, bina jadual taburan kekerapan terkumpul.

[5 marks]
[5 *markah*]

(ii) Based on (i), draw an ogive.
Berdasarkan (i), lukiskan ogif.

[5 marks]
[5 *markah*]

CLO2 (c) The thickness of 200 samples of steel plate is measured and the results (in millimeters) are as in Table 1:

Ketebalan 200 sampel plat keluli diukur dan keputusan (dalam milimeter) adalah seperti di Jadual 1:

Table 1(c) / *Jadual 1 (c)*

Thickness (mm) (*Ketebalan*)	6.2 – 6.4	6.5 – 6.7	6.8 – 7.0	7.1 – 7.3	7.4 – 7.6	7.7 – 7.9
Frequency (*Kekerapan*)	14	46	54	42	38	6

(i) Calculate the mean.

Kirakan nilai purata.

[3 marks]

[3 *markah*]

(ii) Calculate the mode.

Kirakan nilai mod

[3 marks]

[3 *markah*]

(iii) Calculate the standard deviation.

Kirakan nilai sisihan piawai.

[4 marks]

[4 *markah*]

QUESTION 2

SOALAN 2

CLO1

(a) A box containing cards with each of them is written with an alphabet from the word 'TRANSCENDENTAL'. If A represents the event of obtaining consonant card, identify:

Sebuah kotak mengandungi kad yang setiap kadnya ditulis dengan abjad daripada perkataan 'TRANSCENDENTAL'. Jika A mewakili peristiwa mendapatkan kad konsonan, kenal pasti:

(i) Total of sample space, *n(S)* and number of getting a consonant card, *n(A)*.

Jumlah ruang sampel, n(S) dan bilangan mendapat kad konsonan n(A).

[2 marks]

[2 markah]

(ii) Probability of getting a vowel card.

Kebarangkalian mendapat kad vokal.

[3 marks]

[3 markah]

CLO2

(b) The 2024 Malaysia Census found the chance of a household being in a certain size is represented in Table 2 (b). Compute each of the following:
Banci Malaysia 2024 mendapati peluang isi rumah berada dalam saiz tertentu adalah seperti Jadual 2 (b). Hitung setiap yang berikut:

Table 2 (b) / *Jadual 2(b)*

Size of household (X) *(Isi rumah)*	1	2	3	4	5	6	7
$P(X)$	0.267	0.336	0.158	0.137	0.063	0.024	0.015

(i) The mean, μ of X

Purata, μ bagi X

[3 marks]
[3 markah]

(ii) The standard deviation, σ of X
Sisihan piawai, σ bagi X

[3 marks]
[3 markah]

(iii) The probability for size of household is at least 4.
Kebarangkalian untuk saiz isi rumah sekurang-kurangnya 4.

[4 marks]
[4 markah]

CLO2

(c) A manufacturer produces a certain type of bolt. The length of the bolts is normally distributed with a mean of 50mm and a standard deviation of 2mm. Calculate the following:
Seorang pengusaha menghasilkan jenis bolt tertentu. Panjang bolt mempunyai taburan normal dengan min 50mm dan sisihan piawai 2mm. Kirakan yang berikut:

(i) The probability that a randomly selected bolt will be longer than 53mm.
Kebarangkalian bahawa bolt yang dipilih secara rawak akan lebih panjang daripada 53mm.

[5 marks]
[5 markah]

(ii) The probability that a randomly selected bolt is between 48mm and 52mm.
Kebarangkalian bahawa bolt yang dipilih secara rawak adalah antara 48mm dan 52mm.

[5 marks]
[5 markah]

QUESTION 3

SOALAN 3

CLO2

(a) A civil engineer is studying the compressive strength of concrete beams. A random sample of 25 beams is tested, and the average compressive strength is found to be 4000 pounds per square inch (psi) with a standard deviation of 200 psi.

Seorang jurutera awam sedang mengkaji kekuatan mampatan rasuk konkrit. Sampel rawak 25 rasuk diuji, dan purata kekuatan mampatan didapati 4000 paun setiap inci persegi (psi) dengan sisihan piawai 200 psi.

(i) Calculate a 99% confidence interval for the true average compressive strength of all the concrete beams.

Kira selang keyakinan 99% untuk purata kekuatan mampatan sebenar semua rasuk konkrit.

[10 marks]

[10 markah]

(ii) Calculate the number of samples that could be selected if the engineer wants a 90% confidence interval containing true mean with a maximum error of 1 psi.

Kira bilangan sampel yang boleh dipilih jika jurutera mahukan 90% selang keyakinan yang mengandungi min benar dengan ralat maksimum 1 psi.

[5 marks]

[5 markah]

CLO2

(b) A group of 15 real estate agents were given a survey about the average selling price of houses in a particular neighbourhood. The results, are shown in Table 3 (b) and figures are in thousands of ringgit (RM).

Sekumpulan 15 ejen hartanah telah ditinjau tentang purata harga jualan rumah di kawasan kejiranan tertentu. Hasilnya, dalam ribuan ringgit (RM) adalah seperti di Jadual 3(b).

Table 3 (b) / *Jadual 3(b)*

120	135	140	115	125
130	128	132	145	110
135	122	138	120	142

Assuming these values represent a simple random sample from a normally distributed population, calculate:

Dengan mengandaikan nilai ini mewakili sampel rawak mudah daripada populasi taburan normal, kirakan:

(i) The mean and variance

Min dan varian

[5 marks]

[5 markah]

(ii) The confidence interval at the 95% level for the standard deviation

Selang keyakinan 95% untuk sisihan piawai.

[5 marks]

[5 markah]

QUESTION 4

SOALAN 4

CLO1 (a) A pharmaceutical company is testing a new drug to treat a particular disease. They wish to determine if the new drug is more effective than the current treatment. Describe the step-by-step procedures to be followed for hypothesis testing in this scenario.

Sebuah syarikat farmaseutikal sedang menguji ubat baru untuk merawat penyakit tertentu. Mereka ingin menentukan sama ada ubat baru itu lebih berkesan daripada rawatan semasa. Terangkan langkah demi langkah prosedur yang perlu diikuti untuk ujian hipotesis dalam senario ini.

[5 marks]

[5 markah]

CLO2 (b) A company claims that its new fertilizer will increase crop yields by at least 10%. To test this claim, a farmer applies the fertilizer to 25 randomly selected plots of land and measures the crop yields. The average yield increase for the treated plots is 8% with a standard deviation of 3%. At a 0.01 level of significance, is there sufficient evidence to support the company's claim? Construct the hypotheses test.

Sebuah syarikat mendakwa bahawa baja baru mereka akan meningkatkan hasil tanaman sekurang-kurangnya 10%. Untuk menguji dakwaan ini, seorang petani menggunakan baja itu ke atas 25 plot tanah yang dipilih secara rawak dan seterusnya merekodkan hasil tanaman. Purata peningkatan hasil bagi plot yang dirawat ialah 8% dengan sisihan piawai sebanyak 3%. Pada tahap signifikan 0.01, adakah terdapat bukti yang mencukupi untuk menyokong dakwaan syarikat tersebut? Bina ujian hipotesis.

[10 marks]

[10 markah]

CLO2

(c) Two factories produce identical light bulbs. A random sample of 100 bulbs from Factory A has a mean lifespan of 2,000 hours, with a standard deviation of 100 hours. A random sample of 150 bulbs from Factory B has a mean lifespan of 1,950 hours, with a standard deviation of 120 hours. At a 0.01 level of significance, is there sufficient evidence to conclude that the mean lifespan of bulbs from Factory A is different from the mean lifespan of bulbs from Factory B? Construct a hypotheses test by assuming that the population variances are unknown but equal.

Dua buah kilang menghasilkan mentol yang sama. Sampel rawak 100 mentol dari Kilang A mempunyai jangka hayat purata 2,000 jam, dengan sisihan piawai 100 jam. Sampel rawak 150 mentol dari Kilang B mempunyai jangka hayat purata 1,950 jam, dengan sisihan piawai 120 jam. Pada tahap signifikan 0.01, adakah terdapat bukti yang mencukupi untuk membuat kesimpulan bahawa purata jangka hayat mentol dari Kilang A adalah berbeza daripada purata jangka hayat mentol dari Kilang B? Bina ujian hipotesis dengan mengandaikan varian populasi tidak diketahui tetapi sama.

[10 marks]

[10 markah]

SOALAN TAMAT

FORMULA SHEET FOR PROBABILITY & STATISTICS FOR ENGINEERING TECHNOLOGY
BBM30093

DESCRIPTIVE STATISTICS

Ungrouped Data

Mean,

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

Population Variance,

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

Sample Variance,

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

or

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

Mean Deviation,

$$= \frac{\sum f|x-\overline{x}|}{\sum f}$$

Population Standard Deviation,

$$\sigma = \sqrt{\sigma^2}$$

Sample Standard Deviation,

$$s = \sqrt{s^2}$$

Grouped Data

Mean,

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

Population Variance,

$$\sigma^2 = \frac{\sum f.(X-\mu)^2}{\sum f}$$

Sample Variance,

$$s^2 = \frac{\sum f.\left(X-\overline{X}\right)^2}{n-1}$$

or

$$s^2 = \frac{\sum f.X_m^2 - \left(\frac{\left(\sum f.X_m\right)^2}{\sum f}\right)}{n-1}$$

Median,

$$M = L_m + \left(\frac{\frac{N}{2}-F}{f_m}\right)c$$

Mode,

$$M_o = L_{M_0} + \left(\frac{d_1}{d_1+d_2}\right)c$$

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),

$$P(A \cap B) = P(A).P(B)$$

Multiplication Rule (dependent event),

$$P(A \cap B) = P(A).P(B|A)$$

Conditional Probability,

$$P(B|A) = \frac{P(A \cap B)}{P(B)}$$

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,

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

Variance for a probability distribution.

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

Standard deviation for a probability distribution.

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

Expectation of Discrete Random Variable,

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

Binomial probability,

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

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,

$$z = \frac{X - \mu}{\sigma} \text{ or } \frac{X - \overline{X}}{s/\sqrt{n}}$$

Mean of sample mean,

$$\mu_{\overline{X}} = \mu$$

Standard error of the means,

$$\sigma_{\overline{X}} = \frac{\sigma}{\sqrt{n}}$$

Central limit theorem formula,

$$z = \frac{X - \overline{X}}{\sigma/\sqrt{n}}$$

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,

$$n = \left(\frac{Z_{\alpha/2}.\sigma}{E}\right)^2$$

where *E* is the maximum error of estimate.

Confidence interval for a proportion,

$$\hat{p} - Z_{\alpha/2}\sqrt{\frac{\hat{p}\hat{q}}{n}} < \mu < \hat{p} + Z_{\alpha/2}\sqrt{\frac{\hat{p}\hat{q}}{n}}$$

Sample size for proportion,

$$n = \hat{p}\hat{q}\left(\frac{Z_{\alpha/2}.\sigma}{E}\right)^2$$

where *E* is the maximum error of estimate.

Confidence interval for variance,

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

Confidence interval for standard deviation,

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

HYPOTHESIS TESTING

Test for the population mean,

i. *z*-test (variance known)

$$Z = \frac{X-\mu}{\sigma/\sqrt{n}}$$

ii. *z*- test (variance unknown)

$$Z = \frac{X-\mu}{s/\sqrt{n}}$$

iii. *t*- test (small sample)

$$t = \frac{X-\mu}{s/\sqrt{n}}$$

Test for two population mean:

i. *z*-test (variances same)

$$z = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$$

ii. *z*-test (variances not same)

$$z = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

iii. *t*- test (small samples)

$$t = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{\sqrt{s_{p^2}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

Where Pooled Variance is:

$$s_{p^2} = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}$$

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.

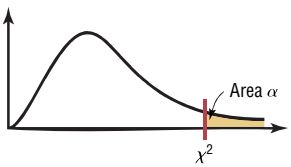

Table B-1 The Standard Normal Distribution

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.

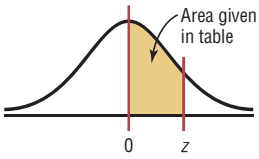

Table F The *t* Distribution

	Confidence intervals	80%	90%	95%	98%	99%
	One tail, α	0.10	0.05	0.025	0.01	0.005
d.f.	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.