UNIVERSITI SAINS MALAYSIA

Final Examination
2015/2016 Academic Session

May/June 2016

JIM 104 – Introduction To Statistics *[Pengantar Statistik]* / JIM 106 – Elementary Statistics *[Asas Statistik]*

Duration : 3 hours
[*Masa: 3 jam*]

Please ensure that this examination paper contains **SEVENTEEN** printed pages before you begin the examination.

Answer **ALL** questions. You may answer either in Bahasa Malaysia or in English.

Read the instructions carefully before answering.

Each question is worth 100 marks.

In the event of any discrepancies, the English version shall be used.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **TUJUH BELAS** muka surat yang bercetak sebelum anda memulakan peperiksaan ini.*

*Jawab **SEMUA** soalan. Anda dibenarkan menjawab sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.*

Baca arahan dengan teliti sebelum anda menjawab soalan.

Setiap soalan diperuntukkan 100 markah.

Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.]

1. (a) The weights of 40 males at a local university are recorded and given below:

Weights (lb)	Frequency
118 - 126	3
127 - 135	5
136 - 144	9
145 - 153	12
154 - 162	5
163 - 171	4
172 - 180	2

(i) Construct an ogive.
(ii) Find the percentage of students that weigh more than 170 pounds based on the ogive in (i).
(iii) Find the mean, median and mode.

(60 marks)

(b) (i) Name the four levels of measurement.
(ii) Give an example of each level of measurement in (i).

(20 marks)

(c) (i) Explain discrete and continous variables.
(ii) Give an example of each variable in (i).

(20 marks)

2. (a) A die with P(1) = 3/12, P(2) = 1/12, P(3) = P(4) = P(5) = P(6) = 1/6 is thrown twice.

(i) List the sample space for this experiment.
(ii) Suppose A is the event of getting a sum of 7 and B is the event of getting a number 3 on the second throw, find P (A) and P (B).
(iii) Are events A and B dependent? Explain.
(iv) Are events A and B mutually exclusive? Explain.

(50 marks)

(b) If at least one child in a family with two children is a girl, what is the probability that both are girls?

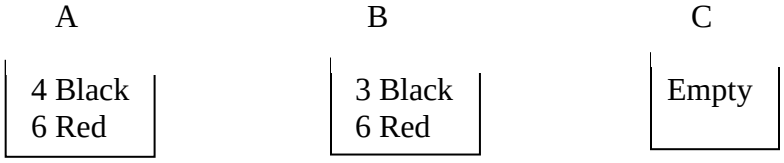
(20 marks)

(c) The probablilities that a text book page will have 0, 1, 2 or 3 typographical errors are 0.79, 0.12, 0.07 and 0.02, respectively. If eight pages are randomly selected, find the probability that four will contain no errors, two will contain 1 error, one will contain 2 errors and one will contain 3 errors.

(30 marks)

…3/-

3. (a) Box A, B and C contains the number of colored marbles as indicated.



A marble is randomly moved from A to B. Then two marbles are randomly moved from B to C and finally a marble is removed from C.

(i) Draw a tree diagram for this random experiment.
(ii) Find the probability that the marble removed from C is red.

(50 marks)

(b) A fair coin is tossed repeatedly until a head appears for the first time. Suppose X is a random variable representing the number of toss.

(i) List the possible values of X.
(ii) Find P ($X = a$) for each possible value of a.
(iii) Find the expected value of X.

(50 marks)

4. (a) A total of 1000 micro-chips were taken from an electronic factory and 35 of them were found damaged.

(i) Find a point estimate of the parameter p, the proportion of micro-chips from the the electronic factory that are damaged.
(ii) Find a 95% confidence interval for p.

(50 marks)

(b) Scores for student assignment for a course last year were normally distributed. If 95.05% of the students have a score of less than 75, and 10.75% of them have less than 15, what is the mean and standard deviation?

(50 marks)

5. (a) Suppose 8 pieces of tires of each brand A and B were mounted on the rear wheels of 8 taxis - Brand A on the left and Brand B on the right. The tires are used until they are worn out. The lifetimes of the tires (in km) are as given:

Taxi	Brand A	Brand B
1	34,400	37,600
2	45,500	48,600
3	37,600	37,700
4	30,200	31,100
5	44,800	48,700
6	38,200	34,600
7	31,800	39,800
8	31,800	35,100

Test the hypothesis that the mean lifetime (km) for brand A and brand B is the same. Use the *p*-value method with $\alpha = 0.05$ and specify all assumptions made.

(60 marks)

(b) In a random sample of 80 workers from a factory in city A, it was found that 5% were unable to read, while in a random sample of 50 workers in city B, 8% were unable to read. Find the 90% confidence interval for the difference of the two proportions.

(40 marks)

1. (a) Berat badan 40 lelaki di sebuah universiti tempatan direkodkan dan diberikan di bawah:

Berat (lb)	Frekuensi
118 - 126	3
127 - 135	5
136 - 144	9
145 - 153	12
154 - 162	5
163 - 171	4
172 - 180	2

(i) Bina ogif.
(ii) Cari peratusan pelajar yang beratnya lebih daripada 170 paun berdasarkan ogif dalam (i).
(iii) Cari min, median dan mod.

(60 markah)

(b) (i) Namakan empat tahap pengukuran.
(ii) Beri satu contoh untuk setiap tahap pengukuran dalam (i).

(20 markah)

(c) (i) Terangkan pembolehubah diskret dan selanjar.
(ii) Beri satu contoh untuk setiap pembolehubah dalam (i).

(20 markah)

2. (a) Sebiji dadu dengan P(1) = 3/12, P(2) = 1/12, P(3) = P(4) = P(5) = P(6) = 1/6 dilemparkan dua kali.

(i) Senaraikan ruang sampel untuk eksperimen ini.
(ii) Katakan A ialah peristiwa mendapat jumlah nombor 7 dan B ialah peristiwa mendapat nombor 3 pada lemparan yang kedua, cari P(A) dan P(B).
(iii) Adakah peristiwa A dan B bersandar? Terangkan.
(iv) Adakah peristiwa A dan B saling tak bercantum? Terangkan.

(50 markah)

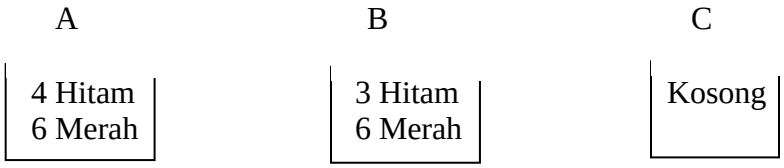
(b) Jika sekurang-kurangnya seorang kanak-kanak adalah perempuan dalam keluarga yang mempunyai dua orang anak, apakah kebarangkalian bahawa kedua-dua kanak-kanak itu perempuan?

(20 markah)

(c) Kebarangkalian bahawa halaman buku teks akan mempunyai 0, 1, 2 atau 3 kesilapan tipografi adalah masing-masing 0.79, 0.12, 0.07 dan 0.02. Jika lapan muka surat dipilih secara rawak, cari kebarangkalian bahawa empat tidak akan mengandungi kesilapan, dua akan mengandungi 1 kesilapan, satu akan mengandungi 2 kesilapan dan satu akan mengandungi 3 kesilapan.

(30 markah)

3. (a) Kotak A, B dan C mengandungi bilangan guli berwarna seperti yang ditunjukkan.



Suatu percubaan rawak seperti berikut dijalankan. Sebiji guli dipindah secara rawak dari A ke B. Kemudian dua biji guli dipindah secara rawak dari B ke C dan akhirnya sebiji guli dikeluarkan dari C.

(i) Lukiskan gambarajah pohon percubaan rawak tersebut.
(ii) Cari kebarangkalian bahawa guli yang dikeluarkan dari C itu berwarna merah.

(50 markah)

(b) Sekeping duit syiling adil dilambungkan berulangkali sehingga kepala muncul buat kali pertama. Katakan X ialah pembolehubah rawak yang melambangkan bilangan lambungan tersebut.

(i) Senaraikan nilai-nilai yang mungkin bagi X.
(ii) Cari $P(X = a)$ untuk setiap nilai a yang mungkin.
(iii) Cari nilai jangkaan bagi X.

(50 markah)

4. (a) Sebanyak 1000 “micro-chip” telah diambil daripada sebuah kilang elektronik dan didapati 35 daripadanya rosak.

(i) Dapatkan anggaran titik untuk parameter p, kadaran “micro-chip” yang rosak daripada kilang elektronik itu.
(ii) Dapatkan selang keyakinan 95% bagi p.

(50 markah)

(b) Markah tugasan pelajar bagi suatu kursus pada tahun yang lepas bertaburan normal. Jika 95.05% daripada pelajar mempunyai markah kurang daripada 75, dan 10.75% daripadanya kurang daripada 15, apakah min dan sisihan piawaianya?

(50 markah)

5. (a) Katakan 8 buah tayar daripada setiap jenama dipasangkan pada roda-roda belakang 8 buah teksi - Jenama A di sebelah kiri dan jenama B di sebelah kanan. Tayar-tayar tersebut digunakan sehingga haus. Keputusan berikut diperolehi:

Teksi	Jenama A	Jenama B
1	34,400	37,600
2	45,500	48,600
3	37,600	37,700
4	30,200	31,100
5	44,800	48,700
6	38,200	34,600
7	31,800	39,800
8	31,800	35,100

Ujikan hipotesis bahawa min masa hayat (km) bagi jenama A dan jenama B adalah sama sahaja. Gunakan kaedah nilai-*p* dengan $\alpha = 0.05$ dan nyatakan segala andaian yang dibuat.

(60 markah)

(b) Dalam satu sampel rawak 80 pekerja dari sebuah kilang di bandar A, didapati 5% tidak dapat membaca, manakala dalam sampel rawak 50 pekerja di bandar B, 8% tidak dapat membaca. Cari selang keyakinan 90% bagi perbezaan di antara kedua kadaran.

(40 markah)

Formulas

Chapter 3 Data Description

Mean for individual data: $\bar{X} = \dfrac{\sum X}{n}$

Mean for grouped data: $\bar{X} = \dfrac{\sum f \cdot X_m}{n}$

Standard deviation for a sample:

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

Standard deviation for grouped data:

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

Range rule of thumb: $s \approx \dfrac{\text{range}}{4}$

Median for grouped data:

$$MD = \frac{(n/2) - cf}{f}(w) + L_m$$

where

n = sum of frequencies
cf = cumulative frequency of class immediately preceding the median class
w = width of median class
f = frequency of median class
L_m = lower boundary of median class

Chapter 4 Probability of Counting Rules

Addition rule 1 (mutually exclusive events):

$$P(A \text{ or } B) = P(A) + P(B)$$

Addition rule 2 (events not mutually exclusive):

$$P(A \text{ or } B) = P(A) + P(B) - P(A \text{ and } B)$$

Multiplication rule 1 (independent events):

$$P(A \text{ and } B) = P(A) \cdot P(B)$$

Multiplication rule 2 (dependent events):

$$P(A \text{ and } B) = P(A) \cdot P(B|A)$$

Conditional probability: $P(B|A) = \dfrac{P(A \text{ and } B)}{P(A)}$

Complementary events: $P(\overline{E}) = 1 - P(E)$

Fundamental counting rule: Total number of outcomes of a sequence when each event has a different number of possibilities: $k_1 \cdot k_2 \cdot k_3 \cdots k_n$

Permutation rule: Number of permutations of *n* objects taking *r* at a time is ${}_nP_r = \dfrac{n!}{(n-r)!}$

Combination rule: Number of combinations of *r* objects selected from *n* objects is ${}_nC_r = \dfrac{n!}{(n-r)!r!}$

Chapter 5 Discrete Probability Distributions

Mean for a probability distribution: $\mu = \sum[X \cdot P(X)]$

Variance and standard deviation for a probability distribution:

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

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

Expectation: $E(X) = \sum[X \cdot P(X)]$

Binomial probability: $P(X) = \dfrac{n!}{(n-X)!X!} \cdot p^X \cdot q^{n-X}$

Mean for binomial distribution: $\mu = n \cdot p$

Variance and standard deviation for the binomial distribution:
$\sigma^2 = n \cdot p \cdot q$ $\sigma = \sqrt{n \cdot p \cdot q}$

Multinomial probability:

$$P(X) = \frac{n!}{X_1!X_2!X_3!\cdots X_k!} \cdot p_1^{X_1} \cdot p_2^{X_2} \cdot p_3^{X_3} \cdots p_k^{X_k}$$

Poisson probability: $P(X;\lambda) = \frac{e^{-\lambda}\lambda^X}{X!}$ where X = 0, 1, 2, ...

Hypergeometric probability: $P(X) = \frac{{}_aC_X \cdot {}_bC_{n-X}}{{}_{a+b}C_n}$

Chapter 6 The Normal Distribution

Standard score: $z = \frac{X-\mu}{\sigma}$ or $\frac{X-\bar{X}}{s}$

Mean of sample means: $\mu_{\bar{X}} = \mu$

Standard error of the mean: $\sigma_{\bar{X}} = \frac{\sigma}{\sqrt{n}}$

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

Chapter 7 Confidence Intervals and Sample Size

z confidence interval for means:

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

t confidence interval for means:

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

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:

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

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Sample size for a proportion: $n = \hat{p}\hat{q}\left(\frac{z_{\alpha/2}}{E}\right)^2$

where $\hat{p} = \frac{X}{n}$ and $\hat{q} = 1 - \hat{p}$

Confidence interval for variance:

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

Confidence interval for standard deviation:

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

Chapter 8 Hypothesis Testing

z test : $z = \frac{\overline{X} - \mu}{\sigma/\sqrt{\text{n}}}$ for any value n. If $n < 30$, population must be normally distributed.

$$z = \frac{\overline{X} - \mu}{s/\sqrt{\text{n}}} \text{ for } \sigma \text{ unknown and } n \geq 30$$

t test : $t = \frac{\overline{X} - \mu}{s/\sqrt{\text{n}}}$ for $n < 30$ (d.f. = $n - 1$)

z test for proportions: $z = \frac{\hat{p} - p}{\sqrt{pq/n}}$

Chi-square test for a single variance: $\chi^2 = \frac{(n-1)s^2}{\sigma^2}$

(d.f. = $n - 1$)

Chapter 9 Testing the Difference Between Two Means, Two Variances and Two Proportions

z test for comparing two means (independent samples);

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

Formula for the confidence interval for difference of two means (large samples):

$$\left(\bar{X}_1 - \bar{X}_2\right) - z_{a/2}\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}} < \mu_1 - \mu_2 < \left(\bar{X}_1 - \bar{X}_2\right) + z_{a/2}\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}$$

Note: s_1^2 and s_2^2 can be used when $n_1 \geq 30$ and $n_2 \geq 30$.

F test for comparing two variances: $F = \frac{s_1^2}{s_2^2}$

where s_1^2 is the larger variance and

$$\text{d.f.N.} = n_1 - 1,\ \text{d.f.D} = n_2 - 1$$

t test for comparing two means (independent samples, variances not equal):

$$t = \frac{\left(\bar{X}_1 - \bar{X}_2\right) - \left(\mu_1 - \mu_2\right)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

(d.f. = the smaller on $n_1 - 1$ or $n_2 - 1$)

Formula for the confidence interval for difference of two means (small independent samples, variance unequal):

$$\left(\bar{X}_1 - \bar{X}_2\right) - t_{\alpha/2}\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}} < \mu_1 - \mu_2 < \left(\bar{X}_1 - \bar{X}_2\right) + t_{\alpha/2}\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$$

(d.f. = smaller of $n_1 - 1$ and $n_2 - 1$)

t test for comparing two means (independent samples, variances equal):

$$t = \frac{\left(\bar{X}_1 - \bar{X}_2\right) - \left(\mu_1 - \mu_2\right)}{\sqrt{\frac{\left(n_1 - 1\right)s_1^2 + \left(n_2 - 1\right)s_2^2}{\left(n_1 + n_2 - 2\right)}}\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

(d.f. = $n_1 + n_2 - 2$)

Formula for the confidence interval for difference of two means (small independent samples, variances equal):

$$\left(\bar{X}_1 - \bar{X}_2\right) - t_{\alpha/2}\sqrt{\frac{\left(n_1 - 1\right)s_1^2 + \left(n_2 - 1\right)s_2^2}{n_1 + n_2 - 2}}\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$$

$$\left(\bar{X}_1 - \bar{X}_2\right) + t_{\alpha/2}\sqrt{\frac{\left(n_1 - 1\right)s_1^2 + \left(n_2 - 1\right)s_2^2}{n_1 + n_2 - 2}}\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$$

and d.f. = $n_1 + n_2 - 2$.

t test for comparing two means for dependent samples:

$$t = \frac{\bar{D} - \mu_D}{s_D / \sqrt{n}} \quad \text{where} \quad \bar{D} = \frac{\sum D}{n} \quad \text{and}$$

$$s_D = \sqrt{\frac{n\sum D^2 - \left(\sum D\right)^2}{n\left(n-1\right)}} \qquad \left(\text{d.f.} = n - 1\right)$$

Formula for confidence interval for the mean of the difference for dependent samples:

$$\bar{D} - t_{\alpha/2}\frac{S_D}{\sqrt{n}} < \mu_D < \bar{D} + t_{\alpha/2}\frac{S_D}{\sqrt{n}}$$

(d.f. = $n - 1$)

t test for comparing two proportions:

$$z = \frac{(\hat{p}_1 - \hat{p}_2) - (p_1 - p_2)}{\sqrt{\overline{pq}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

where $\overline{p} = \frac{X_1 + X_2}{n_1 + n_2}$ $\quad \hat{p}_1 = \frac{X_1}{n_1}$

$\overline{q} = 1 - \overline{p}$ $\quad \hat{p}_2 = \frac{X_2}{n_2}$

Formula for the confidence interval for the difference of two proportions:

$$(\hat{p}_1 - \hat{p}_2) - z_{\alpha/2}\sqrt{\frac{\hat{p}_1\hat{q}_1}{n_1} + \frac{\hat{p}_2\hat{q}_2}{n_2}} < p_1 - p_2 < (\hat{p}_1 - \hat{p}_2) + z_{\alpha/2}\sqrt{\frac{\hat{p}_1\hat{q}_1}{n_1} + \frac{\hat{p}_2\hat{q}_2}{n_2}}$$

Table E The Standard Normal Distribution

Cumulative Standard Normal Distribution

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
−3.4	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0002
−3.3	.0005	.0005	.0005	.0004	.0004	.0004	.0004	.0004	.0004	.0003
−3.2	.0007	.0007	.0006	.0006	.0006	.0006	.0006	.0005	.0005	.0005
−3.1	.0010	.0009	.0009	.0009	.0008	.0008	.0008	.0008	.0007	.0007
−3.0	.0013	.0013	.0013	.0012	.0012	.0011	.0011	.0011	.0010	.0010
−2.9	.0019	.0018	.0018	.0017	.0016	.0016	.0015	.0015	.0014	.0014
−2.8	.0026	.0025	.0024	.0023	.0023	.0022	.0021	.0021	.0020	.0019
−2.7	.0035	.0034	.0033	.0032	.0031	.0030	.0029	.0028	.0027	.0026
−2.6	.0047	.0045	.0044	.0043	.0041	.0040	.0039	.0038	.0037	.0036
−2.5	.0062	.0060	.0059	.0057	.0055	.0054	.0052	.0051	.0049	.0048
−2.4	.0082	.0080	.0078	.0075	.0073	.0071	.0069	.0068	.0066	.0064
−2.3	.0107	.0104	.0102	.0099	.0096	.0094	.0091	.0089	.0087	.0084
−2.2	.0139	.0136	.0132	.0129	.0125	.0122	.0119	.0116	.0113	.0110
−2.1	.0179	.0174	.0170	.0166	.0162	.0158	.0154	.0150	.0146	.0143
−2.0	.0228	.0222	.0217	.0212	.0207	.0202	.0197	.0192	.0188	.0183
−1.9	.0287	.0281	.0274	.0268	.0262	.0256	.0250	.0244	.0239	.0233
−1.8	.0359	.0351	.0344	.0336	.0329	.0322	.0314	.0307	.0301	.0294
−1.7	.0446	.0436	.0427	.0418	.0409	.0401	.0392	.0384	.0375	.0367
−1.6	.0548	.0537	.0526	.0516	.0505	.0495	.0485	.0475	.0465	.0455
−1.5	.0668	.0655	.0643	.0630	.0618	.0606	.0594	.0582	.0571	.0559
−1.4	.0808	.0793	.0778	.0764	.0749	.0735	.0721	.0708	.0694	.0681
−1.3	.0968	.0951	.0934	.0918	.0901	.0885	.0869	.0853	.0838	.0823
−1.2	.1151	.1131	.1112	.1093	.1075	.1056	.1038	.1020	.1003	.0985
−1.1	.1357	.1335	.1314	.1292	.1271	.1251	.1230	.1210	.1190	.1170
−1.0	.1587	.1562	.1539	.1515	.1492	.1469	.1446	.1423	.1401	.1379
−0.9	.1841	.1814	.1788	.1762	.1736	.1711	.1685	.1660	.1635	.1611
−0.8	.2119	.2090	.2061	.2033	.2005	.1977	.1949	.1922	.1894	.1867
−0.7	.2420	.2389	.2358	.2327	.2296	.2266	.2236	.2206	.2177	.2148
−0.6	.2743	.2709	.2676	.2643	.2611	.2578	.2546	.2514	.2483	.2451
−0.5	.3085	.3050	.3015	.2981	.2946	.2912	.2877	.2843	.2810	.2776
−0.4	.3446	.3409	.3372	.3336	.3300	.3264	.3228	.3192	.3156	.3121
−0.3	.3821	.3783	.3745	.3707	.3669	.3632	.3594	.3557	.3520	.3483
−0.2	.4207	.4168	.4129	.4090	.4052	.4013	.3974	.3936	.3897	.3859
−0.1	.4602	.4562	.4522	.4483	.4443	.4404	.4364	.4325	.4286	.4247
−0.0	.5000	.4960	.4920	.4880	.4840	.4801	.4761	.4721	.4681	.4641

For z values less than −3.49, use 0.0001.

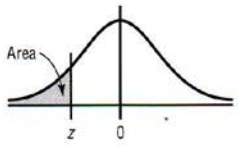

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Table E *(continued)*

Cumulative Standard Normal Distribution

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
0.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
0.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
0.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
0.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
0.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
0.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
0.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
0.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
0.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.9015
1.3	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9279	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9429	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.8	.9641	.9649	.9656	.9664	.9671	.9678	.9686	.9693	.9699	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9761	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9875	.9878	.9881	.9884	.9887	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9916
2.4	.9918	.9920	.9922	.9925	.9927	.9929	.9931	.9932	.9934	.9936
2.5	.9938	.9940	.9941	.9943	.9945	.9946	.9948	.9949	.9951	.9952
2.6	.9953	.9955	.9956	.9957	.9959	.9960	.9961	.9962	.9963	.9964
2.7	.9965	.9966	.9967	.9968	.9969	.9970	.9971	.9972	.9973	.9974
2.8	.9974	.9975	.9976	.9977	.9977	.9978	.9979	.9979	.9980	.9981
2.9	.9981	.9982	.9982	.9983	.9984	.9984	.9985	.9985	.9986	.9986
3.0	.9987	.9987	.9987	.9988	.9988	.9989	.9989	.9989	.9990	.9990
3.1	.9990	.9991	.9991	.9991	.9992	.9992	.9992	.9992	.9993	.9993
3.2	.9993	.9993	.9994	.9994	.9994	.9994	.9994	.9995	.9995	.9995
3.3	.9995	.9995	.9995	.9996	.9996	.9996	.9996	.9996	.9996	.9997
3.4	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9998

For z values greater than 3.49, use 0.9999.

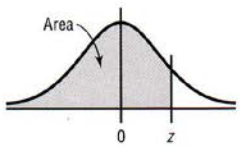

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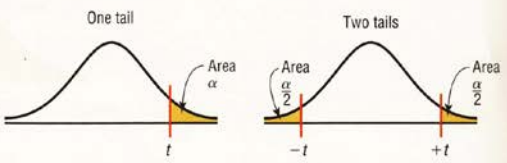
TABLE F The *t* Distribution

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) ∞		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.



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