SULIT

POLITEKNIK MALAYSIA

BAHAGIAN PEPERIKSAAN DAN PENILAIAN
JABATAN PENDIDIKAN POLITEKNIK
KEMENTERIAN PENDIDIKAN TINGGI

JABATAN KEJURUTERAAN AWAM

PEPERIKSAAN AKHIR

SESI DISEMBER 2015

CN 303: STATISTICS

TARIKH : 14 APRIL 2016
MASA : 2.30 PM – 4.30 PM (2 JAM)

Kertas ini mengandungi **SEBELAS (11)** halaman bercetak.
Esei (6 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 **SIX (6)** essay questions. Answer **FOUR (4)** questions only.

ARAHAN:

*Bahagian ini mengandungi **ENAM (6)** soalan esei. Jawab **EMPAT (4)** soalan sahaja.*

QUESTION 1

SOALAN 1

CLO1
C1

(a) Define sample space in probability theories.

Berikan definisi ruang persampelan di dalam teori kebarangkalian.

[2 marks]

[*2 markah*]

CLO 1
C1

(b) Write down the sample space for experiment of two fair coins tossed.

Tuliskan ruang sample bagi eksperimen melambung syiling.

[2 marks]

[*2 markah*]

CLO 1
C2

(c) Let S={1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12}, A={2, 4, 6, 8, 10, 12}, B={4, 8, 12} and C= {3, 6, 9,12}. Solve the following problems:

Katakan S={1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12}, A={2, 4, 6, 8, 10, 12}, B={4, 8, 12} dan C= {3, 6, 9,12}. Selesaikan masalah-masalah berikut:

i) $A \cup B$

[2 marks]

[*2 markah*]

ii) $A \cap C$

[2 marks]

[*2 markah*]

iii) $B \cup C$

[2 marks]

[*2 markah*]

iv) $(B \cup C)'$

[2 marks]
[*2 markah*]

CLO 1
C3

(d) There are 25 boys and 15 girls in the environment laboratory. If one of them is randomly selected, calculate the probability of selected student is a:
Terdapat 25 orang lelaki dan 15 orang perempuan dalam makmal alam sekitar. Jika seorang daripada mereka dipilih secara rawak, kira kebarangkalian pelajar yang dipilih adalah:

i) Boy
Lelaki

[3 marks]
[*3 markah*]

ii) Girl
Perempuan

[3 marks]
[*3 markah*]

CLO 1
C3

e) In a class of Advance Statistic is comprised of 10 juniors, 30 seniors and 10 graduate students. The final grades stated that 3 of the juniors, 10 of the seniors, and 5 of the graduate students received an A for the course.
Sebuah kelas Statistik Lanjutan mengandungi 10 orang junior, 30 orang senior dan 10 orang graduan. Gred akhir menunjukkan 3 orang junior, 10 orang senior dan 5 orang graduan mendapat A untuk kursus ini.

i) Draw a contingency table.
Lukis jadual kontinjensi

[4 marks]
[*4 markah*]

ii) If a student is chosen at randomly from this class and is found to have earned an A, determine the probability that he or she is a senior.
Jika seorang pelajar dipilih secara rawak daripada kelas ini dan mendapat A tentukan kebarangkalian dia adalah senior.

[3 marks]
[*3 markah*]

QUESTION 2
SOALAN 2

CLO 1
C3

a) Determine the number of head occur if 3 coins are tossed in one probability experiment.
Tentukan bilangan kepala jika 3 syiling dilambung dalam satu eksperimen kebarangkalian.

[5 marks]
[*5 markah*]

CLO 1
C2

b) A survey from Forest Research Institute Malaysia shows that 82% of Malaysians aware that illegal dumping will give bad effects towards ecosystems. If 7 individuals are randomly selected, determine the probability that at least 5 of them will be aware of the bad effects on illegal dumping towards environment.
Satu tinjauan daripada Institut Penyelidikan Perhutanan Malaysia menunjukkan bahawa 82% daripada rakyat Malaysia sedar bahawa pembuangan sampah secara haram akan memberi kesan buruk terhadap ekosistem. Jika 7 individu yang dipilih secara rawak, tentukan kebarangkalian bahawa sekurang-kurangnya 5 daripada mereka sedar akan kesan buruk pembuangan sampah secara haram terhadap alam sekitar.

[5 marks]
[*5 markah*]

CLO 1
C3

c) The average time the student take to complete the task based on water sampling experiment is 23.6 minutes. The standard deviation is 5.9 minutes. Calculate these probabilities. Assume the variable is normally distributed.
Purata masa yang diambil oleh pelajar untuk melengkapkna tugasan berdasarkan eksperimen sampel air ialah 23.6 minit. Sisihan piawai ialah 5.9 minit. Tentukan kebarangkalian-kebarangkalian berikut. Anggap pembolehubah bertaburan normal.

(i) It will take a student between 15 to 30 minutes to complete the task.
Pelajar mengambil masa antara 15 sehingga 30 minit untuk melengkapkan tugasan.

[5 marks]
[*5 markah*]

(ii) It will take a student less than 18 minutes or more than 28 minutes to complete the task.
Pelajar mengambil masa kurang daripada 18 minit atau lebih daripada 28 minit untuk melengkapkan tugasan.

[5 marks]
[*5 markah*]

CLO 1
C3

d) The average earned money from selling recycled items is RM800. Suppose the distribution is normal distribution with standard deviation is RM 105. Determine the limit of the money for the middle 50%.
Purata wang daripada jualan bahan kitar semula ialah RM800. Taburan adalah taburan normal dengan sisihan piawai RM105. Tentukan had wang untuk pertengahan 50%.

[5 marks]
[*5 markah*]

QUESTION 3
SOALAN 3

CLO 2
C1

(a) Define Sampling Error.
Definisikan ralat persampelan.

[3 marks]
[*3 markah*]

CLO 2
C2

(b) A sample of 12 students were collected a recycle paper for their mini project (in kilogram) were 10, 9, 12, 11, 8, 15, 9, 7, 8, 6, 12, 10. Calculate standard deviation for the sample.
Sampel bagi 12 pelajar yang mengumpul kertas kitar semula untuk projek mini (dalam kilogram) adalah 10, 9, 12, 11, 8, 15, 9, 7, 8, 6, 12, 10. *Kira sisihan piawai bagi sampel.*

[9 marks]
[*9 markah*]

CLO 2
C3

c) The average age of a vehicle registered in PUSPAKOM is 8 years, or 96 months. Assume the standard deviation is 16 months. If a random sample of 36 vehicles is selected, calculate the probability that the mean of their vehicle age is between 90 and 100 months.
Purata usia kenderaan berdaftar di PUSPAKOM adalah 8 tahun, atau 96 bulan. Andaikan sisihan piawai ialah 16 bulan. Jika sampel rawak 36 kenderaan dipilih, kira kebarangkalian bahawa min usia kereta adalah antara 90 dan 100 bulan.

[6 marks]
[*6 markah*]

CLO 2
C3

(d) The average number of bacteria colony that been found in an experiment is 212. Assume the standard deviation is 25 colonies and the distribution is approximately normal.
Purata bilangan bakteria yang didapati dalam ujikaji adalah 212. Andaikan sisihan piawai adalah 25 dan bilangan bakteria adalah bertabur secara normal.

(i) Calculate the probability of bacteria colony is 224 colony for each experiment.
Kirakan kebarangkalian terdapat 224 koloni bakteria bagi setiap eksperimen.

[3 marks]
[*3 markah*]

(ii) If 40 experiments been conducted, calculate probability in percentage that the mean of the sample will be less that 224 colony for each experiment.
Jika 40 eksperimen dijalankan, kirakan kebarangkalian min sampel sekurang-kurangnya 224 koloni bagi setiap eksperimen.

[4 marks]
[*4 markah*]

QUESTION 4
SOALAN 4

CLO2 C2

a) Describe **THREE (3)** properties of a good estimator.
*Huraikan **TIGA (3)** ciri bagi penganggar terbaik.*

[6 marks]
[*6 markah*]

CLO2 C2

b) Noise level in various areas at hospital was measured in decibles. The mean of the noise levels for 80 corridors was 61.2 decibles and the standard deviation was 7.9. Determine the 95% confidence interval of the true mean.
Tahap bunyi di pelbagai kawasan di hospital diukur dalam decibel. Nilai min tahap bunyi untuk 80 koridor ialah 61.2 desibel dan nilai sisihan piawai ialah 7.9. Tentukan 95% selang keyakinan bagi min sebenar.

[6 marks]
[*6 markah*]

CLO2 C3

c) Calculate the 95% confident interval for the mean the weights of rubbish before undergo the segregation experiment. A random sample of weights of rubbish (grams) is shown in Table 3.
Kirakan 95% selang keyakinan untuk min berat sampah sebelum melalui eksperimen pengasingan. Sampel rawak berat sampah (gram) ditunjukkan seperti dalam Jadual 3.

Table 3/ Jadual 3

Weight of Rubbish (gram)	Frequency
13-19	3
20-26	6
27-33	10
34-40	7
41-47	5
48-54	1
55-61	2
62-68	1

[13 marks]
[*13 markah*]

QUESTION 5
SOALAN 5

CLO1 C2

(a) The average price (in RM) for biodegradable plastic items per kg shown below for 7 suppliers.
Harga purata (dalam RM) untuk bahan plastic mesra alam per kg ditunjukkan di bawah untuk 7 pembekal.

1.90 7.83 2.83 1.91 5.88 2.91 6.08

i) Calculate the mean.
Kirakan min.

[3 marks]
[*3 markah*]

ii) Calculate the standard deviation.
Kirakan sisihan piawai.

[4 marks]
[*4 markah*]

iii) Calculate the true mean price for biodegradable plastic bag with 95 % confidence interval.
Kirakan harga min sebenar untuk beg plastik mesra alam dengan selang keyakinan 95%.

[5 marks]
[*5 markah*]

CLO1 C4

(b) The following gives the results of hydrocarbon emissions (in ppm) at idling speed for 15 randomly selected buses. Calculate the 95% confidence interval for the true mean hydrocarbon emissions for buses.
Berikut merupakan keputusan pelepasan hidrokarbon (dalam ppm) pada kelajuan melahu untuk 15 bas yang dipilih secara rawak. Kirakan 95% selang keyakinan untuk min sebenar bagi pelepasan hidrokarbon untuk bas –bas tersebut.

Table 5 (b)/ *Jadual 5(b)*

167	169	103	497	276	441	220	397
287	403	313	182	159	412	357	

[13 marks]
[*13 markah*]

CLO2 C4

QUESTION 6
SOALAN 6

CLO2 C3

a) The Table 6a shown the data obtained in a study of age and blood pressure of six randomly selected respondents.
Jadual 6a menunjukkan data yang diperolehi dalam kajian umur dan tekanan darah bagi enam orang responden yang terpilih..

Table 6a / *Jadual 6a*

Subject	Age x	Pressure y
A	43	128
B	48	120
C	56	135
D	61	143
E	67	141
F	70	152

i) Calculate the value of the correlation coefficient for the data obtained in the study.
Kirakan nilai pekali korelasi untuk data yang diperolehi dalam kajian ini.

[8 marks]
[*8 markah*]

ii) Explain briefly about the value obtained in Question 6a(i)
Terangkan secara ringkas tentang nilai yang diperolehi dalam Soalan 6a(i)

[2 marks]
[*2 markah*]

b) The Head of Civil Engineering Department wants to determine whether there is any type of relationship between the amount of a contribution from selling reuse items (in ringgit) and the years of selling its. The data are as follow.

Ketua Jabatan Kejuruteraan Awam ingin menentukan hubungkait antara sumbangan dari jualan barangan terpakai (dalam ringgit) dengan jumlah tahun penjualan. Data adalah seperti dibawah:

Years, x *Tahun, x*	1	5	3	10	7	6
Contribution, y *Sumbangan, y*	500	100	300	50	75	80

i) Calculate the value of correlation for data and state if there is a relationship between the data above.
Kirakan nilai kolerasi bagi dan nyatakan hubungkait bagi data diatas.

[8 marks]
[*8 markah*]

ii) Determine the equation of the regression line and the value of y when x = 4 year.
Tentukan persamaan bagi garis regresi dan kirakan nilai y apabila x = 4 tahun.

[7 marks]
[*7 markah*]

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SOALAN TAMAT

Formulas and Tables

Elementary Statistics: A Step-By-Step Approach
Bluman / Mayer, 1st Canadian Edition

Chapter 3 Data Description

Mean for individual data: $\overline{X} = \frac{\Sigma X}{n}$

Mean for grouped data: $\overline{X} = \frac{\Sigma f \cdot X_m}{n}$

Standard deviation for a sample:

$$s = \sqrt{\frac{\Sigma X^2 - [(\Sigma X)^2/n]}{n-1}}$$

Standard deviation for grouped data:

$$s = \sqrt{\frac{\Sigma f \cdot X_m^2 - [(\Sigma f \cdot X_m)^2/n]}{n-1}}$$

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

Chapter 4 Probability and 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):

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

Conditional probability: $P(B \mid A) = \frac{P(A \text{ and } B)}{P(A)}$

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: $k_1 \cdot k_2 \cdot k_3 \cdot \cdots k_n$

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

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

Chapter 5 Discrete Probability Distributions

Mean for a probability distribution: $\mu = \Sigma[X \cdot P(X)]$
Variance and standard deviation for a probability distribution:

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

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

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

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

Mean for binomial distribution: $\mu = n \cdot p$
Variance and standard deviation for the binomial distribution:
$\sigma^2 = n \cdot p \cdot q \qquad \sigma = \sqrt{n \cdot p \cdot q}$
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 $X = 0, 1, 2, \ldots$

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 $\frac{X - \overline{X}}{s}$

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

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

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

Chapter 7 Confidence Intervals and Sample Size

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:

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

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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:

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

Confidence interval for standard deviation:

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

Chapter 8 Hypothesis Testing

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

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

t test: $t = \frac{\overline{X} - \mu}{s/\sqrt{n}}$ 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):

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

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

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

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
d.f.N. $= n_1 - 1$, d.f.D. $= n_2 - 1$

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

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

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

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

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

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

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

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

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

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

$$(\overline{X}_1 - \overline{X}_2) - t_{\alpha/2}\sqrt{\frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1 + n_2 - 2}} \cdot \sqrt{\frac{1}{n_1} + \frac{1}{n_2}} < \mu_1 - \mu_2 < (\overline{X}_1 - \overline{X}_2) + t_{\alpha/2}\sqrt{\frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{(n_1 + n_2 - 2)}} \cdot \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$$

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

t test for comparing two means for dependent samples:

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

$$s_D = \sqrt{\frac{\Sigma D^2 - [(\Sigma D)^2/n]}{n-1}} \quad (\text{d.f.} = n - 1)$$

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

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

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

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z test for comparing two proportions:

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

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

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

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

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

Chapter 10 Correlation and Regression

Correlation coefficient:

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[n(\Sigma x^2) - (\Sigma x)^2][n(\Sigma y^2) - (\Sigma y)^2]}}$$

t test for correlation coefficient: $t = r\sqrt{\frac{n-2}{1-r^2}}$

(d.f. $= n - 2$)

The regression line equation: $y' = a + bx$

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

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

Coefficient of determination: $r^2 = \frac{\text{explained variation}}{\text{total variation}}$

Standard error of estimate:

$$s_{est} = \sqrt{\frac{\Sigma y^2 - a\Sigma y - b\Sigma xy}{n-2}}$$

Prediction interval for y:

$$y' - t_{\alpha/2}s_{est}\sqrt{1 + \frac{1}{n} + \frac{n(x - \overline{X})^2}{n\Sigma x^2 - (\Sigma x)^2}} < y < y' + t_{\alpha/2}s_{est}\sqrt{1 + \frac{1}{n} + \frac{n(x - \overline{X})^2}{n\Sigma x^2 - (\Sigma x)^2}}$$

(d.f. $= n - 2$)

Formula for the multiple correlation coefficient:

$$R = \sqrt{\frac{r_{yx_1}^2 + r_{yx_2}^2 - 2r_{yx_1} \cdot r_{yx_2} \cdot r_{x_1x_2}}{1 - r_{x_1x_2}^2}}$$

Formula for the F test for the multiple correlation coefficient:

$$F = \frac{R^2/k}{(1-R^2)/(n-k-1)}$$

(d.f.N. $= n - k$ and d.f.D. $= n - k - 1$)

Formula for the adjusted R^2:

$$R^2_{adj} = 1 - \left[\frac{(1-R^2)(n-1)}{n-k-1}\right]$$

Chapter 11 Other Chi-Square Tests

Chi-square test for goodness-of-fit:

$$\chi^2 = \sum\frac{(O-E)^2}{E}$$

(d.f. = no. of categories $- 1$)

Chi-square test for independence and homogeneity of proportions:

$$\chi^2 = \sum\frac{(O-E)^2}{E}$$

[d.f. = (rows $- 1$)(col. $- 1$)]

Chapter 12 Analysis of Variance

ANOVA test: $F = \frac{s_B^2}{s_W^2}$ where $\overline{X}_{GM} = \frac{\Sigma X}{N}$

d.f.N. $= k - 1$ where $N = n_1 + n_2 + \cdots + n_k$
d.f.D. $= N - k$ where k = number of groups

$$s_B^2 = \frac{\Sigma n_i(\overline{X}_i - \overline{X}_{GM})^2}{k-1}$$

$$s_W^2 = \frac{\Sigma(n_i - 1)s_i^2}{\Sigma(n_i - 1)}$$

Scheffé test: $F_S = \frac{(\overline{X}_i - \overline{X}_j)^2}{s_W^2(1/n_i + 1/n_j)}$ and

$F' = (k-1)(\text{C.V.})$

Tukey test: $q = \frac{\overline{X}_i - \overline{X}_j}{\sqrt{s_W^2/n}}$

Formulas for two-way ANOVA:

$$MS_A = \frac{SS_A}{a-1} \qquad F_A = \frac{MS_A}{MS_W}$$

$$MS_B = \frac{SS_B}{b-1} \qquad F_B = \frac{MS_B}{MS_W}$$

$$MS_{A\times B} = \frac{SS_{A\times B}}{(a-1)(b-1)} \qquad F_{A\times B} = \frac{MS_{A\times B}}{MS_W}$$

$$MS_W = \frac{SS_W}{ab(n-1)}$$

Formulas and Tables

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Chapter 13 Nonparametric Statistics

z test value in the sign test: $z = \dfrac{(X + 0.5) - (n/2)}{\sqrt{n}/2}$

where n = sample size (greater than or equal to 26)
X = smaller number of + or − signs

Wilcoxon rank sum test: $z = \dfrac{R - \mu_R}{\sigma_R}$

where

$\mu_R = \dfrac{n_1(n_1 + n_2 + 1)}{2}$

$\sigma_R = \sqrt{\dfrac{n_1 n_2(n_1 + n_2 + 1)}{12}}$

R = sum of the ranks for the smaller sample size (n_1)
n_1 = smaller of the sample sizes
n_2 = larger of the sample sizes
$n_1 \geq 10$ and $n_2 \geq 10$

Wilcoxon signed-rank test: $z = \dfrac{w_s - \dfrac{n(n+1)}{4}}{\sqrt{\dfrac{n(n+1)(2n+1)}{24}}}$

where

n = number of pairs where the difference is not 0
w_s = smaller sum in absolute value of the signed ranks

Kruskal-Wallis test:

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

where

R_1 = sum of the ranks of sample 1
n_1 = size of sample 1
R_2 = sum of the ranks of sample 2
n_2 = size of sample 2
⋮
R_k = sum of the ranks of sample k
n_k = size of sample k
$N = n_1 + n_2 + \cdots + n_k$
k = number of samples

Spearman rank correlation coefficient:

$$r_S = 1 - \frac{6\,\Sigma d^2}{n(n^2 - 1)}$$

where

d = difference in the ranks
n = number of data pairs

Procedure Table

Solving Hypothesis-Testing Problems (Traditional Method)

STEP 1 State the hypotheses, and identify the claim.
STEP 2 Find the critical value(s) from the appropriate table in Appendix C.
STEP 3 Compute the test value.
STEP 4 Make the decision to reject or not reject the null hypothesis.
STEP 5 Summarize the results.

Procedure Table

Solving Hypothesis-Testing Problems (*P*-value Method)

STEP 1 State the hypotheses and identify the claim.
STEP 2 Compute the test value.
STEP 3 Find the *P*-value.
STEP 4 Make the decision.
STEP 5 Summarize the results.

Formulas and Tables

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NEGATIVE *z* Scores

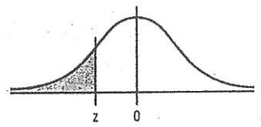

Table E-1 Cumulative Area to the Left of *z* score

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
−3.7	0.0001									
−3.6	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
−3.5	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
−3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002
−3.3	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
−3.2	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
−3.1	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
−3.0	0.0013	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010
−2.9	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
−2.8	0.0026	0.0025	0.0024	0.0023	0.0023	0.0022	0.0021	0.0021	0.0020	0.0019
−2.7	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
−2.6	0.0047	0.0045	0.0044	0.0043	0.0041	0.0040	0.0039	0.0038	0.0037	0.0036
−2.5	0.0062	0.0060	0.0059	0.0057	0.0055	0.0054	0.0052	0.0051	0.0049	0.0048
−2.4	0.0082	0.0080	0.0078	0.0075	0.0073	0.0071	0.0069	0.0068	0.0066	0.0064
−2.3	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
−2.2	0.0139	0.0136	0.0132	0.0129	0.0125	0.0122	0.0119	0.0116	0.0113	0.0110
−2.1	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
−2.0	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
−1.9	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
−1.8	0.0359	0.0351	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
−1.7	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
−1.6	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
−1.5	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
−1.4	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0721	0.0708	0.0694	0.0681
−1.3	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
−1.2	0.1151	0.1131	0.1112	0.1093	0.1075	0.1056	0.1038	0.1020	0.1003	0.0985
−1.1	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
−1.0	0.1587	0.1562	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
−0.9	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
−0.8	0.2119	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
−0.7	0.2420	0.2389	0.2358	0.2327	0.2296	0.2266	0.2236	0.2206	0.2177	0.2148
−0.6	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2483	0.2451
−0.5	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
−0.4	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
−0.3	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
−0.2	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
−0.1	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
0.0	0.5000	0.4960	0.4920	0.4880	0.4840	0.4801	0.4761	0.4721	0.4681	0.4641

Note: For all values less than −3.70, use 0.0001 for the area.

z score	Area
−1.645	0.0500
−2.575	0.0050

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POSITIVE *z* Scores

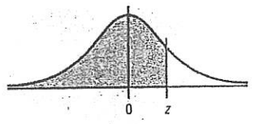

Table E–2 Cumulative Area to the Left of *z* score

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.3	0.9995	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9997
3.4	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998
3.5	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998
3.6	0.9998	0.9998	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999
3.7	0.9999									

Note: For all values greater than 3.70, use 0.9999 for the area.

z score	Area
1.645	0.9500
2.575	0.9950

Formulas and Tables
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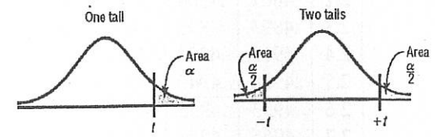
Table F The *t* Distribution

	Confidence intervals	50%	80%	90%	95%	98%	99%
	One tail, α	0.25	0.10	0.05	0.025	0.01	0.005
d.f.	Two tails, α	0.50	0.20	0.10	0.05	0.02	0.01
1		1.000	3.078	6.314	12.706	31.821	63.657
2		.816	1.886	2.920	4.303	6.965	9.925
3		.765	1.638	2.353	3.182	4.541	5.841
4		.741	1.533	2.132	2.776	3.747	4.604
5		.727	1.476	2.015	2.571	3.365	4.032
6		.718	1.440	1.943	2.447	3.143	3.707
7		.711	1.415	1.895	2.365	2.998	3.499
8		.706	1.397	1.860	2.306	2.896	3.355
9		.703	1.383	1.833	2.262	2.821	3.250
10		.700	1.372	1.812	2.228	2.764	3.169
11		.697	1.363	1.796	2.201	2.718	3.106
12		.695	1.356	1.782	2.179	2.681	3.055
13		.694	1.350	1.771	2.160	2.650	3.012
14		.692	1.345	1.761	2.145	2.624	2.977
15		.691	1.341	1.753	2.131	2.602	2.947
16		.690	1.337	1.746	2.120	2.583	2.921
17		.689	1.333	1.740	2.110	2.567	2.898
18		.688	1.330	1.734	2.101	2.552	2.878
19		.688	1.328	1.729	2.093	2.539	2.861
20		.687	1.325	1.725	2.086	2.528	2.845
21		.686	1.323	1.721	2.080	2.518	2.831
22		.686	1.321	1.717	2.074	2.508	2.819
23		.685	1.319	1.714	2.069	2.500	2.807
24		.685	1.318	1.711	2.064	2.492	2.797
25		.684	1.316	1.708	2.060	2.485	2.787
26		.684	1.315	1.706	2.056	2.479	2.779
27		.684	1.314	1.703	2.052	2.473	2.771
28		.683	1.313	1.701	2.048	2.467	2.763
(z) ∞		.674	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, Florida, 1986. Reprinted with permission.



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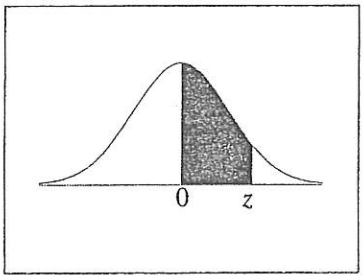
Standard Normal Distribution Table



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
3.5	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998

Gilles Cazelais. Typeset with LaTeX on April 20, 2006.