SULIT

POLITEKNIK MALAYSIA

BAHAGIAN PEPERIKSAAN DAN PENILAIAN
JABATAN PENDIDIKAN POLITEKNIK
KEMENTERIAN PENDIDIKAN TINGGI

JABATAN KEJURUTERAAN AWAM

PEPERIKSAAN AKHIR

SESI JUN 2016

CN303: STATISTICS

TARIKH : 25 OKTOBER 2016
TEMPOH : 8.30 AM – 10.30 AM (2 JAM)

Kertas ini mengandungi **SEBELAS (11)** halaman bercetak.
Esei (6 soalan) : Jawab 4 soalan sahaja
Dokumen sokongan yang disertakan : Formula dan Jadual

JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN

(CLO yang tertera hanya sebagai rujukan)

SULIT

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

CLO 1
C1

(a) Define sample space in the probability theories.

Berikan definisi ruang sample di dalam teori kebarangkalian.

[2 marks]

[*2 markah*]

CLO 1
C1

(b) The sample space consist of a,b,c,d,e,f,g,h. A chart consists of = {a,b,c,d,e}, B = {a,b,d,f,g}, C = {b,c,e,g,h}, D = {d,e,f,g,h}. Identify if:

Ruang sampel mengandungi daripada a,b,c,d,e,f,g,h .Sebuah carta mengandungi A = {a,b,c,d,e}, B = {a,b,d,f,g}, C = {b,c,e,g,h}, D = {d,e,f,g,h}. Kenalpasti jika:

(i) $A \cap (B \cup D)$

[2marks]

[*2markah*]

(ii) $(A \cap D) \cup B$

[2 marks]

[*2 markah*]

(iii) $B \cap C \cap D$

[2 marks]

[2markah]

(iv) B'∩ (C ∪ D)

[2 marks]
[2*markah*]

CLO 1
C3

(c) There are 10 workers in the Research Department (7 males and 3 females), 20 workers in Urban and Drainage Department (8 males and 12 females), and 12 workers in Hydrology and Water Resources Department (7 males and 5 females). If one lecturer was selected randomly. Calculate the probability of:
Terdapat 10 orang pensyarah di Jabatan Penyelidikan (7 lelaki dan 3 wanita), 20 pensyarah di Jabatan Bandar dan Saliran (8 lelaki dan 12 perempuan), dan 12 pensyarah di Jabatan Hidrologi dan Sumber Air (7 lelaki dan 5 perempuan). Jika salah seorang pensyarah dipilih secara rawak. Kirakan kebarangkalian bahawa adalah:

(i) Research Department or Female
Jabatan Penyelidikan atau Wanita

[3 marks]
[*3 markah*]

(ii) Urban and Drainage Department or Male
Jabatan Bandar dan Saliran atau Lelaki

[3 marks]
[*3 markah*]

(iii) Not Hydrology and Water Resources Department
Bukan Jabatan Hidrologi dan Sumber Air

[3 marks]
[*3 markah*]

(iv) Hydrology and Water Resources Department given that Male
Jabatan Hidrologi dan Sumber Air yang diberikan lelaki

[3 marks]
[*3 markah*]

(v) Research Department or Hydrology and Water Resources Department
Jabatan Penyelidikan atau Hidrologi dan Jabatan Sumber Air

[3 marks]
[*3 markah*]

QUESTION 2
SOALAN 2

CLO 1
C1

(a) List **TWO (2)** requirements for a probability distribution.
*Senaraikan **DUA (2)** keperluan bagi taburan kebarangkalian.*

[4 marks]
[*4 markah*]

CLO 1
C3

(b) If **THREE (3)** coins were tossed, calculate the mean of the number of heads that occur.
*Jika **TIGA** (3) keeping duit syiling dilambungkan, kirakan min bilangan kepala yang akan berlaku.*

[6 marks]
[*6 markah*]

CLO 1
C3

(c) A survey from the Ministry Of Health shows that 80% of people in a community use the counselling services at a hospital in one year. Calculate these probabilities for a sample of 10 people.
Satu tinjauan oleh Jabatan Kesihatan mendapati 80% daripada penduduk di satu komuniti menggunakan khidmat kaunseling di hospital dalam setahun.Kirakan kebarangkalian yang berikut:

i. At most **THREE (3)** people used counselling services.
*Paling banyak **TIGA (3)** orang menggunakan khidmat kaunseling.*

[5 marks]
[*5 markah*]

ii. At least **THREE (3)** people used counselling services.
*Sekurang-kurangnya **TIGA (3)**orang menggunakan khidmat kaunseling.*

[5 marks]
[*5 markah*]

CLO 1
C2

(d) The average money from the selling of household items is RM 792. Supposed the distribution is a normal distribution with a standard deviation of RM 103, calculate the limit value of money for the normal distribution graph with 50% in the middle.
Purata wang daripada jualan barangan rumah ialah RM 792. Jika taburan ini merupakan taburan normal dengan sisihan piawai RM 103, kirakan had nilai wang bagi keluasan graf taburan normal 50% di tengah.

[5 marks]
[*5 markah*]

QUESTION 3
SOALAN 3

CLO2
C1

(a) Define population in the sampling distribution concept.
Berikan definisi populasi di dalam konsep taburan persamplean.

[2 marks]
[*2 markah*]

CLO2
C2

(b) The data below shows the number of days the water samples from **ELEVEN (11)** sampling sites are preserved in the laboratory. Calculate the mean for the samples.
*Data dibawah menunjukkan bilangan hari air sampel daripada **SEBELAS (11)** lokasi persampelan diawetkan di dalam makmal. Kirakan min bagi sampel air tersebut.*

Table 1/ *Jadual 1*

Sampling site/ *Tapak pensampelan*	1	2	3	4	5	6	7	8	9	10	11
Number sludge sample/ *Bilangan sampel enapcemar*	20	26	40	36	23	42	35	24	30	12	13

[3 marks]
[*3 markah*]

CLO2
C3

(c) A study shows the mean time for sample preservation is 5.9 hours, with a standard deviation of 10 hours. If the number of samples was 20, calculate the probability that the mean time for sample preservation will be less than 2.7 hours.
Kajian menunjukkan min masa untuk pengawetan sampel ialah 5.9 jam, dengan sisihan piawai 10 jam. Jika bilangan sampel adalah 20, kirakan kebarangkalian masa untuk sampel pemeliharaan kurang daripada 2.7 jam.

[6 marks]
[*6 markah*]

CLO2
C3

(d) **Table 2** shows the size (cm) of an insect colony at field with the distribution frequency. Calculate the mean, variance and standard deviation for the data.
Jadual 2 *menunjukkan saiz (sm) koloni serangga di padang dengan taburan frekuensinya. Kirakan nilai min, varian dan sisihan piawai bagi data tersebut*

Table 2 / *Jadual 2*

Class (size of colony in cm)	Frequency
5.5-10.5	1
10.5-15.5	2
15.5-20.5	3
20.5-25.5	5
25.5-30.5	4
30.5-35.5	3
35.5-40.5	2

[14 marks]
[14 markah]

QUESTION 4
SOALAN 4

CLO2
C2

(a) A research is required to estimate the depth of a river. This study would like to ensure 99% confident that the estimation should be accurate within 2 foot. The standard deviation from the previous study was 2.5 ft. Calculate the large sample needed.
Satu kajian diperlukan untuk menganggarkan kedalaman sungai.Kajian ini ingin menjadi 99% yakin bahawa anggaran ini tepat dalam 1 kaki. Sisihan piawai daripada kajian sebelum ini ialah 2.5 kaki. Kirakan kebesaran sampel yang diperlukan.

[5 marks]
[*5markah*]

CLO2
C3

(b) **Table 3** shows the vale of viscosity in green apple pulp. Calculate:
Jadual 3 *menunjukkan nilai kelikatan dalam pulpa epal hijau. Kirakan*

(i) variance [7 marks]
varians [7*markah*]

(i) standard deviation. [3 marks]
sisihan piawai [3*markah*]

Table 3

Class limits	13-19	20-26	27-33	34-40	41-47	48-54	55-61	62-68
Frequency	2	7	12	5	6	1	0	2

CLO2
C3

(c) **Table 4** represents the concentration of COD (mg/L) from 30 sampling points around Malaysia that was reported by an environment officer. Calculate the 90% confidence interval of the mean.
Jadual 4 *mewakili nilai kepekatan COD (mg/L) daripada 30 titik persampelan di sekeliling Malaysia yang dilaporkan oleh seorang pegawai alam sekitar. Kirakan min 90% selang keyakinan.*

Table 4 / *Jadual 4*

12.23	16.65	4.39
2.89	1.24	2.17
13.19	9.16	1.42
73.25	1.91	14.64
11.59	6.69	1.06
8.74	3.17	18.13
7.92	4.78	16.85
40.22	2.42	21.58
5.01	1.47	12.24
2.27	12.77	2.76

[10 marks]
[*10 markah*]

QUESTION 5
SOALAN 5

CLO1
C1

(a) List **THREE (3)** properties of a good estimator
*Senaraikan **TIGA (3)** ciri – ciri penganggar terbaik.*

[3 marks]
[*3 markah*]

CLO1
C3

(b) **Table 5** shows that the average concentration of Magnesium (Mg) for 8 sampling points. Calculate the true mean concentration of Magnesium (Mg) with 95 % confidence.
Jadual 5 *menunjukkan nilai kepekatan purata Magnesium (Mg) untuk 8 titik persampelan. Kira kepekatan min sebenar Magnesium (Mg) dengan keyakinan 95%*

Table 5 / *Jadual 5*

3.56	1.90	7.83	2.83	1.91	5.88	2.91	6.08

[11 marks]
[*11markah*]

CLO1
C4

(c) The following data represents the amount of PM_{10} ($\mu g/m^3$) on air. Construct a 98% confidence interval based on the data.
Data di bawah menunjukan nilai PM_{10} ($\mu g/m^3$) di udara. Bina selang keyakinan 98% berdasarkan data.

Table 6 / *Jadual 6*

61	12	6	40	27	38	93	5	13	40

[11 marks]
[*11 markah*]

CLO2 C3

QUESTION 6

SOALAN 6

(a) The Green Save Sdn. Bhd Organization wants to determine whether there is any type of relationship between the amount of contribution from reuse activity (in ringgit) with the number of days per month of recycling activity done by this organization as shown in **Table 7.**
Organisasi Green Save Sdn. Bhd ingin mengenalpasti hubungan diantara jumlah sumbangan daripada aktiviti mengguna semula (dalam ringgit) dengan jumlah hari dalam sebulan aktiviti kitar semula yang dilaksanakan oleh organisasi ini set ditunjukkan di dalam ***Jadual*** *7.*

Table 7 / *Jadual 7*

Number of days (reuse activity) per month, x *Jumlah Hari (aktiviti mengguna semula) dalam sebulan, x*	6	2	15	9	12	5	8
Contribution, y Sumbangan, y	82	86	43	74	58	90	78

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

[9 marks]
[9 markah]

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

[8 marks]
[8 markah]

CLO1 C3

(b) The survey of total number of working days and salary per week for six people is shown in **Table 8**. Compute the value for correlation coefficient from the data below.
Kajian jumlah hari bekerja dan jumlah gaji dalam seminggu bagi enam orang adalah seperti di dalam Jadual 8. Kirakan nilai pekali kolerasi daripada data dibawah.

[8 marks]
[8 markah]

Table 8 / *Jadual 8*

Working Days ,x *Bilangan hari bekerja ,x*	Salary , y *Gaji y*
43	128
48	120
56	135
61	143
67	141
70	152

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: $\overline{X} = \dfrac{\Sigma X}{n}$

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

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: $s \approx \dfrac{\text{range}}{4}$

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

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

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

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

Variance and standard deviation for the binomial distribution:

$\sigma^2 = n \cdot p \cdot q \qquad \sigma = \sqrt{n \cdot p \cdot q}$

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: $P(X; \lambda) = \dfrac{e^{-\lambda}\lambda^X}{X!}$ where $X = 0, 1, 2, \ldots$

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

Chapter 6 The Normal Distribution

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

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

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

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

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: $n = \left(\dfrac{z_{\alpha/2} \cdot \sigma}{E}\right)^2$ where E is the maximum error of estimate

Confidence interval for a proportion:

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

Formulas and Tables

Elementary Statistics: A Step-By-Step Approach

Bluman / Mayer, 1st Canadian Edition

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

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

$z = \dfrac{\overline{X} - \mu}{s/\sqrt{n}}$ for σ unknown and $n \geq 30$

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

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

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

(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):

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

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: $F = \dfrac{s_1^2}{s_2^2}$

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):

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

(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):

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

(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:

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

$s_D = \sqrt{\dfrac{\Sigma D^2 - [(\Sigma D)^2/n]}{n-1}}$ (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 $\bar{p} = \frac{X_1 + X_2}{n_1 + n_2}$ $\quad \hat{p}_1 = \frac{X_1}{n_1}$

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

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

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

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:

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

Prediction interval for y:

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

(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:

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

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 $\bar{X}_{\text{GM}} = \frac{\Sigma X}{N}$

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

d.f.D. $= N - k$ where k = number of groups

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

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

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

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

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

Formulas for two-way ANOVA:

$\text{MS}_A = \frac{\text{SS}_A}{a - 1}$ $\quad F_A = \frac{\text{MS}_A}{\text{MS}_W}$

$\text{MS}_B = \frac{\text{SS}_B}{b - 1}$ $\quad F_B = \frac{\text{MS}_B}{\text{MS}_W}$

$\text{MS}_{A\times B} = \frac{\text{SS}_{A\times B}}{(a - 1)(b - 1)}$ $\quad F_{A\times B} = \frac{\text{MS}_{A\times B}}{\text{MS}_W}$

$\text{MS}_W = \frac{\text{SS}_W}{ab(n - 1)}$

Chapter 13 Nonparametric Statistics

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

where n = sample size (greater than or equal to 26)

X = smaller number of + or − signs

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

where

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

$$\sigma_R = \sqrt{\frac{n_1n_2(n_1 + n_2 + 1)}{12}}$$

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: $z = \frac{w_s - \frac{n(n + 1)}{4}}{\sqrt{\frac{n(n + 1)(2n + 1)}{24}}}$

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

Elementary Statistics: A Step-By-Step Approach
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NEGATIVE *z* Scores

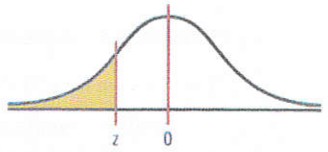

Table E-1 Cumulative Area to the Left of *z* score

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

Formulas and Tables

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POSITIVE *z* Scores

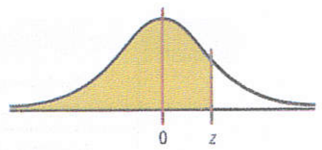

Table E-2 Cumulative Area to the Left of *z* score

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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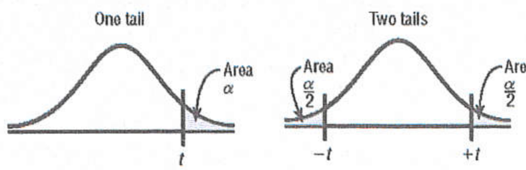
Table F The *t* Distribution

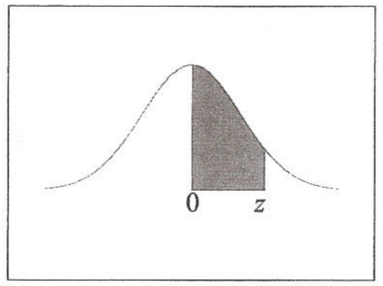
d.f.	Confidence intervals	50%	80%	90%	95%	98%	99%
	One tail, α	0.25	0.10	0.05	0.025	0.01	0.005
	Two tails, α	0.50	0.20	0.10	0.05	0.02	0.01
1		1.000	3.078	6.314	12.706	31.821	63.657
2		.816	1.886	2.920	4.303	6.965	9.925
3		.765	1.638	2.353	3.182	4.541	5.841
4		.741	1.533	2.132	2.776	3.747	4.604
5		.727	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.



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.