UNIVERSITI SAINS MALAYSIA

Final Examination
2016/2017 Academic Session

May/June 2017

JIB 323 – Biostatistics
[Biostatistik]

Duration : 3 hours
[Masa : 3 jam]

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

Ensure Appendix (formula and distribution tables) are enclosed with the question paper.

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

All answers must be written in the answer booklet provided.

Each question is worth 20 marks and the mark for each sub question is given at the end of that sub question.

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

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

Sila pastikan Appendiks (formula dan jadual taburan) disertakan bersama kertas soalan.

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

Setiap jawapan mesti dijawab di dalam buku jawapan yang disediakan.

Setiap soalan bernilai 20 markah dan markah subsoalan diperlihatkan di penghujung subsoalan itu.

Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.

Answer FIVE questions
Jawab LIMA soalan

1. The red-tailed tropic bird, *Phaethon rubricauda,* is a sea bird that nests on several islands of the Queensland Coast of Australia. Table 1 showed the weights of these birds in kg.

Table 1: Weight of *Phaethon rubricauda* (kg)							
Female	2.45	2.57	2.81	2.37	2.01	2.50	2.32
Male	2.86	2.65	2.75	2.60	2.30	2.49	2.84

(a) Calculate the descriptive characteristics for the weights of the females: mean, standard deviation and variance.

(9 marks)

(b) Calculate the descriptive characteristics for the weights of the males: mean, standard deviation and variance.

(9 marks)

(c) Comment on the differences and/or similarities between the two data sets.

(2 marks)

Burung tropika ekor merah, Phaethon rubricauda*, ialah burung laut yang bersarang di beberapa pulau di pantai Queensland Australia. Jadual 1 menunjukkan berat burung tersebut dalam kg.*

Jadual 1: Berat burung Phaethon rubricauda *(kg)*							
Betina	*2.45*	*2.57*	*2.81*	*2.37*	*2.01*	*2.50*	*2.32*
Jantan	*2.86*	*2.65*	*2.75*	*2.60*	*2.30*	*2.49*	*2.84*

(a) *Kira ciri deskriptif untuk berat betina: min, sisihan piawai dan varians.*

(9 markah)

(b) *Kira ciri deskriptif untuk berat jantan: min, sisihan piawai dan varians.*

(9 markah)

(c) *Komen perbezaan dan/atau persamaan antara dua set data.*

(2 markah)

2. Table 2 summarizes the fate of passengers of the sinking Titanic.

Table 2: Summary of passengers				
	Men	Women	Boys	Girls
Survive	332	318	29	27
Did not survive	1360	104	35	18

If one of the Titanic passengers is randomly selected, find;

(a) The probability of getting someone who is a woman or child.

(5 marks)

(b) The probability of getting someone who is a man or someone who survived the sinking.

(5 marks)

(c) The probability of getting a child or someone who survived the sinking.

(5 marks)

(d) The probability of getting a woman or someone who did not survive the sinking.

(5 marks)

Jadual 2 meringkaskan takdir para penumpang Titanic yang tenggelam.

Jadual 2: Ringkasan para penumpang				
	Lelaki Dewasa	*Wanita Dewasa*	*Kanak-kanak lelaki*	*Kanak-kanak perempuan*
Terselamat	*332*	*318*	*29*	*27*
Tidak terselamat	*1360*	*104*	*35*	*18*

Jika salah seorang penumpang Titanic dipilih secara rawak, cari;

(a) Kebarangkalian mendapat seseorang wanita atau kanak-kanak.

(5 markah)

(b) *Kebarangkalian mendapat seorang lelaki atau seorang yang terselamat daripada tenggelam.*

(5 markah)

(c) *Kebarangkalian mendapat seorang kanak-kanak atau seorang yang terselamat daripada tenggelam.*

(5 markah)

(d) *Kebarangkalian mendapat seorang wanita atau seorang yang tidak terselamat daripada tenggelam.*

(5 markah)

3. In a study of a giant tarantula, *Grammostola mollicoma,* a researcher found that the carapace length of the adult male is normally distributed with mean 18.14 mm and a standard deviation 1.76 mm.

(a) Find the percentage of adult male of *G. mollicoma* that have carapace length between 16 and 17 mm. Sketch a graph.

(8 marks)

(b) Find the percentage of adult male of *G. mollicoma* that have carapace length exceeding 19 mm. Sketch a graph.

(8 marks)

(c) Obtain and interpret the 95 percentile for carapace length of the adult male *G. mollicoma.*

(4 marks)

Dalam satu kajian mengenai tarantula gergasi, Grammostola mollicoma, *seorang penyelidik mendapati panjang karapes jantan dewasa bertaburan normal dengan min 18.14 mm dan sisihan piawai 1.76 mm.*

(a) *Cari peratusan jantan dewasa G. mollicoma yang mempunyai panjang karapes antara 16 dan 17 mm. Lakarkan satu graf.*

(8 markah)

(b) *Cari peratusan jantan dewasa G. mollicoma yang mempunyai panjang karapes melebihi 19 mm. Lakarkan satu graf.*

(8 markah)

(c) *Dapatkan dan tafsirkan 95 persentil untuk panjang karapes jantan dewasa* G. mollicoma.

(4 markah)

4. Table 3 showed the birth weights (kg) of male babies born to mothers taking a special vitamin supplement.

Table 3 : Birth weights (kg) of male babies							
3.73	4.37	3.73	4.33	3.39	3.68	4.68	3.52
3.02	4.09	2.47	4.13	4.47	3.22	3.43	2.54

Test the claim that this sample comes from a population with a standard deviation equal to 0.470 kg. Does the vitamin supplement appear to affect the variation among birth weights?

Jadual 3 menunjukkan berat lahir (kg) bayi lelaki yang dilahirkan oleh ibu yang mengambil vitamin tambahan.

Jadual 3: Berat lahir (kg) bayi lelaki							
3.73	4.37	3.73	4.33	3.39	3.68	4.68	3.52
3.02	4.09	2.47	4.13	4.47	3.22	3.43	2.54

Uji dakwaan yang sampel ini datang daripada populasi dengan sisihan piawai bersamaan dengan 0.470 kg. Adakah vitamin tambahan mempengaruhi variasi antara berat lahir?

(20 marks/*markah*)

5. An instructor at Universiti Sains Malaysia recorded the study hours of eight students that were chosen randomly for a calculus course in a period of 2 weeks. Table 4 showed total hours studied (x) and test score (y) after 2 weeks.

Table 4 : Total hours studied (x) and test score (y) after 2 weeks								
x	8	10	12	14	16	18	20	22
y	74	80	80	81	84	84	85	92

(a) Which is the independent variable (IV) and dependent variable (DV)?

(1 mark)

(b) Determine the slope (b_1) of the regression line.

(6 marks)

(c) Determine the y-axis (b_0) intercept of the regression line.

(6 marks)

(d) Write the regression equation.

(2 marks)

(e) What is the estimated test score if a student studied for 9.5 hours?

(5 marks)

Seorang instruktor di Universiti Sains Malaysia merekodkan masa ulangkaji 8 pelajar yang dipilih secara rawak untuk kursus kalkulus dalam jangka masa 2 minggu. Jadual 4 menunjukkan jumlah jam (x) dan markah ujian (y) selepas 2 minggu.

Jadual 4 : Jumlah jam ulangkaji (x) dan markah ujian (y) selepas 2 minggu

x	8	10	12	14	16	18	20	22
y	74	80	80	81	84	84	85	92

(a) *Mana satu pembolehubah tak bersandar (IV) dan pembolehubah bersandar (DV)?*

(1 markah)

(b) *Tentukan kecerunan (b_1) garis regresi linear tersebut.*

(6 markah)

(c) *Tentukan pintasan y-axis(b_0) garisan regresi.*

(6 markah)

(d) *Tulis persamaan regresi linear.*

(2 markah)

(e) *Apakah anggaran markah ujian jika seorang pelajar ulangkaji selama 9.5 jam?*

(5 markah)

6. Independent random samples of copepods were placed in containers containing lipid rich diatoms, bacteria or leafy macroalgae. There were 12 containers in total with four replicates per diet. Five egg-bearing females were place in each container. After 14 days, the number of copepods in each container is shown in Table 5. At 5% significance level, do the data provide sufficient evidence to conclude that a difference exists in mean number of copepods among the three different diet?

Table 5 : Number of copepods

Diatoms	Bacteria	Macroalgae
426	303	277
467	301	324
438	293	302
497	328	272

Sampel rawak bebas kopepod diletakkan di dalam bekas yang mengandungi diatom kaya lipid, bakteria atau makroalga berdaun. Terdapat sejumlah 12 bekas dengan empat replikat setiap diet. Lima ekor betina yang mempunyai telur diletakkan dalam setiap bekas. Selepas 14 hari, bilangan kopepod dalam setiap bekas ditunjukkan dalam Jadual 5. Pada aras keertian 5%, adakah data memberikan bukti yang cukup untuk menyimpulkan wujud perbezaan min bilangan kopepod antara tiga diet yang berbeza?

Jadual 5 : Bilangan kopepod

Diatom	*Bakteria*	*Makroalga*
426	303	277
467	301	324
438	293	302
497	328	272

(20 marks/*markah*)

…10/-

APPENDIX – FORMULA AND TABLES

Ch. 2: Descriptive Statistics

$\bar{x} = \frac{\Sigma x}{n}$ Mean

$\bar{x} = \frac{\Sigma f \cdot x}{\Sigma f}$ Mean (frequency table)

$s = \sqrt{\frac{\Sigma (x - \bar{x})^2}{n - 1}}$ Standard deviation

$s = \sqrt{\frac{n(\Sigma x^2) - (\Sigma x)^2}{n(n - 1)}}$ Standard deviation (shortcut)

$s = \sqrt{\frac{n[\Sigma (f \cdot x^2)] - [\Sigma (f \cdot x)]^2}{n(n - 1)}}$ Standard deviation (frequency table)

variance $= s^2$

Variance $s^2 = \frac{n(\sum x^2) - (\sum x)^2}{n(n-1)}$

Coefficient of variation $CV = \frac{s}{\bar{x}} \times 100$

Ch. 3: Probability

$P(A \text{ or } B) = P(A) + P(B)$ if A, B are mutually exclusive

$P(A \text{ or } B) = P(A) + P(B) - P(A \text{ and } B)$
if A, B are not mutually exclusive

$P(A \text{ and } B) = P(A) \cdot P(B)$ if A, B are independent

$P(A \text{ and } B) = P(A) \cdot P(B|A)$ if A, B are dependent

$P(\bar{A}) = 1 - P(A)$ Rule of complements

${}_nP_r = \frac{n!}{(n - r)!}$ Permutations (no elements alike)

$\frac{n!}{n_1!\, n_2! \ldots n_k!}$ Permutations (n_1 alike, ...)

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

Ch. 5: Normal Distribution

$z = \dfrac{x - \bar{x}}{s}$ or $\dfrac{x - \mu}{\sigma}$ Standard score

$\mu_{\bar{x}} = \mu$ Central limit theorem

$\sigma_{\bar{x}} = \dfrac{\sigma}{\sqrt{n}}$ Central limit theorem (Standard error)

Ch. 7: Test Statistics (one population)

$z = \dfrac{\hat{p} - p}{\sqrt{\dfrac{pq}{n}}}$ Proportion—one population

$z = \dfrac{\bar{x} - \mu}{\sigma/\sqrt{n}}$ Mean—one population (σ known)

$t = \dfrac{\bar{x} - \mu}{s/\sqrt{n}}$ Mean—one population (σ unknown)

$\chi^2 = \dfrac{(n-1)s^2}{\sigma^2}$ Standard deviation or variance—one population

Ch. 9: Linear Correlation/Regression

Correlation $r = \dfrac{n\Sigma xy - (\Sigma x)(\Sigma y)}{\sqrt{n(\Sigma x^2) - (\Sigma x)^2}\sqrt{n(\Sigma y^2) - (\Sigma y)^2}}$

$b_1 = \dfrac{n\Sigma xy - (\Sigma x)(\Sigma y)}{n(\Sigma x^2) - (\Sigma x)^2}$

$b_0 = \bar{y} - b_1\bar{x}$ or $b_0 = \dfrac{(\Sigma y)(\Sigma x^2) - (\Sigma x)(\Sigma xy)}{n(\Sigma x^2) - (\Sigma x)^2}$

$\hat{y} = b_0 + b_1 x$ Estimated eq. of regression line

$r^2 = \dfrac{\text{explained variation}}{\text{total variation}}$

$s_e = \sqrt{\dfrac{\Sigma(y - \hat{y})^2}{n - 2}}$ or $\sqrt{\dfrac{\Sigma y^2 - b_0\Sigma y - b_1\Sigma xy}{n - 2}}$

$\hat{y} - E < y < \hat{y} + E$

where $E = t_{\alpha/2}s_e\sqrt{1 + \dfrac{1}{n} + \dfrac{n(x_0 - \bar{x})^2}{n(\Sigma x^2) - (\Sigma x)^2}}$

Ch. 11: One-Way Analysis of a Variance

$df_{between} = k - 1$

$df_{within} = N - k$

$df_{total} = N - 1$

$\bar{\bar{x}} = \frac{\Sigma x}{N}$ mean of all values combined

$F = \frac{variance\ between\ samples}{variance\ within\ samples}$ or $F = \frac{MS_{between}}{MS_{within}}$

$MS_{between} = \frac{SS_{between}}{k-1}$ $MS_{within} = \frac{SS_{within}}{N-k}$ $MS_{total} = \frac{SS_{total}}{N-1}$

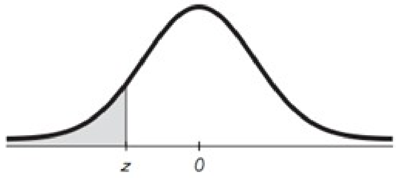
$SS_{between} = n_1(\bar{x}_1 - \bar{\bar{x}})^2 + n_2(\bar{x}_2 - \bar{\bar{x}})^2 + \ldots + n_k(\bar{x}_k - \bar{\bar{x}})^2$

$SS_{within} = \sum_1 (x_{i1} - \bar{x}_1)^2 + \sum_2 (x_{i2} - \bar{x}_2)^2 + \ldots + \sum_k (x_{ik} - \bar{x}_k)^2$

$SS_{total} = \sum_1 (x_{i1} - \bar{\bar{x}}_1)^2 + \sum_2 (x_{i2} - \bar{\bar{x}}_2)^2 + \ldots + \sum_k (x_{ik} - \bar{\bar{x}}_k)^2$

$= \Sigma (x - \bar{\bar{x}})^2$

$SS_{total} = SS_{between} + SS_{within}$



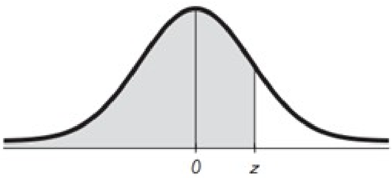
NEGATIVE *z* Scores

TABLE A-2 Standard Normal (*z*) Distribution: Cumulative Area from the LEFT

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
−3.50 and lower	.0001									
−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

NOTE: For values of *z* below −3.49, use 0.0001 for the area.
*Use these common values that result from interpolation:

z score	Area
−1.645	0.0500
−2.575	0.0050



POSITIVE *z* Scores

TABLE A-2 (continued) Cumulative Area from the LEFT

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
3.50 and up	.9999									

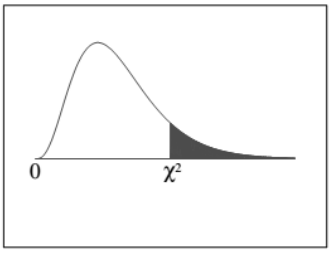
NOTE: For values of *z* above 3.49, use 0.9999 for the area.
*Use these common values that result from interpolation:

z score	Area
1.645	0.9500
2.575	0.9950

Common Critical Values

Confidence Level	Critical Value
0.90	1.645
0.95	1.96
0.99	2.575

Chi-Square Distribution Table



The shaded area is equal to α for $\chi^2 = \chi^2_\alpha$.

df	$\chi^2_{.995}$	$\chi^2_{.990}$	$\chi^2_{.975}$	$\chi^2_{.950}$	$\chi^2_{.900}$	$\chi^2_{.100}$	$\chi^2_{.050}$	$\chi^2_{.025}$	$\chi^2_{.010}$	$\chi^2_{.005}$
1	0.000	0.000	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	11.070	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	28.300
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	14.041	30.813	33.924	36.781	40.289	42.796
23	9.260	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	43.195	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	14.256	16.047	17.708	19.768	39.087	42.557	45.722	49.588	52.336
30	13.787	14.953	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

…16/-

F Values for $\alpha = 0.05$

d_2 \ d_1	1	2	3	4	5	6	7	8	9
1	161.4	199.5	215.7	224.6	230.2	234.0	236.8	238.9	240.5
2	18.51	19.00	19.16	19.25	19.3	19.33	19.35	19.37	19.38
3	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30
25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28
26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27
27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25
28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24
29	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04
120	3.92	3.07	2.68	2.45	2.29	2.17	2.09	2.02	1.96
inf	3.84	3.00	2.60	2.37	2.21	2.10	2.01	1.94	1.88

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