Concordia University

Department of Economics

ECONOMICS 221/2

FINAL EXAMINATION

The examination comprises two sections: Section A and Section B. Section A contains 10 multiple choice questions worth 2 marks each for a total of 20 marks. Section B contains 4 questions worth 20 marks each for a total of 80 marks. Candidates should attempt each and every question. Please indicate the best answer to each question in Section A on the IBM computer sheet provided. Answers to questions in Section B should be written in the examination answer booklet. Non-programmable calculators are permitted.

Section A

This section contains 10 questions worth 2 marks each for a total of 20 marks. Please indicate the best answer to each question on the computer sheet provided.

1. The 95% confidence interval for the population mean μ is $101.2 \leq \mu \leq 112.8$, the interpretation of which is:
   a) The population mean varies between 101.2 and 112.8 95% of the time
   b) 95% of the time the true mean lies between 101.2 and 112.8
   c) The bounds, 101.2 and 112.8 for this sample, vary from sample to sample and in 95% of samples corresponding limits will contain the true value of the parameter μ
   d) In 95 of every 100 samples, the limits 101.2 and 112.8 will contain the true value of μ

2. In testing a null hypothesis H_o against an alternative H_a, the size or significance level α of the test is:
   a) the number of times H_o will be rejected
   b) the probability that H_o will be rejected on the hypothesis that H_o holds
   c) the probability that H_o will be rejected on the hypothesis that H_a holds
   d) the probability that H_a will be rejected on the hypothesis that H_o holds

3. In testing a statistical hypothesis H_o against an alternative H_a, the significance level is α and power of the test is:
   a) $(1-\alpha)$
   b) Pr (do not reject $H_o \mid H_a$ holds)
   c) Pr (reject $H_o \mid H_a$ holds)
   d) Pr (reject $H_o \mid H_o$ holds)
   e) None of the above

Questions 4 – 6 are based on the following information. The number of between-meal snacks eaten by students in a day during final examinations is thought to depend on the number of exams a student had to take on that day. The accompanying table displays the joint probability distribution.

Number of Snacks (Y)	Number of Exams (X)			
	0	1	2	3
0	0.07	0.09	0.06	0.01
1	0.07	0.06	0.07	0.01
2	0.06	0.07	0.14	0.03
3	0.02	0.04	0.16	0.04

4. E(X) is
   a) 1.65
   b) 2.21
   c) 1.39
   d) 1.59
   e) None of the above

5. E(X + Y) is
   a) 3.00
   b) 2.98
   c) 2.78
   d) 3.18
   e) None of the above

6. The variance of (3X – 4Y) is
   a) 19.5504
   b) 27.2715
   c) 20.0139
   d) 19.1139
   e) 10.3399

SECTION B

This section contains 4 questions worth 20 marks each for a total of 80 marks. Please write your answers in the examination answer booklet.

11. A certain normal population is known to have a standard deviation of 25 units. You are asked, as a statistician, to estimate through random sampling the mean of this population so that your estimate is within 4 units of its true value, with 98% confidence.

    (a) By carrying out appropriate calculations, what sample size would you choose?

    (b) If the confidence level were 95%, instead of 98%, without doing any further calculations, how would your answer to (a) change? Would the sample size increase or decrease or stay the same? Explain.

    (c) If, when the sample is drawn, the sample standard deviation turns out to be $s = 23.42$, which standard deviation would you use to find a confidence interval for the true mean: $\sigma = 25$ or $s = 23.42$? Explain carefully the inherent difference between σ and s and how this is accommodated in the distribution you apply to find a confidence interval.

12. A social scientist claims that, on average, adults watch *less than* 26 hours of television per week. Data are collected on the television-viewing habits of 25 randomly selected individuals. This sample indicates that the mean number of hours per week of watching television for an individual is 22.4 hours.

    (a)Formulate a suitable null and alternative hypothesis for testing the social scientist's claim.

    (b) If the population standard deviation is known to be $\sigma = 8$ hours, can it be concluded, at the 1% significance level, that the social scientist is right?

    (c) Would your answer to (b) change if the population standard deviation were unknown but was estimated to be $s = 8$ hours? Explain.

    (d) What is the p - value of the calculated test statistic in (b)?

13. An automobile manufacturer asks you to examine the number of defects in the cars it produces. From its output, 10 cars are randomly selected and the following numbers of defects (x_i) are observed ($i = 1, 2, \ldots, 10$)

10, 8, 6, 12, 15, 9, 11, 10, 8, 11.

Assuming these observations are drawn from a normal population:

(a) Calculate the mean ($\bar{x}$) and the variance (s^2) of the sample.

(b) Estimate, with 90% confidence, the (true) mean number of defects among the automobile manufacturer's cars.

(c) Estimate, with 90% confidence, the (true) variance of the number of defects in the manufacturer's cars.

14. In a rural economic development programme, a random sample of 27 fields were planted with rice using an established procedure and the sample mean output was 60 bushels per hectare with a sample variance of 100 bushels^2 per hectare. The next year a new procedure was used yielding a sample mean output of 64 bushels per hectare and a sample variance of 150 bushels^2 per hectare. Assuming normality with the population variances equal:

(a) Test the hypothesis, with probability of type I error = 0.05, that the new process leads to higher output per hectare.

(b) Using an appropriate test at the same level of significance, do the observed variances lead to the conclusion that the population variances are equal?

Name..

Student ID Number..

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Department of Economics

ECONOMICS 221/2

ALTERNATE FINAL EXAMINATION

Fall 2010

The examination comprises two sections: Section A and Section B. Section A contains 10 multiple choice questions worth 2 marks each for a total of 20 marks. Section B contains 4 questions worth 20 marks each for a total of 80 marks. Candidates should attempt each and every question. Please indicate the best answer to each question in Section A on the IBM computer sheet provided. Answers to questions in Section B should be written in the examination answer booklet. Non-programmable calculators are permitted.

Section A

This section contains 10 questions worth 2 marks each for a total of 20 marks. Please indicate the best answer to each question on the computer sheet provided.

1. The 95% confidence interval for the population mean μ is $101.2 \leq \mu \leq 112.8$, the interpretation of which is:
   - a) The population mean varies between 101.2 and 112.8 95% of the time
   - b) 95% of the time the true mean lies between 101.2 and 112.8
   - c) The bounds, 101.2 and 112.8 for this sample, vary from sample to sample and in 95% of samples corresponding limits will contain the true value of the parameter μ
   - d In 95 of every 100 samples, the limits 101.2 and 112.8 will contain the true value of μ
   - e) All of the above

2. In testing a statistical hypothesis H_o against an alternative H_a, the significance level is α and power of the test is:
   - a) $(1-\alpha)$
   - b) Pr (do not reject $H_o | H_a$ holds)
   - c) Pr (reject $H_o | H_a$ holds)
   - d) Pr (reject $H_o | H_o$ holds)
   - e) None of the above

3. In testing a null hypothesis H_o against an alternative H_a, the size or significance level of the test is:
   - a) the number of times H_o will be rejected
   - b) the probability that H_o will be rejected on the hypothesis that H_o holds
   - c) the probability that H_o will be rejected on the hypothesis that H_a holds
   - d) the probability that H_a will be rejected on the hypothesis that H_o holds
   - e) None of the above

4. If $X \sim N(\mu, \sigma^2)$ and $\{x_1, x_2, \ldots, x_n\}$ is a random sample from this distribution, yielding $\bar{x} = (1/n)\Sigma x_i$ and $s^2 = \{\Sigma(x_1 - \bar{x})^2 / (n - 1)\}$, then $\{(n-1)\, s^2/\sigma^2\}$ is distributed as:

a) t(n-1)
b) F(1, n-1)
c) χ^2(n-1)
d) N(0,1)
e) None of the above

5. A multiple-choice quiz contains five questions, each having five possible answers, a, b,....,e. A student, who has not studied for the quiz, decides to answer each question by randomly selecting the answer from the five possible answers. The probability that the student will get at least one answer correct is:

a) 0.3023
b) 0.6723
c) 0.2467
d) 0.6199
e) None of the above

6. In a certain population, the probability that a person has an Internet connection at home is 0.37. Similarly, the probability that a person has access to the Internet at work is 0.41. Of all the people who have access to the Internet at work, the probability that they have corresponding access at home is 0.60. Of all the people who have an Internet connection at home, the probability that they have corresponding access at work is:

a) 0.3324
b) 0.5585
c) 0.6649
d) 0.4149
e) 0.5824

7. Four women and six men are proposed for a committee of four. An election is held in which voting is random. The probability that the committee will comprise two women and two men is:

a) .4386
b) .6543
c) .6824
d) .3456
e) .4286

8. Men (M) and Women (W) in a sample have either blue (B_1) or brown (B_2) eyes. $P(W|B_1)$ is equal to:

a) $P(W \cap B_1) / P(B_1)$
b) $P(B_1|W) P(W) / P(B_1)$
c) $P(B_1|W) P(W) / P(B_1|W) P(W) + P(B_1|M) P(M)$
d) a) and b) but not a)
e) a), b) and c)

9. If X and Y are any random variables, which of the following is **NOT** always true?

a) $E(X+Y) = E(X) + E(Y)$
b) $V(X+Y) = V(X) + V(Y)$
c) $E(4X+5Y) = 4E(X) + 5E(Y)$
d) $V(4X+5Y) = 16V(X) + 25V(Y) + 40cov(X,Y,)$
e) $Cov(X,Y,) = E(XY) - E(X)E(Y)$

10. All deliveries to a warehouse are by these companies: Smith and Co., Jones Ltd. and Evans and Son Inc. 30% of all deliveries are by Smith; 50% are by Jones and 20% are by Evans. If Smith delivers, 4% of the deliveries are damaged; if Jones delivers, 2% are damaged and if delivery is by Evans, 3% are damaged. An item is selected randomly from the warehouse and is found to be damaged. That item was most likely to have been delivered by:

a) Jones or Smith, equally likely
b) Evans
c) Smith
d) Jones
e) Evans or Jones, equally likely

SECTION B

This section contains 4 questions worth 20 marks each for a total of 80 marks. Please write your answers in the examination answer booklet.

11. A certain normal population is known to have a standard deviation of 25 units. You are asked, as a statistician, to estimate through random sampling the mean of this population so that the margin of error is at most 4 units on each side of the sample mean, with 98% confidence.

    a) By carrying out appropriate calculations, what sample size would you choose?

    b) If the confidence level were 95%, instead of 98%, how would your answer to a) change? Would the sample size increase or decrease or stay the same? Explain carefully.

    c) If, when the sample is drawn, the sample standard deviation turns out to be $s = 23.42$, which standard deviation would you use to find a confidence interval for the true mean: $\sigma = 25$ or $s = 23.42$? And which distribution would you apply, depending on which standard deviation is used?

    d) *Explain carefully* the inherent difference between σ and s and how this is accommodated in the distribution you apply to find a confidence interval.

12. In a rural economic development programme, a random sample of 27 fields were planted with rice, using an established procedure, and the sample mean output was 60 bushels per hectare with a sample variance of 100 bushels^2 per hectare. The next year a new procedure was used yielding a sample mean output of 64 bushels per hectare and a sample variance of 150 bushels^2 per hectare, from a random sample of 31 fields. Assuming normality with the population variances equal:

    a) Using an appropriate test, with probability of type 1 error = 0.06, do the observed variances lead to the conclusion that the population variances are equal?

b) Using the outcomes of a) test the hypothesis, at the same level of significance, that the new process leads to higher output per hectare.

c) What is the p-value for the test in b)?

d) *Explain carefully* why the outcome of the test in part a) is important for the test you execute in part b).

13. An automobile manufacturer asks you to examine the number of defects in the cars it produces. From its output, 10 cars are randomly selected and the following numbers of defects (x_i) are observed ($i = 1, 2, \ldots, 10$)

10, 8, 6, 12, 15, 9, 11, 10, 8, 11.

Assuming these observations are drawn from a normal population:

a) Calculate the mean ($\bar{x}$) and the variance (s^2) of the sample

b) Estimate, with 90% confidence, the (true) mean number of defects among the automobile manufacturer's cars.

c) Estimate, with 90% confidence, the (true) variance of the number of defects in the manufacturer's cars.

d) Explain carefully why it is important that the observations come from a normal distribution.

14. To compare the effectiveness of two different drugs for the treatment of cholesterol, a paired sampling approach was adopted. Each member of a pair was matched according to various relevant characteristics. Drug X was then administered to one person randomly chosen from each pair and drug Y was given to the other individual of the pair. A random sample of 8 pairs of patients was selected from the large population of people with cholesterol problems, and differences in the reduction of cholesterol, $x_i - y_i = di$, were obtained, yielding a sample mean $\bar{d} = 1.625$ and a sample standard deviation $s = 3.777$.

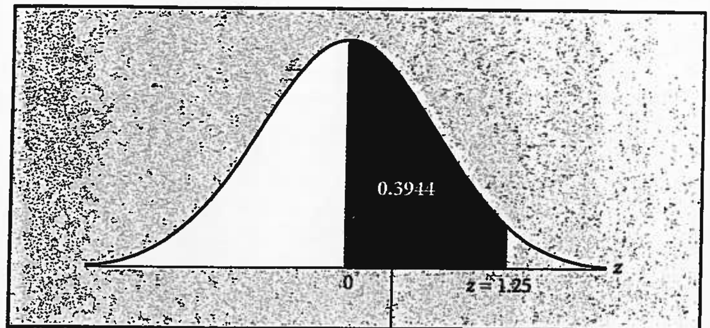
a) Compute the 99% confidence interval for the difference in population means, $\mu_x - \mu_y$.

b) What can you conclude about the relative effectiveness of the two drugs from this confidence interval? Which, if any, of the two drugs is more effective in reducing cholesterol, at the 99% level of confidence?

c) On what assumptions is your 99% confidence interval based?

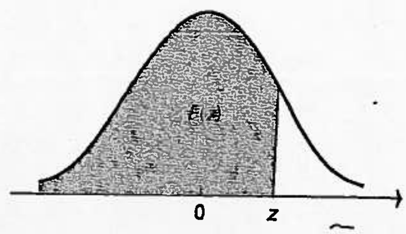
d) You are now asked to test $H_o : \mu_x - \mu_y = 0$ against the one-sided alternative H_a: $\mu_x - \mu_y > 0$ at the 1% level of significance. Is the result of this test consistent with your answer to (b) above? Explain.

Standard Normal Distribution Table

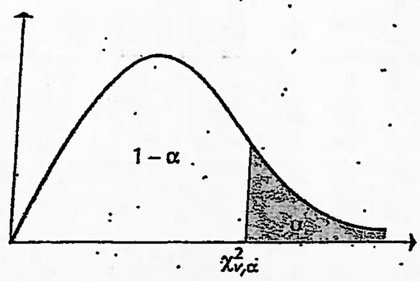


z	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.0
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.03
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.07
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.11
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.15
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.18
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.22
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.25
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.28
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.31
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.33
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.36
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.38
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.40
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.41
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.43
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.44
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.45
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.46
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.47
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.47
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.48
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.48
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.48
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.49
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.49
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.49
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.49
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.49
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.49
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.49
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.49

Cumulative Distribution Function of the Standard Normal Distribution

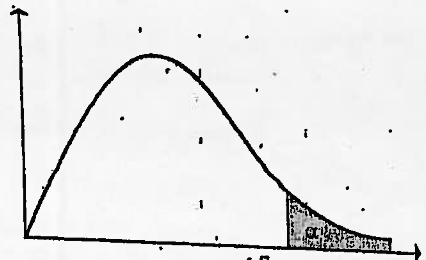


z	F(z)	z	F(z)	z	F(z)	z	F(z)	z	F(z)	z	F(z)
.00	.5000										
.01	.5040	.31	.6217	.61	.7291	.91	.8186	1.21	.8869	1.51	.9345
.02	.5080	.32	.6255	.62	.7324	.92	.8212	1.22	.8888	1.52	.9357
.03	.5120	.33	.6293	.63	.7357	.93	.8238	1.23	.8907	1.53	.9370
.04	.5160	.34	.6331	.64	.7389	.94	.8264	1.24	.8925	1.54	.9382
.05	.5199	.35	.6368	.65	.7422	.95	.8289	1.25	.8944	1.55	.9394
.06	.5239	.36	.6406	.66	.7454	.96	.8315	1.26	.8962	1.56	.9406
.07	.5279	.37	.6443	.67	.7486	.97	.8340	1.27	.8980	1.57	.9418
.08	.5319	.38	.6480	.68	.7517	.98	.8365	1.28	.8997	1.58	.9429
.09	.5359	.39	.6517	.69	.7549	.99	.8389	1.29	.9015	1.59	.9441
.10	.5398	.40	.6554	.70	.7580	1.00	.8413	1.30	.9032	1.60	.9452
.11	.5438	.41	.6591	.71	.7611	1.01	.8438	1.31	.9049	1.61	.9463
.12	.5478	.42	.6628	.72	.7642	1.02	.8461	1.32	.9066	1.62	.9474
.13	.5517	.43	.6664	.73	.7673	1.03	.8485	1.33	.9082	1.63	.9484
.14	.5557	.44	.6700	.74	.7704	1.04	.8508	1.34	.9099	1.64	.9495
.15	.5596	.45	.6736	.75	.7734	1.05	.8531	1.35	.9115	1.65	.9505
.16	.5636	.46	.6772	.76	.7764	1.06	.8554	1.36	.9131	1.66	.9515
.17	.5675	.47	.6803	.77	.7794	1.07	.8577	1.37	.9147	1.67	.9525
.18	.5714	.48	.6844	.78	.7823	1.08	.8599	1.38	.9162	1.68	.9535
.19	.5753	.49	.6879	.79	.7852	1.09	.8621	1.39	.9177	1.69	.9545
.20	.5793	.50	.6915	.80	.7881	1.10	.8643	1.40	.9192	1.70	.9554
.21	.5832	.51	.6950	.81	.7910	1.11	.8665	1.41	.9207	1.71	.9564
.22	.5871	.52	.6985	.82	.7939	1.12	.8686	1.42	.9222	1.72	.9573
.23	.5910	.53	.7019	.83	.7967	1.13	.8708	1.43	.9236	1.73	.9582
.24	.5948	.54	.7054	.84	.7995	1.14	.8729	1.44	.9251	1.74	.9591
.25	.5987	.55	.7088	.85	.8023	1.15	.8749	1.45	.9265	1.75	.9599
.26	.6026	.56	.7123	.86	.8051	1.16	.8770	1.46	.9279	1.76	.9608
.27	.6064	.57	.7157	.87	.8078	1.17	.8790	1.47	.9292	1.77	.9616
.28	.6103	.58	.7190	.88	.8106	1.18	.8810	1.48	.9306	1.78	.9625
.29	.6141	.59	.7224	.89	.8133	1.19	.8830	1.49	.9319	1.79	.9633
.30	.6179	.60	.7257	.90	.8159	1.20	.8849	1.50	.9332	1.80	.9641



For selected probabilities α, the table shows the values $\chi^2_{v,\alpha}$ such that $\alpha = P(\chi^2_v > \chi^2_{v,\alpha})$, where χ^2_v is a chi-square random variable with v degrees of freedom. For example, the probability is .100 that a chi-square random variable with 10 degrees of freedom is greater than 15.99.

v	α									
	.995	.990	.975	.950	.900	.100	.050	.025	.010	.005
1	0.0^4393	0.0^3157	0.0^3982	0.0^2393	0.0158	2.71	3.84	5.02	6.63	7.88
2	0.0100	0.0201	0.0506	0.103	0.211	4.61	5.99	7.38	9.21	10.60
3	0.072	0.115	0.216	0.352	0.584	6.25	7.81	9.35	11.34	12.84
4	0.207	0.297	0.484	0.711	1.064	7.78	9.49	11.14	13.28	14.86
5	0.412	0.554	0.831	1.145	1.61	9.24	11.07	12.83	15.09	16.75
6	0.676	0.872	1.24	1.64	2.20	10.64	12.59	14.45	16.81	18.55
7	0.989	1.24	1.69	2.17	2.83	12.02	14.07	16.01	18.48	20.28
8	1.34	1.65	2.18	2.73	3.49	13.36	15.51	17.53	20.09	21.96
9	1.73	2.09	2.70	3.33	4.17	14.68	16.92	19.02	21.67	23.59
10	2.16	2.56	3.25	3.94	4.87	15.99	18.31	20.48	23.21	25.19
11	2.60	3.05	3.82	4.57	5.58	17.28	19.68	21.92	24.73	26.76
12	3.07	3.57	4.40	5.23	6.30	18.55	21.03	23.34	26.22	28.30
13	3.57	4.11	5.01	5.89	7.04	19.81	22.36	24.74	27.69	29.82
14	4.07	4.66	5.63	6.57	7.79	21.06	23.68	26.12	29.14	31.32
15	4.60	5.23	6.26	7.26	8.55	22.31	25.00	27.49	30.58	32.80
16	5.14	5.81	6.91	7.96	9.31	23.54	26.30	28.85	32.00	34.27
17	5.70	6.41	7.56	8.67	10.09	24.77	27.59	30.19	33.41	35.72
18	6.26	7.01	8.23	9.39	10.86	25.99	28.87	31.53	34.81	37.16
19	6.84	7.63	8.91	10.12	11.65	27.20	30.14	32.85	36.19	38.58
20	7.43	8.26	9.59	10.85	12.44	28.41	31.41	34.17	37.57	40.00
21	8.03	8.90	10.28	11.59	13.24	29.62	32.67	35.48	38.93	41.40
22	8.64	9.54	10.98	12.34	14.04	30.81	33.92	36.78	40.29	42.80
23	9.26	10.20	11.69	13.09	14.85	32.01	35.17	38.08	41.64	44.18
24	9.89	10.86	12.40	13.85	15.66	33.20	36.42	39.36	42.98	45.56
25	10.52	11.52	13.12	14.61	16.47	34.38	37.65	40.65	44.31	46.93
26	11.16	12.20	13.84	15.38	17.29	35.56	38.89	41.92	45.64	48.29
27	11.81	12.88	14.57	16.15	18.11	36.74	40.11	43.19	46.96	49.64
28	12.46	13.56	15.31	16.93	18.94	37.92	41.34	44.46	48.28	50.99
29	13.12	14.26	16.05	17.71	19.77	39.09	42.56	45.72	49.59	52.34
30	13.79	14.95	16.79	18.49	20.60	40.26	43.77	46.98	50.89	53.67
40	20.71	22.16	24.43	26.51	29.05	51.81	55.76	59.34	63.69	66.77
50	27.99	29.71	32.36	34.76	37.69	63.17	67.50	71.42	76.15	79.49
60	35.53	37.48	40.48	43.19	46.46	74.40	79.08	83.30	88.38	91.95
70	43.28	45.44	48.76	51.74	55.33	85.53	90.53	95.02	100.4	104.2
80	51.17	53.54	57.15	60.39	64.28	96.58	101.9	106.6	112.3	116.3
90	59.20	61.75	65.65	69.13	73.29	107.6	113.1	118.1	124.1	128.3
100	67.33	70.06	74.22	77.93	82.36	118.5	124.3	129.6	135.8	140.2



For probabilities $\alpha = 0.5$ and $\alpha = .01$, the tables show the values $F_{v_1,v_2,\alpha}$ such that $P(F_{v_1,v_2} > F_{v_1,v_2,\alpha}) = \alpha$, where F_{v_1,v_2} is an F random variable, with numerator degrees of freedom v_1 and denominator degrees of freedom v_2. For example, the probability is .05 that an $F_{3,7}$ random variable exceeds 4.35.

$\alpha = .05$

DENOMINATOR v_2	NUMERATOR v_1																		
	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	∞
1	161.4	199.5	215.7	224.6	230.2	234.0	236.8	238.9	240.5	241.9	243.9	245.9	248.0	249.1	250.1	251.1	252.2	253.3	254.3
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38	19.40	19.41	19.43	19.45	19.45	19.46	19.47	19.48	19.49	19.50
3	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.74	8.70	8.66	8.64	8.62	8.59	8.57	8.55	8.53
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.91	5.86	5.80	5.77	5.75	5.72	5.69	5.66	5.63
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.68	4.62	4.56	4.53	4.50	4.46	4.43	4.40	4.36
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.00	3.94	3.87	3.84	3.81	3.77	3.74	3.70	3.67
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.57	3.51	3.44	3.41	3.38	3.34	3.30	3.27	3.23
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.28	3.22	3.15	3.12	3.08	3.04	3.01	2.97	2.93
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.07	3.01	2.94	2.90	2.86	2.83	2.79	2.75	2.71
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.91	2.85	2.77	2.74	2.70	2.66	2.62	2.58	2.54
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85	2.79	2.72	2.65	2.61	2.57	2.53	2.49	2.45	2.40
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75	2.69	2.62	2.54	2.51	2.47	2.43	2.38	2.34	2.30
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	2.60	2.53	2.46	2.42	2.38	2.34	2.30	2.25	2.21
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	2.53	2.46	2.39	2.35	2.31	2.27	2.22	2.18	2.13
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.48	2.40	2.33	2.29	2.25	2.20	2.16	2.11	2.07
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	2.42	2.35	2.28	2.24	2.19	2.15	2.11	2.06	2.01
17	4.45	3.59	3.20	2.96	2.81	2.70	2.62	2.55	2.49	2.45	2.38	2.31	2.23	2.19	2.15	2.10	2.06	2.01	1.96
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41	2.34	2.27	2.19	2.15	2.11	2.06	2.02	1.97	1.92
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38	2.31	2.23	2.16	2.11	2.07	2.03	1.98	1.93	1.88
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.28	2.20	2.12	2.08	2.04	1.99	1.95	1.90	1.84
21	4.32	3.47	3.07	2.84	2.68	2.67	2.49	2.42	2.37	2.32	2.25	2.18	2.10	2.05	2.01	1.96	1.92	1.87	1.81
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30	2.23	2.15	2.07	2.03	1.98	1.94	1.89	1.84	1.78
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32	2.27	2.20	2.13	2.05	2.01	1.96	1.91	1.86	1.81	1.76
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.25	2.18	2.11	2.03	1.98	1.94	1.89	1.84	1.79	1.73
25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28	2.24	2.16	2.09	2.01	1.96	1.92	1.87	1.82	1.77	1.71
26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27	2.22	2.15	2.07	1.99	1.95	1.90	1.85	1.80	1.75	1.69
27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25	2.20	2.13	2.06	1.97	1.93	1.88	1.84	1.79	1.73	1.67
28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24	2.19	2.12	2.04	1.96	1.91	1.87	1.82	1.77	1.71	1.65
29	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22	2.18	2.10	2.03	1.94	1.90	1.85	1.81	1.75	1.70	1.64

Cumulative Distribution Function of the Standard Normal Distribution Continued

z	F(z)	z	F(z)	z	F(z)	z	F(z)	z	F(z)	z	F(z)
1.81	.9649	2.21	.9864	2.61	.9955	3.01	.9987	3.41	.9997	3.81	.9999
1.82	.9656	2.22	.9868	2.62	.9956	3.02	.9987	3.42	.9997	3.82	.9999
1.83	.9664	2.23	.9871	2.63	.9957	3.03	.9988	3.43	.9997	3.83	.9999
1.84	.9671	2.24	.9875	2.64	.9959	3.04	.9988	3.44	.9997	3.84	.9999
1.85	.9678	2.25	.9878	2.65	.9960	3.05	.9989	3.45	.9997	3.85	.9999
1.86	.9686	2.26	.9881	2.66	.9961	3.06	.9989	3.46	.9997	3.86	.9999
1.87	.9693	2.27	.9884	2.67	.9962	3.07	.9989	3.47	.9997	3.87	.9999
1.88	.9699	2.28	.9887	2.68	.9963	3.08	.9990	3.48	.9997	3.88	.9999
1.89	.9706	2.29	.9890	2.69	.9964	3.09	.9990	3.49	.9998	3.89	1.0000
1.90	.9713	2.30	.9893	2.70	.9965	3.10	.9990	3.50	.9998	3.90	1.0000
1.91	.9719	2.31	.9896	2.71	.9966	3.11	.9991	3.51	.9998	3.91	1.0000
1.92	.9726	2.32	.9898	2.72	.9967	3.12	.9991	3.52	.9998	3.92	1.0000
1.93	.9732	2.33	.9901	2.73	.9968	3.13	.9991	3.53	.9998	3.93	1.0000
1.94	.9738	2.34	.9904	2.74	.9969	3.14	.9992	3.54	.9998	3.94	1.0000
1.95	.9744	2.35	.9906	2.75	.9970	3.15	.9992	3.55	.9998	3.95	1.0000
1.96	.9750	2.36	.9909	2.76	.9971	3.16	.9992	3.56	.9998	3.96	1.0000
1.97	.9756	2.37	.9911	2.77	.9972	3.17	.9992	3.57	.9998	3.97	1.0000
1.98	.9761	2.38	.9913	2.78	.9973	3.18	.9993	3.58	.9998	3.98	1.0000
1.99	.9767	2.39	.9916	2.79	.9974	3.19	.9993	3.59	.9998	3.99	1.0000
2.00	.9772	2.40	.9918	2.80	.9974	3.20	.9993	3.60	.9998		
2.01	.9778	2.41	.9920	2.81	.9975	3.21	.9993	3.61	.9998		
2.02	.9783	2.42	.9922	2.82	.9976	3.22	.9994	3.62	.9999		
2.03	.9788	2.43	.9925	2.83	.9977	3.23	.9994	3.63	.9999		
2.04	.9793	2.44	.9927	2.84	.9977	3.24	.9994	3.64	.9999		
2.05	.9798	2.45	.9929	2.85	.9978	3.25	.9994	3.65	.9999		
2.06	.9803	2.46	.9931	2.86	.9979	3.26	.9994	3.66	.9999		
2.07	.9808	2.47	.9932	2.87	.9979	3.27	.9995	3.67	.9999		
2.08	.9812	2.48	.9934	2.88	.9980	3.28	.9995	3.68	.9999		
2.09	.9817	2.49	.9936	2.89	.9981	3.29	.9995	3.69	.9999		
2.10	.9821	2.50	.9938	2.90	.9981	3.30	.9995	3.70	.9999		
2.11	.9826	2.51	.9940	2.91	.9982	3.31	.9995	3.71	.9999		
2.12	.9830	2.52	.9941	2.92	.9982	3.32	.9996	3.72	.9999		
2.13	.9834	2.53	.9943	2.93	.9983	3.33	.9996	3.73	.9999		
2.14	.9838	2.54	.9945	2.94	.9984	3.34	.9996	3.74	.9999		
2.15	.9842	2.55	.9946	2.95	.9984	3.35	.9996	3.75	.9999		
2.16	.9846	2.56	.9948	2.96	.9985	3.36	.9996	3.76	.9999		
2.17	.9850	2.57	.9949	2.97	.9985	3.37	.9996	3.77	.9999		
2.18	.9854	2.58	.9951	2.98	.9986	3.38	.9996	3.78	.9999		
2.19	.9857	2.59	.9952	2.99	.9986	3.39	.9997	3.79	.9999		
2.20	.9861	2.60	.9953	3.00	.9986	3.40	.9997	3.80	.9999		