

APR 07 2017

KATHMANDU UNIVERSITY
End Semester Examination
March/April 2017

Marks Scored:

Level : B.E./B.Sc.
Year : II

Course : MATH 208
Semester: I

Exam. Roll No.: _____ Time: 30 mins.

F.M. : 20

Registration No.: _____

Date : _____

SECTION "A"
[10 Q. × 1 = 10 marks]

Fill in the blanks space(s) by most appropriate word(s) or symbol(s).

- Q1. The number of parameters involved in a Poisson distribution is.....
- Q2. The normal distribution is symmetric about.....
- Q3. is a plot of n observations on X_i and Y_i , where each observation is represented by the point (X_i, Y_i)
- Q4. The sample mean minus its hypothesized value by the standard error of the sample mean is test statistics. Here sample size is less than 30 and population variance is not known.
- Q5. The probability of not rolling any 6's in four rolls of a balanced die is
- Q6. The regression equation Y on X hasas independent variable andas dependent variable.
- Q7.Variable takes infinite number of possible values that are not countable
- Q8.is as subset of population being studied.
- Q9. If the inference is to be made about the population mean μ with a given population variance σ^2 , sample size n and the sample mean \bar{X} the appropriate test statistic is
- Q10. The amount of milk produced yearly by a particular cow is random variable.

SECTION: "B"
[10 Q. × 1 = 10 marks]

- Q11. The expected value of a discrete random variable
- a. is the outcome that is most likely to occur.
 - b. can be found by determining the 50% value in the cumulative distribution function
 - c. equals the population median.
 - d. is computed as a weighted average of the possible outcome of that random variable, where the weights are the probabilities of that outcome.

- Q12. Let Y be a random variable. Then $\text{Var}(Y)$ equals
- a. $\sqrt{E(Y - \mu_Y)^2}$ b. $E(|Y - \mu_Y|)$ c. $E(Y - \mu_Y)^2$ d. $E(Y - \mu_Y)$
- Q13. If X is a random variable having the probability density function $f(x)$, then $E(X)$ is called.....
- a. arithmetic mean b. geometric mean c. harmonic mean d. first quartile
- Q14. In a Binomial Distribution with parameters n and p , the relationship between mean and variance is.....
- a. Mean = variance b. Mean < variance
c. Mean > variance d. None of these
- Q15. The area under the standard normal curve beyond the lines $z = \pm 1.96$ is.....
- a. 95% b. 90% c. 5% d. 10%
- Q16. The cumulative probability distribution shows the probability.....
- a. that a random variable is less than or equal to a particular value.
b. of two or more events occurring at once.
c. of all possible events occurring.
d. that a random variable takes on a particular value given that another event has happened
- Q17. Two random variables X and Y are independently distributed if all of the following conditions hold, with *the exception of*.....
- a. $P(Y = y | X = x) = P(Y = y)$.
b. knowing the value of one of the variables provides no information about the other.
c. if the conditional distribution of Y given X equals the marginal distribution of Y .
d. $E(Y) = E[XY]$.
- Q18. The relationship between hours studied at home for a subject and marks obtained in the examination in that subject are examples of
- a. positive correlation b. negative correlation
c. zero correlation d. none of these
- Q19. If we reject a true null hypothesis we say thaterror has been made.
- a) Type I error b) Type II error
c) level of significance d) power of the test.
- Q20. The probability of not rolling any 4's in four rolls of a balanced die is
- (a) $\frac{625}{1296}$ (b) $\frac{1}{1296}$ (c) $\frac{1295}{1296}$ (d) $\frac{671}{1296}$

KATHMANDU UNIVERSITY
End Semester Examination
March/April 2017

APR 07 2017

Level : B.E./B.Sc.
Year : II
Time : 2 hrs. 30 mins.

Course : MATH 208
Semester: I
F.M. : 55

SECTION "C"

[3 Q.×7=21 marks]

1. The level of impurity (in percent) in the product of a certain chemical process is a random variable with probability density function [2+2+3]

$$\begin{cases} \frac{3}{64}x^2(4-x) & 0 < x < 4 \\ 0 & \text{otherwise} \end{cases}$$

- What is the probability that the impurity level is greater than 3%?
 - What is the probability that the impurity level is between 2% and 3%?
 - Find the cumulative distribution function of the impurity level.
2. The calculation of the ages of several sediments sample taken at various depths (in cm) are given below. [1+ 2+2+2]

Depth	Age
284.5	125.5
407.5	3390
512.0	5560
551.0	6670
578.5	7160
697.0	9820
746.5	11030

- Construct a scatter plot of age (y) versus depth (x). Verify that a linear model is appropriate.
- Compute the least squares line for predicting age from depth.
- If two samples differ by 100 cm in depth, by how much would you predict their age to differ?
- Predict the age for a specimen whose depth is 600cm.

3. A group of eight individuals with high cholesterol levels were given a new drug that was designed to lower cholesterol levels. Cholesterol levels, in mg/dL, were measured before and after treatment for each individual, with the following results: [4+ 3]

Subject	Before	After
1	283	215
2	299	206
3	274	187
4	284	212
5	248	178
6	275	212
7	293	192
8	277	196

- a. Can you conclude that the mean cholesterol level after treatment is less than the mean before treatment?
- b. Find a 95 % confidence interval for the mean difference between before and after treatments.

SECTION "D"

[6Q.×4 = 24 marks]

4. Math scores are each distributed normally with $N(500, 10000)$ (a) What fraction of students scores above 750? b) Between 420 and 530? c) Above 480
5. In a sample of 100 steel wires the average breaking strength is 50kN, with a standard deviation of 2kN. Find a 95% confidence interval for the mean breaking strength of this type of wire.
6. In 64 randomly selected hours of production, the mean and standard deviation of the number of acceptable pieces produced by an automatic stamping machine are $\bar{x} = 1038$ and $s = 146$. At the .05 level of significance does this enable us to reject the null hypothesis $\mu = 1000$ against the alternative hypothesis $\mu > 1000$?

7. Each hour, a $10m^2$ section of a fabric is inspected for flaws. The number of flaws observed for the last 20 hours are as follows:

38 35 35 49 33 48 40 47 45 46 41 53 36
 41 51 63 35 58 55 57

- a. Compute the upper and lower 3σ limits for c chart
- b. Is the process in control? If not, when is it first detected to be out of control

8. Following are the concentrations of total ester(in mg/L) in each of the wimes.
284.34, 173.01, 229.55, 312.95, 215.34, 188.72, 144.39, 172.79, 139.38, 197.81, 303.28, 254.02, 658.38, 105.14, 295.24, 170.41

Compute Mean and Median concentrations

9. For the data given in Question 8 find the a) first quartile of the concentration b) Third quartile of the concentrations c) Construct and interpret box plot

SECTION "E"

[5Q. \times 2=10 marks]

10. Life times of batteries in a certain application are normally distributed with mean 50 hours and standard deviation 5 hours. Find the probability that a randomly chosen battery lasts between 42 and 52 hours.
11. In a sample of 123 hip surgeries of a certain type, average surgery time was 136.9 minutes with a standard deviation of 22.6 minutes. A surgeon claims that the mean surgery time is between 133.9 and 139.9 minutes. With what level of confidence can this statement be made?
12. With reference to question no. 11, approximately how many surgeries must be sampled so that 95%confidence interval will specify the mean to within ± 3 minutes.
13. A random sample of weight of 10 filled bags of candy in oz is given below.
15.87 16.02 15.78 15.83 15.69 15.81 16.04 15.81 15.92 16.10
On the basis of these data, can you conclude that the mean weight is actually less than 16 oz? Let $\alpha = 0.05$
14. The length of a rivet manufactured by a certain process has mean equal to 50 mm and standard deviation is equal to 0.45 mm. Use Chebyshev's inequality to find the largest possible probability that the length of the rivet is outside the interval 49.1 – 50.9 mm.

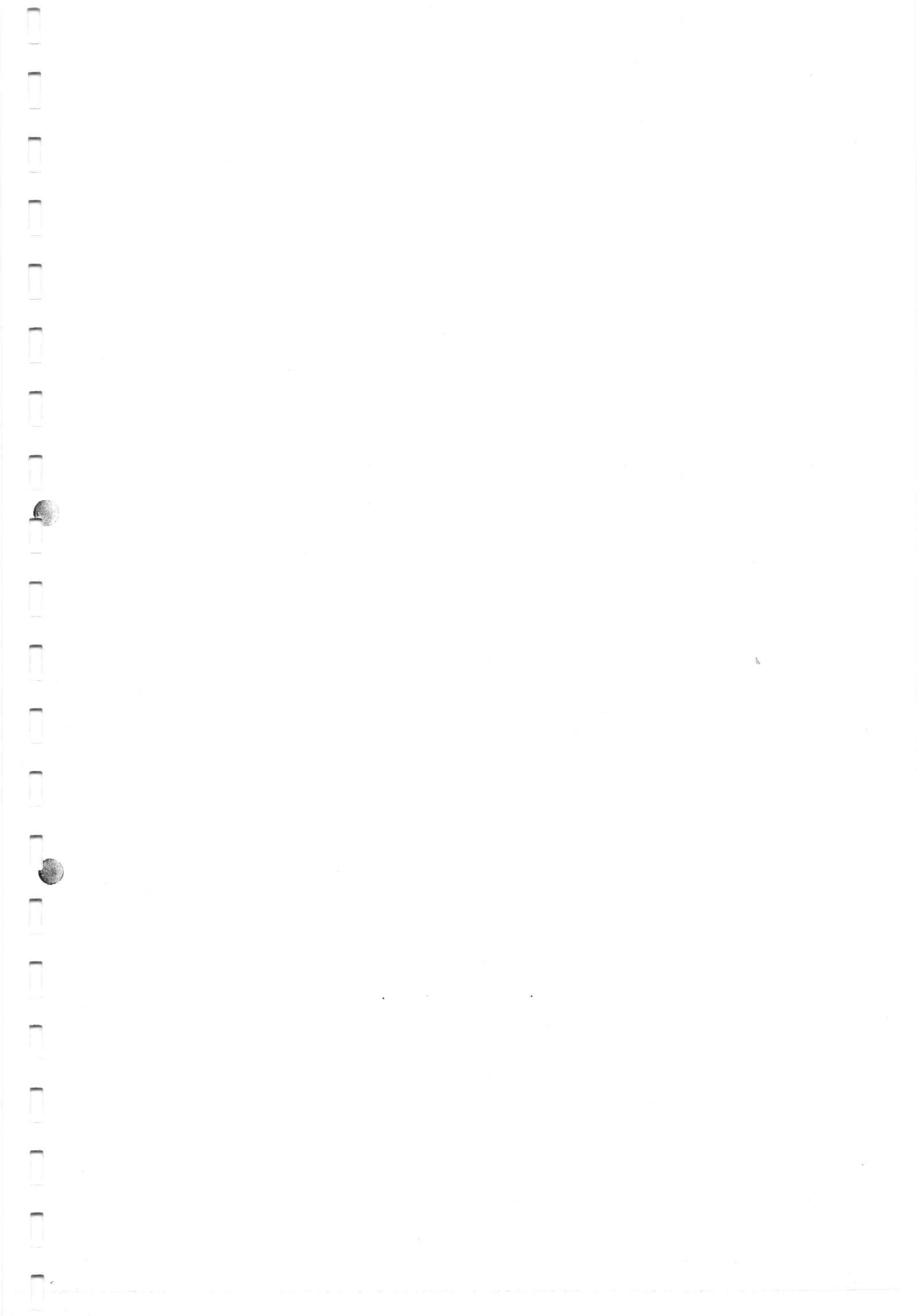


Table II Cumulative Standard Normal Distribution

$$\Phi(z) = \int_{-\infty}^z \frac{1}{\sqrt{2\pi}} e^{-u^2/2} du$$

z	0.00	0.01	0.02	0.03	0.04	z
0.0	0.50000	0.50399	0.50798	0.51197	0.51595	0.0
0.1	0.53983	0.54379	0.54776	0.55172	0.55567	0.1
0.2	0.57926	0.58317	0.58706	0.59095	0.59483	0.2
0.3	0.61791	0.62172	0.62551	0.62930	0.63307	0.3
0.4	0.65542	0.65910	0.66276	0.66640	0.67003	0.4
0.5	0.69146	0.69497	0.69847	0.70194	0.70540	0.5
0.6	0.72575	0.72907	0.73237	0.73565	0.73891	0.6
0.7	0.75803	0.76115	0.76424	0.76730	0.77035	0.7
0.8	0.78814	0.79103	0.79389	0.79673	0.79954	0.8
0.9	0.81594	0.81859	0.82121	0.82381	0.82639	0.9
1.0	0.84134	0.84375	0.84613	0.84849	0.85083	1.0
1.1	0.86433	0.86650	0.86864	0.87076	0.87285	1.1
1.2	0.88493	0.88686	0.88877	0.89065	0.89251	1.2
1.3	0.90320	0.90490	0.90658	0.90824	0.90988	1.3
1.4	0.91924	0.92073	0.92219	0.92364	0.92506	1.4
1.5	0.93319	0.93448	0.93574	0.93699	0.93822	1.5
1.6	0.94520	0.94630	0.94738	0.94845	0.94950	1.6
1.7	0.95543	0.95637	0.95728	0.95818	0.95907	1.7
1.8	0.96407	0.96485	0.96562	0.96637	0.96711	1.8
1.9	0.97128	0.97193	0.97257	0.97320	0.97381	1.9
2.0	0.97725	0.97778	0.97831	0.97882	0.97932	2.0
2.1	0.98214	0.98257	0.98300	0.98341	0.98382	2.1
2.2	0.98610	0.98645	0.98679	0.98713	0.98745	2.2
2.3	0.98928	0.98956	0.98983	0.99010	0.99036	2.3
2.4	0.99180	0.99202	0.99224	0.99245	0.99266	2.4
2.5	0.99379	0.99396	0.99413	0.99430	0.99446	2.5
2.6	0.99534	0.99547	0.99560	0.99573	0.99585	2.6
2.7	0.99653	0.99664	0.99674	0.99683	0.99693	2.7
2.8	0.99744	0.99752	0.99760	0.99767	0.99774	2.8
2.9	0.99813	0.99819	0.99825	0.99831	0.99836	2.9
3.0	0.99865	0.99869	0.99874	0.99878	0.99882	3.0
3.1	0.99903	0.99906	0.99910	0.99913	0.99916	3.1
3.2	0.99931	0.99934	0.99936	0.99938	0.99940	3.2
3.3	0.99952	0.99953	0.99955	0.99957	0.99958	3.3
3.4	0.99966	0.99968	0.99969	0.99970	0.99971	3.4
3.5	0.99977	0.99978	0.99978	0.99979	0.99980	3.5
3.6	0.99984	0.99985	0.99985	0.99986	0.99986	3.6
3.7	0.99989	0.99990	0.99990	0.99990	0.99991	3.7
3.8	0.99993	0.99993	0.99993	0.99994	0.99994	3.8
3.9	0.99995	0.99995	0.99996	0.99996	0.99996	3.9

(continues)

Table II Cumulative Standard Normal Distribution (continued)

$$\Phi(z) = \int_{-\infty}^z \frac{1}{\sqrt{2\pi}} e^{-u^2/2} du$$

z	0.05	0.06	0.07	0.08	0.09
0.0	0.51994	0.52392	0.52790	0.53188	0.53586
0.1	0.55962	0.56356	0.56749	0.57142	0.57534
0.2	0.59871	0.60257	0.60642	0.61026	0.61409
0.3	0.63683	0.64058	0.64431	0.64803	0.65173
0.4	0.67364	0.67724	0.68082	0.68438	0.68793
0.5	0.70884	0.71226	0.71566	0.71904	0.72240
0.6	0.74215	0.74537	0.74857	0.75175	0.75490
0.7	0.77337	0.77637	0.77935	0.78230	0.78523
0.8	0.80234	0.80510	0.80785	0.81057	0.81327
0.9	0.82894	0.83147	0.83397	0.83646	0.83891
1.0	0.85314	0.85543	0.85769	0.85993	0.86214
1.1	0.87493	0.87697	0.87900	0.88100	0.88297
1.2	0.89435	0.89616	0.89796	0.89973	0.90147
1.3	0.91149	0.91308	0.91465	0.91621	0.91773
1.4	0.92647	0.92785	0.92922	0.93056	0.93189
1.5	0.93943	0.94062	0.94179	0.94295	0.94408
1.6	0.95053	0.95154	0.95254	0.95352	0.95448
1.7	0.95994	0.96080	0.96164	0.96246	0.96327
1.8	0.96784	0.96856	0.96926	0.96995	0.97062
1.9	0.97441	0.97500	0.97558	0.97615	0.97670
2.0	0.97982	0.98030	0.98077	0.98124	0.98169
2.1	0.98422	0.98461	0.98500	0.98537	0.98574
2.2	0.98778	0.98809	0.98840	0.98870	0.98899
2.3	0.99061	0.99086	0.99111	0.99134	0.99158
2.4	0.99286	0.99305	0.99324	0.99343	0.99361
2.5	0.99461	0.99477	0.99492	0.99506	0.99520
2.6	0.99598	0.99609	0.99621	0.99632	0.99643
2.7	0.99702	0.99711	0.99720	0.99728	0.99736
2.8	0.99781	0.99788	0.99795	0.99801	0.99807
2.9	0.99841	0.99846	0.99851	0.99856	0.99861
3.0	0.99886	0.99889	0.99893	0.99897	0.99900
3.1	0.99918	0.99921	0.99924	0.99926	0.99929
3.2	0.99942	0.99944	0.99946	0.99948	0.99950
3.3	0.99960	0.99961	0.99962	0.99964	0.99965
3.4	0.99972	0.99973	0.99974	0.99975	0.99976
3.5	0.99981	0.99981	0.99982	0.99983	0.99983
3.6	0.99987	0.99987	0.99988	0.99988	0.99989
3.7	0.99991	0.99992	0.99992	0.99992	0.99992
3.8	0.99994	0.99994	0.99995	0.99995	0.99995
3.9	0.99996	0.99996	0.99996	0.99997	0.99997

APR 07 2004

Table III Percentage Points of the χ^2 Distribution*

v	α	0.995	0.990	0.975	0.950	0.900	0.500	0.100	0.050	0.025	0.010	0.005
1		0.00+	0.00+	0.00+	0.00+	0.02	0.45	2.71	3.84	5.02	6.63	7.88
2		0.01	0.02	0.05	0.10	0.21	1.39	4.61	5.99	7.38	9.21	10.60
3		0.07	0.11	0.22	0.35	0.58	2.37	6.25	7.81	9.35	11.34	12.84
4		0.21	0.30	0.48	0.71	1.06	3.36	7.78	9.49	11.14	13.28	14.86
5		0.41	0.55	0.83	1.15	1.61	4.35	9.24	11.07	12.83	15.09	16.75
6		0.68	0.87	1.24	1.64	2.20	5.35	10.65	12.59	14.45	16.81	18.55
7		0.99	1.24	1.69	2.17	2.83	6.35	12.02	14.07	16.01	18.48	20.28
8		1.34	1.65	2.18	2.73	3.49	7.34	13.36	15.51	17.53	20.09	21.96
9		1.73	2.09	2.70	3.33	4.17	8.34	14.68	16.92	19.02	21.67	23.59
10		2.16	2.56	3.25	3.94	4.87	9.34	15.99	18.31	20.48	23.21	25.19
11		2.60	3.05	3.82	4.57	5.58	10.34	17.28	19.68	21.92	24.72	26.76
12		3.07	3.57	4.40	5.23	6.30	11.34	18.55	21.03	23.34	26.22	28.30
13		3.57	4.11	5.01	5.89	7.04	12.34	19.81	22.36	24.74	27.69	29.82
14		4.07	4.66	5.63	6.57	7.79	13.34	21.06	23.68	26.12	29.14	31.32
15		4.60	5.23	6.27	7.26	8.55	14.34	22.31	25.00	27.49	30.58	32.80
16		5.14	5.81	6.91	7.96	9.31	15.34	23.54	26.30	28.85	32.00	34.27
17		5.70	6.41	7.56	8.67	10.09	16.34	24.77	27.59	30.19	33.41	35.72
18		6.26	7.01	8.23	9.39	10.87	17.34	25.99	28.87	31.53	34.81	37.16
19		6.84	7.63	8.91	10.12	11.65	18.34	27.20	30.14	32.85	36.19	38.58
20		7.43	8.26	9.59	10.85	12.44	19.34	28.41	31.41	34.17	37.57	40.00
21		8.03	8.90	10.28	11.59	13.24	20.34	29.62	32.67	35.48	38.93	41.40
22		8.64	9.54	10.98	12.34	14.04	21.34	30.81	33.92	36.78	40.29	42.80
23		9.26	10.20	11.69	13.09	14.85	22.34	32.01	35.17	38.08	41.64	44.18
24		9.89	10.86	12.40	13.85	15.66	23.34	33.20	36.42	39.36	42.98	45.56
25		10.52	11.52	13.12	14.61	16.47	24.34	34.28	37.65	40.65	44.31	46.93
26		11.16	12.20	13.84	15.38	17.29	25.34	35.56	38.89	41.92	45.64	48.29
27		11.81	12.88	14.57	16.15	18.11	26.34	36.74	40.11	43.19	46.96	49.65
28		12.46	13.57	15.31	16.93	18.94	27.34	37.92	41.34	44.46	48.28	50.99
29		13.12	14.26	16.05	17.71	19.77	28.34	39.09	42.56	45.72	49.59	52.34
30		13.79	14.95	16.79	18.49	20.60	29.34	40.26	43.77	46.98	50.89	53.67
40		20.71	22.16	24.43	26.51	29.05	39.34	51.81	55.76	59.34	63.69	66.77
50		27.99	29.71	32.36	34.76	37.69	49.33	63.17	67.50	71.42	76.15	79.49
60		35.53	37.48	40.48	43.19	46.46	59.33	74.40	79.08	83.30	88.38	91.95
70		43.28	45.44	48.76	51.74	55.33	69.33	85.53	90.53	95.02	100.42	104.22
80		51.17	53.54	57.15	60.39	64.28	79.33	96.58	101.88	106.63	112.33	116.32
90		59.20	61.75	65.65	69.13	73.29	89.33	107.57	113.14	118.14	124.12	128.30
100		67.33	70.06	74.22	77.93	82.36	99.33	118.50	124.34	129.56	135.81	140.17

* v = degrees of freedom.

Table IV Percentage Points of the *t* Distribution

ν \ α	0.40	0.25	0.10	0.05	0.025	0.01	0.005	0.0025	0.001	0.0005
1	0.325	1.000	3.078	6.314	12.706	31.821	63.657	127.32	318.31	636.62
2	0.289	0.816	1.886	2.920	4.303	6.965	9.925	14.089	23.326	31.598
3	0.277	0.765	1.638	2.353	3.182	4.541	5.841	7.453	10.213	12.924
4	0.271	0.741	1.533	2.132	2.776	3.747	4.604	5.598	7.173	8.610
5	0.267	0.727	1.476	2.015	2.571	3.365	4.032	4.773	5.893	6.869
6	0.265	0.718	1.440	1.943	2.447	3.143	3.707	4.317	5.208	5.959
7	0.263	0.711	1.415	1.895	2.365	2.998	3.499	4.029	4.785	5.408
8	0.262	0.706	1.397	1.860	2.306	2.896	3.355	3.833	4.501	5.041
9	0.261	0.703	1.383	1.833	2.262	2.821	3.250	3.690	4.297	4.781
10	0.260	0.700	1.372	1.812	2.228	2.764	3.169	3.581	4.144	4.587
11	0.260	0.697	1.363	1.796	2.201	2.718	3.106	3.497	4.025	4.437
12	0.259	0.695	1.356	1.782	2.179	2.681	3.055	3.428	3.930	4.318
13	0.259	0.694	1.350	1.771	2.160	2.650	3.012	3.372	3.852	4.221
14	0.258	0.692	1.345	1.761	2.145	2.624	2.977	3.326	3.787	4.140
15	0.258	0.691	1.341	1.753	2.131	2.602	2.947	3.286	3.733	4.073
16	0.258	0.690	1.337	1.746	2.120	2.583	2.921	3.252	3.686	4.015
17	0.257	0.689	1.333	1.740	2.110	2.567	2.898	3.222	3.646	3.965
18	0.257	0.688	1.330	1.734	2.101	2.552	2.878	3.197	3.610	3.922
19	0.257	0.688	1.328	1.729	2.093	2.539	2.861	3.174	3.579	3.883
20	0.257	0.687	1.325	1.725	2.086	2.528	2.845	3.153	3.552	3.850
21	0.257	0.686	1.323	1.721	2.080	2.518	2.831	3.135	3.527	3.819
22	0.256	0.686	1.321	1.717	2.074	2.508	2.819	3.119	3.505	3.792
23	0.256	0.685	1.319	1.714	2.069	2.500	2.807	3.104	3.485	3.767
24	0.256	0.685	1.318	1.711	2.064	2.492	2.797	3.091	3.467	3.745
25	0.256	0.684	1.316	1.708	2.060	2.485	2.787	3.078	3.450	3.725
26	0.256	0.684	1.315	1.706	2.056	2.479	2.779	3.067	3.435	3.707
27	0.256	0.684	1.314	1.703	2.052	2.473	2.771	3.057	3.421	3.690
28	0.256	0.683	1.313	1.701	2.048	2.467	2.763	3.047	3.408	3.674
29	0.256	0.683	1.311	1.699	2.045	2.462	2.756	3.038	3.396	3.659
30	0.256	0.683	1.310	1.697	2.042	2.457	2.750	3.030	3.385	3.646
40	0.255	0.681	1.303	1.684	2.021	2.423	2.704	2.971	3.307	3.551
60	0.254	0.679	1.296	1.671	2.000	2.390	2.660	2.915	3.232	3.460
120	0.254	0.677	1.289	1.658	1.980	2.358	2.617	2.860	3.160	3.373
∞	0.253	0.674	1.282	1.645	1.960	2.326	2.576	2.807	3.090	3.291

Source: This table is adapted from *Biometrika Tables for Statisticians*, Vol. 1, 3rd edition, 1966, by permission of the Biometrika Trustees.

APR 07 2017

Table V Percentage Points of the F Distribution

v_2	v_1	$F_{0.25, v_1, v_2}$																		
		Degrees of freedom for the numerator (v_1)																		
		1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	∞
1	1	5.83	7.50	8.20	8.58	8.82	8.98													
2	1	2.57	3.00	3.15	3.23	3.28	3.31	3.34	3.35	3.37	3.38	3.39	3.41	3.43	3.43	3.44	3.45	3.46	3.47	3.48
3	1	2.02	2.28	2.36	2.39	2.41	2.42	2.43	2.44	2.44	2.44	2.45	2.46	2.46	2.46	2.47	2.47	2.47	2.47	2.47
4	1	1.81	2.00	2.05	2.06	2.07	2.08	2.08	2.08	2.08	2.08	2.08	2.08	2.08	2.08	2.08	2.08	2.08	2.08	2.08
5	1	1.69	1.85	1.88	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.88	1.88	1.88	1.87	1.87	1.87
6	1	1.62	1.76	1.78	1.79	1.79	1.78	1.78	1.78	1.77	1.77	1.77	1.76	1.76	1.75	1.75	1.75	1.74	1.74	1.74
7	1	1.57	1.70	1.72	1.72	1.71	1.71	1.70	1.70	1.69	1.68	1.68	1.68	1.67	1.67	1.66	1.66	1.65	1.65	1.65
8	1	1.54	1.66	1.67	1.66	1.66	1.65	1.64	1.64	1.63	1.63	1.62	1.62	1.61	1.60	1.60	1.59	1.59	1.58	1.58
9	1	1.51	1.62	1.63	1.63	1.62	1.61	1.60	1.60	1.59	1.59	1.58	1.57	1.56	1.56	1.55	1.54	1.54	1.53	1.53
10	1	1.49	1.60	1.60	1.59	1.59	1.58	1.57	1.56	1.55	1.54	1.53	1.52	1.51	1.50	1.50	1.49	1.49	1.48	1.48
11	1	1.47	1.58	1.58	1.57	1.56	1.55	1.54	1.53	1.52	1.51	1.50	1.49	1.48	1.47	1.46	1.45	1.44	1.43	1.42
12	1	1.46	1.56	1.56	1.55	1.54	1.53	1.52	1.51	1.50	1.49	1.48	1.47	1.46	1.45	1.44	1.43	1.42	1.41	1.40
13	1	1.45	1.55	1.55	1.53	1.52	1.51	1.50	1.49	1.48	1.47	1.46	1.45	1.44	1.43	1.42	1.41	1.40	1.39	1.38
14	1	1.44	1.53	1.53	1.52	1.51	1.50	1.49	1.48	1.47	1.46	1.45	1.44	1.43	1.41	1.40	1.39	1.38	1.37	1.36
15	1	1.43	1.52	1.52	1.51	1.49	1.48	1.47	1.46	1.45	1.44	1.43	1.42	1.41	1.40	1.39	1.38	1.37	1.36	1.35
16	1	1.42	1.51	1.51	1.50	1.48	1.47	1.46	1.45	1.44	1.43	1.42	1.41	1.40	1.39	1.38	1.37	1.36	1.35	1.34
17	1	1.42	1.51	1.50	1.49	1.47	1.46	1.45	1.44	1.43	1.42	1.41	1.40	1.39	1.38	1.37	1.36	1.35	1.34	1.33
18	1	1.41	1.50	1.49	1.48	1.46	1.45	1.44	1.43	1.42	1.41	1.40	1.39	1.38	1.37	1.36	1.35	1.34	1.33	1.32
19	1	1.41	1.49	1.49	1.47	1.46	1.45	1.44	1.43	1.42	1.41	1.40	1.39	1.38	1.37	1.36	1.35	1.34	1.33	1.32
20	1	1.40	1.49	1.48	1.47	1.46	1.44	1.43	1.42	1.41	1.40	1.39	1.38	1.37	1.36	1.35	1.34	1.33	1.32	1.31
21	1	1.40	1.48	1.47	1.46	1.44	1.43	1.42	1.41	1.40	1.39	1.38	1.37	1.36	1.35	1.34	1.33	1.32	1.31	1.30
22	1	1.40	1.48	1.47	1.45	1.44	1.43	1.42	1.41	1.40	1.39	1.38	1.37	1.36	1.35	1.34	1.33	1.32	1.31	1.29
23	1	1.39	1.47	1.47	1.45	1.44	1.42	1.41	1.40	1.39	1.38	1.37	1.36	1.34	1.33	1.32	1.31	1.30	1.29	1.28
24	1	1.39	1.47	1.46	1.44	1.43	1.41	1.40	1.39	1.38	1.37	1.36	1.35	1.34	1.33	1.32	1.31	1.30	1.29	1.28
25	1	1.39	1.47	1.46	1.44	1.42	1.41	1.40	1.39	1.38	1.37	1.36	1.35	1.34	1.33	1.32	1.31	1.30	1.28	1.27
26	1	1.38	1.46	1.45	1.44	1.42	1.41	1.40	1.39	1.38	1.37	1.36	1.34	1.33	1.32	1.31	1.30	1.29	1.28	1.26
27	1	1.38	1.46	1.45	1.43	1.42	1.41	1.39	1.38	1.37	1.36	1.34	1.33	1.32	1.31	1.30	1.29	1.28	1.27	1.25
28	1	1.38	1.46	1.45	1.43	1.41	1.40	1.39	1.38	1.37	1.36	1.35	1.33	1.32	1.31	1.30	1.29	1.28	1.26	1.25
29	1	1.38	1.45	1.45	1.43	1.41	1.40	1.39	1.38	1.37	1.36	1.34	1.33	1.31	1.30	1.29	1.28	1.27	1.26	1.24
30	1	1.38	1.45	1.44	1.42	1.41	1.40	1.38	1.37	1.36	1.35	1.34	1.32	1.31	1.30	1.29	1.28	1.27	1.25	1.23
40	1	1.36	1.44	1.42	1.40	1.39	1.37	1.36	1.35	1.34	1.32	1.31	1.30	1.29	1.28	1.27	1.26	1.25	1.23	1.21
60	1	1.35	1.42	1.41	1.38	1.37	1.35	1.33	1.32	1.31	1.30	1.29	1.28	1.27	1.26	1.25	1.24	1.22	1.21	1.19
120	1	1.34	1.40	1.39	1.37	1.35	1.33	1.31	1.30	1.29	1.28	1.26	1.24	1.22	1.21	1.19	1.18	1.16	1.13	1.10
∞	1	1.32	1.39	1.37	1.35	1.33	1.31	1.29	1.28	1.27	1.25	1.24	1.22	1.19	1.18	1.16	1.14	1.12	1.08	1.00

Source: Adapted with permission from *Biometrika Tables for Statisticians*, Vol. 1, 3rd edition, by E. S. Pearson and H. O. Hartley, Cambridge University Press, Cambridge, 1966.

(continues)

Table V Percentage Points of the *F* Distribution (continued)

		$F_{0.10, v_1, v_2}$																		
		Degrees of freedom for the numerator (v_1)																		
$v_2 \backslash v_1$		1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	∞
1		39.86	49.50	53.59	55.83	57.24	58.20	58.91	59.44	59.86	60.19	60.71	61.22	61.74	62.00	62.26	62.53	62.79	63.06	63.33
2		8.53	9.00	9.16	9.24	9.29	9.33	9.35	9.37	9.38	9.39	9.41	9.42	9.44	9.45	9.46	9.47	9.47	9.48	9.49
3		5.54	5.46	5.39	5.34	5.31	5.28	5.27	5.25	5.24	5.23	5.22	5.20	5.18	5.18	5.17	5.16	5.15	5.14	5.13
4		4.54	4.32	4.19	4.11	4.05	4.01	3.98	3.95	3.94	3.92	3.90	3.87	3.84	3.83	3.82	3.80	3.79	3.78	3.76
5		4.06	3.78	3.62	3.52	3.45	3.40	3.37	3.34	3.32	3.30	3.27	3.24	3.21	3.19	3.17	3.16	3.14	3.12	3.10
6		3.78	3.46	3.29	3.18	3.11	3.05	3.01	2.98	2.96	2.94	2.90	2.87	2.84	2.82	2.80	2.78	2.76	2.74	2.72
7		3.59	3.26	3.07	2.96	2.88	2.83	2.78	2.75	2.72	2.70	2.67	2.63	2.59	2.58	2.56	2.54	2.51	2.49	2.47
8		3.46	3.11	2.92	2.81	2.73	2.67	2.62	2.59	2.56	2.54	2.50	2.46	2.42	2.40	2.38	2.36	2.34	2.32	2.29
9		3.36	3.01	2.81	2.69	2.61	2.55	2.51	2.47	2.44	2.42	2.38	2.34	2.30	2.28	2.25	2.23	2.21	2.18	2.16
10		3.29	2.92	2.73	2.61	2.52	2.46	2.41	2.38	2.35	2.32	2.28	2.24	2.20	2.18	2.16	2.13	2.11	2.08	2.06
11		3.23	2.86	2.66	2.54	2.45	2.39	2.34	2.30	2.27	2.25	2.21	2.17	2.12	2.10	2.08	2.05	2.03	2.00	1.97
12		3.18	2.81	2.61	2.48	2.39	2.33	2.28	2.24	2.21	2.19	2.15	2.10	2.06	2.04	2.01	1.99	1.96	1.93	1.90
13		3.14	2.76	2.56	2.43	2.35	2.28	2.23	2.20	2.16	2.14	2.10	2.05	2.01	1.98	1.96	1.93	1.90	1.88	1.85
14		3.10	2.73	2.52	2.39	2.31	2.24	2.19	2.15	2.12	2.10	2.05	2.01	1.96	1.94	1.91	1.89	1.86	1.83	1.80
15		3.07	2.70	2.49	2.36	2.27	2.21	2.16	2.12	2.09	2.06	2.02	1.97	1.92	1.90	1.87	1.85	1.82	1.79	1.76
16		3.05	2.67	2.46	2.33	2.24	2.18	2.13	2.09	2.06	2.03	1.99	1.94	1.89	1.87	1.84	1.81	1.78	1.75	1.72
17		3.03	2.64	2.44	2.31	2.22	2.15	2.10	2.06	2.03	2.00	1.96	1.91	1.86	1.84	1.81	1.78	1.75	1.72	1.69
18		3.01	2.62	2.42	2.29	2.20	2.13	2.08	2.04	2.00	1.98	1.93	1.89	1.84	1.81	1.78	1.75	1.72	1.69	1.66
19		2.99	2.61	2.40	2.27	2.18	2.11	2.06	2.02	1.98	1.96	1.91	1.86	1.81	1.79	1.76	1.73	1.70	1.67	1.63
20		2.97	2.59	2.38	2.25	2.16	2.09	2.04	2.00	1.96	1.94	1.89	1.84	1.79	1.77	1.74	1.71	1.68	1.64	1.61
21		2.96	2.57	2.36	2.23	2.14	2.08	2.02	1.98	1.95	1.92	1.87	1.83	1.78	1.75	1.72	1.69	1.66	1.62	1.59
22		2.95	2.56	2.35	2.22	2.13	2.06	2.01	1.97	1.93	1.90	1.86	1.81	1.76	1.73	1.70	1.67	1.64	1.60	1.57
23		2.94	2.55	2.34	2.21	2.11	2.05	1.99	1.95	1.92	1.89	1.84	1.80	1.74	1.72	1.69	1.66	1.62	1.59	1.55
24		2.93	2.54	2.33	2.19	2.10	2.04	1.98	1.94	1.91	1.88	1.83	1.78	1.73	1.70	1.67	1.64	1.61	1.57	1.53
25		2.92	2.53	2.32	2.18	2.09	2.02	1.97	1.93	1.89	1.87	1.82	1.77	1.72	1.69	1.66	1.63	1.59	1.56	1.52
26		2.91	2.52	2.31	2.17	2.08	2.01	1.96	1.92	1.88	1.86	1.81	1.76	1.71	1.68	1.65	1.61	1.58	1.54	1.50
27		2.90	2.51	2.30	2.17	2.07	2.00	1.95	1.91	1.87	1.85	1.80	1.75	1.70	1.67	1.64	1.60	1.57	1.53	1.49
28		2.89	2.50	2.29	2.16	2.06	2.00	1.94	1.90	1.87	1.84	1.79	1.74	1.69	1.66	1.63	1.59	1.56	1.52	1.48
29		2.89	2.50	2.28	2.15	2.06	1.99	1.93	1.89	1.86	1.83	1.78	1.73	1.68	1.65	1.62	1.58	1.55	1.51	1.47
30		2.88	2.49	2.28	2.14	2.03	1.98	1.93	1.88	1.85	1.82	1.77	1.72	1.67	1.64	1.61	1.57	1.54	1.50	1.46
40		2.84	2.44	2.23	2.09	2.00	1.93	1.87	1.83	1.79	1.76	1.71	1.66	1.61	1.57	1.54	1.51	1.47	1.42	1.38
60		2.79	2.39	2.18	2.04	1.95	1.87	1.82	1.77	1.74	1.71	1.66	1.60	1.54	1.51	1.48	1.44	1.40	1.35	1.29
120		2.75	2.35	2.13	1.99	1.90	1.82	1.77	1.72	1.68	1.65	1.60	1.55	1.48	1.45	1.41	1.37	1.32	1.26	1.19
∞		2.71	2.30	2.08	1.94	1.85	1.77	1.72	1.67	1.63	1.60	1.55	1.49	1.42	1.38	1.34	1.30	1.24	1.17	1.00

APR 07 2011

Table V Percentage Points of the *F* Distribution (continued)

v_2	v_1	$F_{0.05, v_1, v_2}$																		
		1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	∞
1	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	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	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	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	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	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	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	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	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	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	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	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	2.39	2.35	2.30
13	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	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	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	2.21	2.16	2.12	2.07
16	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	2.20	2.16	2.11	2.06	2.01
17	17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45	2.38	2.30	2.23	2.19	2.15	2.11	2.06	2.02	1.97
18	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	1.98	1.92
19	19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.37	2.30	2.23	2.16	2.12	2.08	2.04	2.00	1.95	1.89
20	20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.34	2.27	2.20	2.12	2.08	2.04	2.00	1.96	1.91	1.84
21	21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.36	2.31	2.24	2.17	2.10	2.06	2.02	1.98	1.94	1.89	1.81
22	22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.29	2.22	2.15	2.07	2.03	2.00	1.96	1.92	1.87	1.78
23	23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.38	2.32	2.27	2.20	2.13	2.05	2.01	1.96	1.92	1.88	1.81	1.71
24	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	2.00	1.96	1.91	1.87	1.81	1.71
25	25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28	2.23	2.16	2.09	2.01	1.97	1.92	1.88	1.84	1.79	1.69
26	26	4.23	3.37	2.98	2.74	2.59	2.48	2.39	2.33	2.27	2.22	2.15	2.07	2.00	1.95	1.90	1.85	1.80	1.75	1.65
27	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	1.63
28	28	4.18	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	1.86	1.81	1.76	1.70	1.60
29	29	4.17	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22	2.17	2.10	2.03	1.94	1.90	1.85	1.81	1.76	1.70	1.60
30	30	4.17	3.32	2.92	2.69	2.53	2.43	2.33	2.28	2.22	2.16	2.09	2.01	1.93	1.89	1.84	1.79	1.74	1.68	1.58
40	40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.06	2.00	1.92	1.84	1.79	1.74	1.69	1.64	1.58	1.51
60	60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99	1.92	1.84	1.75	1.70	1.65	1.59	1.53	1.47	1.39
120	120	3.92	3.07	2.68	2.45	2.29	2.25	2.17	2.10	2.04	1.96	1.91	1.83	1.75	1.66	1.61	1.55	1.50	1.44	1.35
∞	∞	3.84	3.00	2.60	2.37	2.21	2.10	2.01	1.94	1.88	1.83	1.75	1.67	1.57	1.52	1.46	1.39	1.32	1.22	1.00

Degrees of freedom for the denominator (v_2)

Table V Percentage Points of the *F* Distribution (continued)

v_1	$F_{0.025, v_1, v_2}$																			
	Degrees of freedom for the numerator (v_2)																			
v_2	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	∞	
1	647.8	799.5	864.2	899.6	921.8	937.1	948.2	956.7	963.3	968.6	976.7	984.9	993.1	997.2	1001	1006	1010	1014	1018	
2	38.51	39.00	39.17	39.25	39.30	39.33	39.36	39.37	39.39	39.40	39.41	39.43	39.45	39.46	39.46	39.47	39.48	39.49	39.50	
3	17.44	16.04	15.44	15.10	14.88	14.73	14.62	14.54	14.47	14.42	14.34	14.25	14.17	14.12	14.08	14.04	13.99	13.95	13.90	
4	12.22	10.65	9.98	9.60	9.36	9.20	9.07	8.98	8.90	8.84	8.75	8.66	8.56	8.51	8.46	8.41	8.36	8.31	8.26	
5	10.01	8.43	7.76	7.39	7.15	6.98	6.85	6.76	6.68	6.62	6.52	6.43	6.33	6.28	6.23	6.18	6.12	6.07	6.02	
6	8.81	7.26	6.60	6.23	5.99	5.82	5.70	5.60	5.52	5.46	5.37	5.27	5.17	5.12	5.07	5.01	4.96	4.90	4.85	
7	8.07	6.54	5.89	5.52	5.29	5.12	4.99	4.82	4.76	4.66	4.57	4.47	4.37	4.32	4.26	4.21	4.15	4.10	4.05	
8	7.57	6.06	5.42	5.05	4.82	4.65	4.53	4.43	4.36	4.30	4.20	4.10	4.00	3.95	3.89	3.84	3.78	3.73	3.67	
9	7.21	5.71	5.08	4.72	4.48	4.32	4.20	4.10	4.03	3.96	3.87	3.77	3.67	3.61	3.56	3.51	3.45	3.39	3.33	
10	6.94	5.46	4.83	4.47	4.24	4.07	3.95	3.85	3.78	3.72	3.62	3.52	3.42	3.37	3.31	3.26	3.20	3.14	3.08	
11	6.72	5.26	4.63	4.27	4.04	3.88	3.76	3.66	3.59	3.53	3.43	3.33	3.23	3.17	3.12	3.06	3.00	2.94	2.88	
12	6.55	5.10	4.47	4.12	3.89	3.73	3.61	3.51	3.44	3.37	3.28	3.18	3.07	3.02	2.96	2.91	2.85	2.79	2.72	
13	6.41	4.97	4.35	4.00	3.77	3.60	3.48	3.39	3.31	3.25	3.15	3.05	2.95	2.89	2.84	2.78	2.72	2.66	2.60	
14	6.30	4.86	4.24	3.89	3.66	3.49	3.38	3.29	3.21	3.15	3.05	2.95	2.84	2.79	2.73	2.67	2.61	2.55	2.49	
15	6.20	4.77	4.15	3.80	3.58	3.41	3.29	3.20	3.12	3.06	2.96	2.86	2.76	2.70	2.64	2.59	2.52	2.46	2.40	
16	6.12	4.69	4.08	3.73	3.50	3.34	3.22	3.12	3.05	2.99	2.89	2.79	2.68	2.62	2.56	2.50	2.44	2.38	2.32	
17	6.04	4.62	4.01	3.66	3.44	3.28	3.16	3.06	2.98	2.92	2.82	2.72	2.62	2.56	2.50	2.44	2.38	2.32	2.25	
18	5.98	4.56	3.95	3.61	3.38	3.22	3.10	3.01	2.93	2.87	2.77	2.67	2.56	2.50	2.44	2.38	2.32	2.26	2.19	
19	5.92	4.51	3.90	3.56	3.33	3.17	3.05	2.96	2.88	2.82	2.72	2.62	2.51	2.45	2.39	2.33	2.27	2.20	2.13	
20	5.87	4.46	3.86	3.51	3.29	3.13	3.01	2.91	2.84	2.77	2.68	2.57	2.46	2.40	2.34	2.28	2.22	2.16	2.09	
21	5.83	4.42	3.82	3.48	3.25	3.09	2.97	2.87	2.80	2.73	2.64	2.53	2.42	2.37	2.31	2.25	2.19	2.12	2.04	
22	5.79	4.38	3.78	3.44	3.22	3.05	2.93	2.83	2.76	2.70	2.60	2.50	2.39	2.33	2.27	2.21	2.15	2.08	2.00	
23	5.75	4.35	3.75	3.41	3.18	3.02	2.90	2.81	2.73	2.67	2.57	2.47	2.36	2.30	2.24	2.18	2.11	2.04	1.97	
24	5.72	4.32	3.72	3.38	3.15	2.99	2.87	2.78	2.70	2.64	2.54	2.44	2.33	2.27	2.21	2.15	2.08	2.01	1.94	
25	5.69	4.29	3.69	3.35	3.13	2.97	2.85	2.75	2.68	2.61	2.51	2.41	2.30	2.24	2.18	2.12	2.05	1.98	1.91	
26	5.66	4.27	3.67	3.33	3.10	2.94	2.82	2.73	2.65	2.59	2.49	2.39	2.28	2.22	2.16	2.09	2.03	1.95	1.88	
27	5.63	4.24	3.63	3.30	3.08	2.92	2.80	2.71	2.63	2.57	2.47	2.36	2.25	2.19	2.13	2.07	2.00	1.93	1.85	
28	5.61	4.22	3.63	3.29	3.06	2.90	2.78	2.69	2.61	2.55	2.45*	2.34	2.23	2.17	2.11	2.05	1.98	1.91	1.83	
29	5.59	4.20	3.61	3.27	3.04	2.88	2.76	2.67	2.59	2.53	2.43	2.32	2.21	2.15	2.09	2.03	1.96	1.89	1.81	
30	5.57	4.18	3.59	3.25	3.03	2.87	2.75	2.65	2.57	2.51	2.41	2.31	2.20	2.14	2.07	2.01	1.94	1.87	1.79	
40	5.42	4.05	3.46	3.13	2.90	2.74	2.62	2.53	2.45	2.39	2.29	2.18	2.07	2.01	1.94	1.88	1.80	1.72	1.64	
60	5.29	3.93	3.34	3.01	2.79	2.63	2.51	2.41	2.33	2.27	2.17	2.06	1.94	1.88	1.81	1.74	1.67	1.58	1.48	
120	5.15	3.80	3.23	2.90	2.67	2.52	2.39	2.30	2.22	2.16	2.05	1.94	1.82	1.76	1.69	1.61	1.53	1.43	1.31	
∞	5.02	3.69	3.12	2.79	2.57	2.41	2.29	2.19	2.11	2.05	1.94	1.83	1.71	1.64	1.57	1.48	1.39	1.27	1.00	

10710

Table V Percentage Points of the *F* Distribution (continued)

		$F_{0.01, v_1, v_2}$																		
		Degrees of freedom for the numerator (v_1)																		
Degrees of freedom for the denominator (v_2)	v_1	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	∞
	1	4052	4999.5	5403	5625	5764	5859	5928	5982	6022	6056	6106	6157	6209	6235	6261	6287	6313	6339	6366
2	98.50	99.00	99.17	99.25	99.30	99.33	99.36	99.37	99.39	99.40	99.42	99.43	99.45	99.46	99.47	99.47	99.48	99.49	99.50	
3	34.12	30.82	29.46	28.71	28.24	27.91	27.67	27.49	27.35	27.23	27.05	26.87	26.69	26.00	26.50	26.41	26.32	26.22	26.13	
4	21.20	18.00	16.69	15.98	15.52	15.21	14.98	14.80	14.66	14.55	14.37	14.20	14.02	13.93	13.84	13.75	13.65	13.56	13.46	
5	16.26	13.27	12.06	11.39	10.97	10.67	10.46	10.29	10.16	10.05	9.89	9.72	9.55	9.47	9.38	9.29	9.20	9.11	9.02	
6	13.75	10.92	9.78	9.15	8.75	8.47	8.26	8.10	7.98	7.87	7.72	7.56	7.40	7.31	7.23	7.14	7.06	6.97	6.88	
7	12.25	9.55	8.45	7.85	7.46	7.19	6.99	6.84	6.72	6.62	6.47	6.31	6.16	6.07	5.99	5.91	5.82	5.74	5.65	
8	11.26	8.65	7.59	7.01	6.63	6.37	6.18	6.03	5.91	5.81	5.67	5.52	5.36	5.28	5.20	5.12	5.03	4.95	4.86	
9	10.56	8.02	6.99	6.42	6.06	5.80	5.61	5.47	5.35	5.26	5.11	4.96	4.81	4.73	4.65	4.57	4.48	4.40	4.31	
10	10.04	7.56	6.55	5.99	5.64	5.39	5.20	5.06	4.94	4.85	4.71	4.56	4.41	4.33	4.25	4.17	4.08	4.00	3.91	
11	9.65	7.21	6.22	5.67	5.32	5.07	4.89	4.74	4.63	4.54	4.40	4.25	4.10	4.02	3.94	3.86	3.78	3.69	3.60	
12	9.33	6.93	5.95	5.41	5.06	4.82	4.64	4.50	4.39	4.30	4.16	4.01	3.86	3.78	3.70	3.62	3.54	3.45	3.36	
13	9.07	6.70	5.74	5.21	4.86	4.62	4.44	4.30	4.19	4.10	3.96	3.82	3.66	3.59	3.51	3.43	3.34	3.25	3.17	
14	8.86	6.51	5.56	5.04	4.69	4.46	4.28	4.14	4.03	3.94	3.80	3.66	3.51	3.43	3.35	3.27	3.18	3.09	3.00	
15	8.68	6.36	5.42	4.89	4.56	4.32	4.14	4.00	3.89	3.80	3.67	3.52	3.37	3.29	3.21	3.13	3.05	2.96	2.87	
16	8.53	6.23	5.29	4.77	4.44	4.20	4.03	3.89	3.78	3.69	3.55	3.41	3.26	3.18	3.10	3.02	2.93	2.84	2.75	
17	8.40	6.11	5.18	4.67	4.34	4.10	3.93	3.79	3.68	3.59	3.46	3.31	3.16	3.08	3.00	2.92	2.84	2.75	2.66	
18	8.29	6.01	5.09	4.58	4.25	4.01	3.84	3.71	3.60	3.51	3.37	3.23	3.08	3.00	2.92	2.84	2.75	2.66	2.57	
19	8.18	5.93	5.01	4.50	4.17	3.94	3.77	3.63	3.52	3.43	3.30	3.15	3.00	2.92	2.84	2.76	2.67	2.58	2.50	
20	8.10	5.85	4.94	4.43	4.10	3.87	3.70	3.56	3.46	3.37	3.23	3.09	2.94	2.86	2.78	2.69	2.61	2.52	2.44	
21	8.02	5.78	4.87	4.37	4.04	3.81	3.64	3.51	3.40	3.31	3.17	3.03	2.88	2.80	2.72	2.64	2.55	2.46	2.38	
22	7.95	5.72	4.82	4.31	3.99	3.76	3.59	3.45	3.35	3.26	3.12	2.98	2.83	2.75	2.67	2.58	2.50	2.40	2.31	
23	7.88	5.66	4.76	4.26	3.94	3.71	3.54	3.41	3.30	3.21	3.07	2.93	2.78	2.70	2.62	2.54	2.45	2.35	2.26	
24	7.82	5.61	4.72	4.22	3.90	3.67	3.50	3.36	3.26	3.17	3.03	2.89	2.74	2.66	2.58	2.49	2.40	2.31	2.21	
25	7.77	5.57	4.68	4.18	3.85	3.63	3.46	3.32	3.22	3.13	2.99	2.85	2.70	2.62	2.54	2.45	2.36	2.27	2.17	
26	7.72	5.53	4.64	4.14	3.82	3.59	3.42	3.29	3.18	3.09	2.96	2.81	2.66	2.58	2.50	2.42	2.33	2.23	2.13	
27	7.68	5.49	4.60	4.11	3.78	3.56	3.39	3.26	3.15	3.06	2.93	2.78	2.63	2.55	2.47	2.38	2.29	2.20	2.10	
28	7.64	5.45	4.57	4.07	3.75	3.53	3.36	3.23	3.12	3.03	2.90	2.75	2.60	2.52	2.44	2.35	2.26	2.17	2.06	
29	7.60	5.42	4.54	4.04	3.73	3.50	3.33	3.20	3.09	3.00	2.87	2.73	2.57	2.49	2.41	2.33	2.23	2.14	2.03	
30	7.56	5.39	4.51	4.02	3.70	3.47	3.30	3.17	3.07	2.98	2.84	2.70	2.55	2.47	2.39	2.30	2.21	2.11	2.01	
40	7.31	5.18	4.31	3.83	3.51	3.29	3.12	2.99	2.89	2.80	2.66	2.52	2.37	2.29	2.20	2.11	2.02	1.92	1.80	
60	7.08	4.98	4.13	3.65	3.34	3.12	2.95	2.82	2.72	2.63	2.50	2.35	2.20	2.12	2.03	1.94	1.84	1.73	1.60	
120	6.85	4.79	3.95	3.48	3.17	2.96	2.79	2.66	2.56	2.47	2.34	2.19	2.03	1.95	1.86	1.76	1.66	1.53	1.38	
∞	6.63	4.61	3.78	3.32	3.02	2.80	2.64	2.51	2.41	2.32	2.18	2.04	1.88	1.79	1.70	1.59	1.47	1.32	1.00	

T.M. - 2017 (K). NUTIH - 208 12/18 -

APR 07 2017

Table XIII Factors for Quality-Control Charts

n ^a	\bar{X} Chart		R Chart		
	Factors for Control Limits		Factors for Central Line	Factors for Control Limits	
	A ₁	A ₂	d ₂	D ₃	D ₄
2	3.760	1.880	1.128	0	3.267
3	2.394	1.023	1.693	0	2.575
4	1.880	0.729	2.059	0	2.282
5	1.596	0.577	2.326	0	2.115
6	1.410	0.483	2.534	0	2.004
7	1.277	0.419	2.704	0.076	1.924
8	1.175	0.373	2.847	0.136	1.864
9	1.094	0.337	2.970	0.184	1.816
10	1.028	0.308	3.078	0.223	1.777
11	0.973	0.285	3.173	0.256	1.744
12	0.925	0.266	3.258	0.284	1.716
13	0.884	0.249	3.336	0.308	1.692
14	0.848	0.235	3.407	0.329	1.671
15	0.816	0.223	3.472	0.348	1.652
16	0.788	0.212	3.532	0.364	1.636
17	0.762	0.203	3.588	0.379	1.621
18	0.738	0.194	3.640	0.392	1.608
19	0.717	0.187	3.689	0.404	1.596
20	0.697	0.180	3.735	0.414	1.586
21	0.679	0.173	3.778	0.425	1.575
22	0.662	0.167	3.819	0.434	1.566
23	0.647	0.162	3.858	0.443	1.557
24	0.632	0.157	3.895	0.452	1.548
25	0.619	0.153	3.931	0.459	1.541

^an > 25; A₁ = 3/√n . n = number of observations in sample.