

UNIVERSITY OF SWAZILAND

MAIN EXAMINATION PAPER 2013

TITLE OF PAPER : PROBABILITY AND STATISTICS

COURSE CODE : EE 301

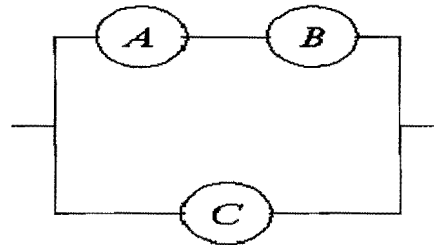
TIME ALLOWED : THREE (3) HOURS

INSTRUCTIONS : ANSWER ANY FIVE QUESTIONS.

**REQUIREMENTS : SCIENTIFIC CALCULATOR AND
STATISTICAL TABLES**

Question 1

- (a) The electrical apparatus in the diagram works so long as current can flow from left to right. The three components are independent. The probability that component A works is 0.8, the probability that component B works is 0.9, and the probability that component C works is 0.75. Find the probability that the apparatus works.



(10 Marks)

- (b) A company has three factories (1, 2 and 3) that produce the same chip, each producing 15%, 35% and 50% of the total production. The probability of a defective chip at 1, 2, 3 is 0.01, 0.05, 0.02, respectively. Suppose someone shows us a defective chip. What is the probability that this chip comes from factory 1?

(10 Marks)

Question 2

Suppose X has the following pdf, where A is a constant to be determined:

$$f_X(u) = \begin{cases} A(1 - u^2) & -1 \leq u \leq 1 \\ 0 & \text{else.} \end{cases}$$

Find A , $P\{0.5 < X < 1.5\}$, $F_X(u)$, μ_X , and $\text{Var}(X)$.

(4+4+4+6+2 Marks)

Question 3

- (a) Telephone calls enter the UNISWA switchboard on the average of two every 3 minutes. What is the probability of five or more calls arriving in a 9-minute period?
(6 Marks)
- (b) A manufacturer of Christmas tree bulbs knows that 2% of its bulbs are defective. What is the probability that a box of 100 of these bulbs contains at most three defective bulbs?
(6 Marks)
- (c) Suppose that an average of 30 customers per hour is connected to electricity by Swaziland Electricity (SEC). What is the probability that SEC will wait more than 5 minutes before both of the first two customers are connected?
(8 Marks)

Question 4

The thickness of a printed circuit board is required to lie between the specification limits of $0.150 - 0.004$ and $0.150 + 0.004$ cm. A machine produces circuit boards with a thickness that is normally distributed with mean 0.151 cm and standard deviation 0.003 cm.

- (a) What is the probability that the thickness X of a circuit board which is produced by this machine falls within the specification limits?
- (b) Now consider the mean thickness for a batch of 25 circuit boards. What is the probability that this batch mean will fall within the specification limits? Assume that X_1, \dots, X_{25} are independent random variables with the same distribution as X above.

Question 5

Suppose that X and Y are independent random variables with the same probability density function (pdf) $f(x)$.

- (a) Write down, without proof, a formula for the pdf of $X + Y$. (2 Marks)
- (b) Suppose that $f(x) = x/2$ for $0 < x < 2$ (and $f(x) = 0$ elsewhere). Find the pdf of $W = X + Y$ for $0 < w < 2$ and for $2 < w < 4$. (12 Marks)
- (c) Find the pdf of $V = (X - 1)^2$. (6 Marks)

Question 6

An element has two electrons. Each of the electrons can occupy one of the four orbits of this element. Let the random variables X and Y denote the orbit number occupied by these two electrons. The joint probability distribution is given as:

$f(x,y)$	$x=1$	$x=2$	$x=3$	$x=4$
$y=1$	0	1/16	1/16	0
$y=2$	1/16	1/8	1/8	1/16
$y=3$	1/16	1/8	1/8	1/16
$y=4$	0	1/16	1/16	0

- (a) Are these random variables independent? Prove your answer. (8 Marks)

- (b) You have a vacuum chamber containing 6 atoms of this element type. If the sum of the orbit numbers for any atom is greater than 5, there is an 80% chance that this atom will release a photon. If the sum of the orbit numbers for any atom is less than or equal to 5, no photon will be released. What is the probability that exactly 3 photons will be released from the atoms in the vacuum chamber?

(12 Marks)

Question 7

A company manufacturing light bulbs is testing a new model. The company is going to test the hypothesis that the mean life time is 1000 hours vs. the alternative hypothesis that it is less than 1000 hours at the significance level $\alpha = 0.02$. Assume that the population distribution for life time is approximately normal.

A sample of 16 light bulbs are found to have sample mean $\bar{x} = 987.5$ hours and sample variance $S^2 = 400$.

- (a) State the critical region and answer whether the null hypothesis H_0 is rejected. (12 Marks)
- (b) Find a 90% confidence interval for the population variance σ^2 . (8 Marks)

Appendix

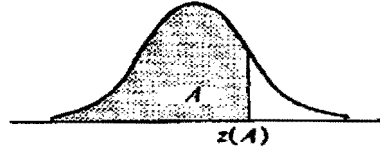
C

STATISTICAL TABLES

Normal Distribution

Table C-1. Cumulative Probabilities of the Standard Normal Distribution.

Entry is area A under the standard normal curve from $-\infty$ to $z(A)$

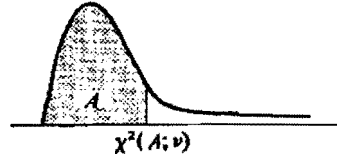


z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
.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

Chi-Square Distribution

Table C-2. Percentiles of the χ^2 Distribution

Entry is $\chi^2(A; \nu)$ where $P\{\chi^2(\nu) \leq \chi^2(A; \nu)\} = A$



ν	A									
	.005	.010	.025	.050	.100	.900	.950	.975	.990	.995
1	0.004393	0.02157	0.05982	0.10393	0.2158	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

Binomial Distribution

Table C-3. Binomial Distribution

$$B(x; n, p) = \sum_{0 \leq y \leq x} b(y; n, p)$$

The values of $B(x; n, p)$ for $0.5 < p < 1.0$ are obtained by using the formula

$$B(x; n, 1 - p) = 1 - B(n - 1 - x; n, p)$$

<i>n</i>	<i>x</i>	<i>p</i>									
		0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
5	0	0.774	0.590	0.444	0.328	0.237	0.168	0.116	0.078	0.050	0.031
	1	0.977	0.919	0.835	0.737	0.633	0.528	0.428	0.337	0.256	0.188
	2	0.999	0.991	0.973	0.942	0.896	0.837	0.765	0.683	0.593	0.500
	3	1.000	1.000	0.998	0.993	0.984	0.969	0.946	0.913	0.869	0.813
	4	1.000	1.000	1.000	1.000	0.999	0.998	0.995	0.990	0.982	0.969
	5	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10	0	0.599	0.349	0.197	0.107	0.056	0.028	0.013	0.006	0.003	0.001
	1	0.914	0.736	0.544	0.376	0.244	0.149	0.086	0.046	0.023	0.011
	2	0.988	0.930	0.820	0.678	0.526	0.383	0.262	0.167	0.100	0.055
	3	0.999	0.987	0.950	0.879	0.776	0.650	0.514	0.382	0.266	0.172
	4	1.000	0.998	0.990	0.967	0.922	0.850	0.751	0.633	0.504	0.377
	5	1.000	1.000	0.999	0.994	0.980	0.953	0.905	0.834	0.738	0.623
	6	1.000	1.000	1.000	0.999	0.996	0.989	0.974	0.945	0.898	0.828
	7	1.000	1.000	1.000	1.000	1.000	0.998	0.995	0.988	0.973	0.945
	8	1.000	1.000	1.000	1.000	1.000	1.000	0.999	0.998	0.995	0.989
	9	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.999
	10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
15	0	0.463	0.206	0.087	0.035	0.013	0.005	0.002	0.000	0.000	0.000
	1	0.829	0.549	0.319	0.167	0.080	0.035	0.014	0.005	0.002	0.000
	2	0.964	0.816	0.604	0.398	0.236	0.127	0.062	0.027	0.011	0.004
	3	0.995	0.944	0.823	0.648	0.461	0.297	0.173	0.091	0.042	0.018
	4	0.999	0.987	0.938	0.836	0.686	0.515	0.352	0.217	0.120	0.059
	5	1.000	0.998	0.983	0.939	0.852	0.722	0.564	0.403	0.261	0.151
	6	1.000	1.000	0.996	0.982	0.943	0.869	0.755	0.610	0.452	0.304
	7	1.000	1.000	0.999	0.996	0.983	0.950	0.887	0.787	0.654	0.500
	8	1.000	1.000	1.000	0.999	0.996	0.985	0.958	0.905	0.818	0.696
	9	1.000	1.000	1.000	1.000	0.999	0.996	0.988	0.966	0.923	0.849
	10	1.000	1.000	1.000	1.000	1.000	0.999	0.997	0.991	0.975	0.941
	11	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.998	0.994	0.982
	12	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.999	0.996
	13	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	14	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	15	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

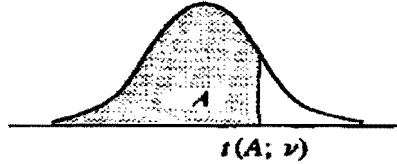
Table C-3 (Continued) Binomial Distribution

n	x	p										
		0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	
20	0	0.358	0.122	0.039	0.012	0.003	0.001	0.000	0.000	0.000	0.000	0.000
	1	0.736	0.392	0.176	0.069	0.024	0.008	0.002	0.001	0.000	0.000	0.000
	2	0.925	0.677	0.405	0.206	0.091	0.035	0.012	0.004	0.001	0.000	0.000
	3	0.984	0.867	0.648	0.411	0.225	0.107	0.044	0.016	0.005	0.001	0.000
	4	0.997	0.957	0.830	0.630	0.415	0.238	0.118	0.051	0.019	0.006	0.000
	5	1.000	0.989	0.933	0.804	0.617	0.416	0.245	0.126	0.055	0.021	0.001
	6	1.000	0.998	0.978	0.913	0.786	0.608	0.417	0.250	0.130	0.058	0.021
	7	1.000	1.000	0.994	0.968	0.898	0.772	0.601	0.416	0.252	0.132	0.058
	8	1.000	1.000	0.999	0.990	0.959	0.887	0.762	0.596	0.414	0.252	0.132
	9	1.000	1.000	1.000	0.997	0.986	0.952	0.878	0.755	0.591	0.412	0.252
	10	1.000	1.000	1.000	0.999	0.996	0.983	0.947	0.872	0.751	0.588	0.258
	11	1.000	1.000	1.000	1.000	0.999	0.995	0.980	0.943	0.869	0.748	0.258
	12	1.000	1.000	1.000	1.000	1.000	0.999	0.994	0.979	0.942	0.868	0.258
	13	1.000	1.000	1.000	1.000	1.000	1.000	0.998	0.994	0.979	0.942	0.258
	14	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.998	0.994	0.979	0.258
	15	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.998	0.994	0.258
	16	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.999	0.258
	17	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.258
	18	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.258
	19	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.258
20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.258	
25	0	0.277	0.072	0.017	0.004	0.001	0.000	0.000	0.000	0.000	0.000	0.000
	1	0.642	0.271	0.093	0.027	0.007	0.002	0.000	0.000	0.000	0.000	0.000
	2	0.873	0.537	0.254	0.098	0.032	0.009	0.002	0.000	0.000	0.000	0.000
	3	0.966	0.764	0.471	0.234	0.096	0.033	0.010	0.002	0.000	0.000	0.000
	4	0.993	0.902	0.682	0.421	0.214	0.090	0.032	0.009	0.002	0.000	0.000
	5	0.999	0.967	0.838	0.617	0.378	0.193	0.083	0.029	0.009	0.002	0.000
	6	1.000	0.991	0.930	0.780	0.561	0.341	0.173	0.074	0.026	0.007	0.000
	7	1.000	0.998	0.975	0.891	0.727	0.512	0.306	0.154	0.064	0.022	0.001
	8	1.000	1.000	0.992	0.953	0.851	0.677	0.467	0.274	0.134	0.054	0.015
	9	1.000	1.000	0.998	0.983	0.929	0.811	0.630	0.425	0.242	0.115	0.045
	10	1.000	1.000	1.000	0.994	0.970	0.902	0.771	0.586	0.384	0.212	0.095
	11	1.000	1.000	1.000	0.998	0.989	0.956	0.875	0.732	0.543	0.345	0.195
	12	1.000	1.000	1.000	1.000	0.997	0.983	0.940	0.846	0.694	0.500	0.325
	13	1.000	1.000	1.000	1.000	0.999	0.994	0.975	0.922	0.817	0.655	0.475
	14	1.000	1.000	1.000	1.000	1.000	0.998	0.991	0.966	0.904	0.788	0.635
	15	1.000	1.000	1.000	1.000	1.000	1.000	0.997	0.987	0.956	0.885	0.765
	16	1.000	1.000	1.000	1.000	1.000	1.000	0.999	0.996	0.983	0.946	0.865
	17	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.999	0.994	0.978	0.935
	18	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.998	0.993	0.978
	19	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.998	0.993
	20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.998
	21	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.998
	22	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.998
	23	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.998
	24	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.998
25	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.998	

Student's Distribution (t Distribution)

Table C-4 Percentiles of the t Distribution

Entry is $t(A; \nu)$ where $P\{t(\nu) \leq t(A; \nu)\} = A$



ν	A						
	.60	.70	.80	.85	.90	.95	.975
1	0.325	0.727	1.376	1.963	3.078	6.314	12.706
2	0.289	0.617	1.061	1.386	1.886	2.920	4.303
3	0.277	0.584	0.978	1.250	1.638	2.353	3.182
4	0.271	0.569	0.941	1.190	1.533	2.132	2.776
5	0.267	0.559	0.920	1.156	1.476	2.015	2.571
6	0.265	0.553	0.906	1.134	1.440	1.943	2.447
7	0.263	0.549	0.896	1.119	1.415	1.895	2.365
8	0.262	0.546	0.889	1.108	1.397	1.860	2.306
9	0.261	0.543	0.883	1.100	1.383	1.833	2.262
10	0.260	0.542	0.879	1.093	1.372	1.812	2.228
11	0.260	0.540	0.876	1.088	1.363	1.796	2.201
12	0.259	0.539	0.873	1.083	1.356	1.782	2.179
13	0.259	0.537	0.870	1.079	1.350	1.771	2.160
14	0.258	0.537	0.868	1.076	1.345	1.761	2.145
15	0.258	0.536	0.866	1.074	1.341	1.753	2.131
16	0.258	0.535	0.865	1.071	1.337	1.746	2.120
17	0.257	0.534	0.863	1.069	1.333	1.740	2.110
18	0.257	0.534	0.862	1.067	1.330	1.734	2.101
19	0.257	0.533	0.861	1.066	1.328	1.729	2.093
20	0.257	0.533	0.860	1.064	1.325	1.725	2.086
21	0.257	0.532	0.859	1.063	1.323	1.721	2.080
22	0.256	0.532	0.858	1.061	1.321	1.717	2.074
23	0.256	0.532	0.858	1.060	1.319	1.714	2.069
24	0.256	0.531	0.857	1.059	1.318	1.711	2.064
25	0.256	0.531	0.856	1.058	1.316	1.708	2.060
26	0.256	0.531	0.856	1.058	1.315	1.706	2.056
27	0.256	0.531	0.855	1.057	1.314	1.703	2.052
28	0.256	0.530	0.855	1.056	1.313	1.701	2.048
29	0.256	0.530	0.854	1.055	1.311	1.699	2.045
30	0.256	0.530	0.854	1.055	1.310	1.697	2.042
40	0.255	0.529	0.851	1.050	1.303	1.684	2.021
60	0.254	0.527	0.848	1.045	1.296	1.671	2.000
120	0.254	0.526	0.845	1.041	1.289	1.658	1.980
∞	0.253	0.524	0.842	1.036	1.282	1.645	1.960

Table C-4 (Continued) Percentiles of the *t* Distribution

<i>v</i>	A						
	.98	.985	.99	.9925	.995	.9975	.9995
1	15.895	21.205	31.821	42.434	63.657	127.322	636.590
2	4.849	5.643	6.965	8.073	9.925	14.089	31.598
3	3.482	3.896	4.541	5.047	5.841	7.453	12.924
4	2.999	3.298	3.747	4.088	4.604	5.598	8.610
5	2.757	3.003	3.365	3.634	4.032	4.773	6.869
6	2.612	2.829	3.143	3.372	3.707	4.317	5.959
7	2.517	2.715	2.998	3.203	3.499	4.029	5.408
8	2.449	2.634	2.896	3.085	3.355	3.833	5.041
9	2.398	2.574	2.821	2.998	3.250	3.690	4.781
10	2.359	2.527	2.764	2.932	3.169	3.581	4.587
11	2.328	2.491	2.718	2.879	3.106	3.497	4.437
12	2.303	2.461	2.681	2.836	3.055	3.428	4.318
13	2.282	2.436	2.650	2.801	3.012	3.372	4.221
14	2.264	2.415	2.624	2.771	2.977	3.326	4.140
15	2.249	2.397	2.602	2.746	2.947	3.286	4.073
16	2.235	2.382	2.583	2.724	2.921	3.252	4.015
17	2.224	2.368	2.567	2.706	2.898	3.222	3.965
18	2.214	2.356	2.552	2.689	2.878	3.197	3.922
19	2.205	2.346	2.539	2.674	2.861	3.174	3.883
20	2.197	2.336	2.528	2.661	2.845	3.153	3.849
21	2.189	2.328	2.518	2.649	2.831	3.135	3.819
22	2.183	2.320	2.508	2.639	2.819	3.119	3.792
23	2.177	2.313	2.500	2.629	2.807	3.104	3.768
24	2.172	2.307	2.492	2.620	2.797	3.091	3.745
25	2.167	2.301	2.485	2.612	2.787	3.078	3.725
26	2.162	2.296	2.479	2.605	2.779	3.067	3.707
27	2.158	2.291	2.473	2.598	2.771	3.057	3.690
28	2.154	2.286	2.467	2.592	2.763	3.047	3.674
29	2.150	2.282	2.462	2.586	2.756	3.038	3.659
30	2.147	2.278	2.457	2.581	2.750	3.030	3.646
40	2.123	2.250	2.423	2.542	2.704	2.971	3.551
60	2.099	2.223	2.390	2.504	2.660	2.915	3.460
120	2.076	2.196	2.358	2.468	2.617	2.860	3.373
∞	2.054	2.170	2.326	2.432	2.576	2.807	3.291