

Ve401 Probabilistic Methods in Engineering

Spring 2020 Final Exam

Statistical Tables



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Cumulative Standard Normal (Z) Distribution

The table lists the probabilities $P[0 \leq Z \leq z]$ for various values of z .

Cumulative Chi-Squared Distribution

The table lists the values x of $P[X_\gamma^2 \leq x] = p$ for various values of p .

γ	p												
	0.005	0.010	0.025	0.05	0.10	0.25	0.50	0.75	0.90	0.95	0.975	0.99	0.995
1	0.000	0.000	0.000	0.004	0.016	0.102	0.455	1.32	2.71	3.84	5.02	6.63	7.88
2	0.010	0.020	0.051	0.103	0.211	0.575	1.39	2.77	4.61	5.99	7.38	9.21	10.6
3	0.072	0.115	0.216	0.352	0.584	1.21	2.37	4.11	6.25	7.81	9.35	11.3	12.8
4	0.207	0.297	0.484	0.711	1.06	1.92	3.36	5.39	7.78	9.49	11.1	13.3	14.9
5	0.412	0.554	0.831	1.15	1.61	2.67	4.35	6.63	9.24	11.1	12.8	15.1	16.7
6	0.676	0.872	1.24	1.64	2.20	3.45	5.35	7.84	10.6	12.6	14.4	16.8	18.5
7	0.989	1.24	1.69	2.17	2.83	4.25	6.35	9.04	12.0	14.1	16.0	18.5	20.3
8	1.34	1.65	2.18	2.73	3.49	5.07	7.34	10.2	13.4	15.5	17.5	20.1	22.0
9	1.73	2.09	2.70	3.33	4.17	5.9	8.34	11.4	14.7	16.9	19.0	21.7	23.6
10	2.16	2.56	3.25	3.94	4.87	6.74	9.34	12.5	16.0	18.3	20.5	23.2	25.2
11	2.60	3.05	3.82	4.57	5.58	7.58	10.3	13.7	17.3	19.7	21.9	24.7	26.8
12	3.07	3.57	4.40	5.23	6.30	8.44	11.3	14.8	18.5	21.0	23.3	26.2	28.3
13	3.57	4.11	5.01	5.89	7.04	9.3	12.3	16.0	19.8	22.4	24.7	27.7	29.8
14	4.07	4.66	5.63	6.57	7.79	10.2	13.3	17.1	21.1	23.7	26.1	29.1	31.3
15	4.60	5.23	6.26	7.26	8.55	11.0	14.3	18.2	22.3	25.0	27.5	30.6	32.8
16	5.14	5.81	6.91	7.96	9.31	11.9	15.3	19.4	23.5	26.3	28.8	32.0	34.3
17	5.70	6.41	7.56	8.67	10.1	12.8	16.3	20.5	24.8	27.6	30.2	33.4	35.7
18	6.26	7.01	8.23	9.39	10.9	13.7	17.3	21.6	26.0	28.9	31.5	34.8	37.2
19	6.84	7.63	8.91	10.1	11.7	14.6	18.3	22.7	27.2	30.1	32.9	36.2	38.6
20	7.43	8.26	9.59	10.9	12.4	15.5	19.3	23.8	28.4	31.4	34.2	37.6	40.0
21	8.03	8.90	10.3	11.6	13.2	16.3	20.3	24.9	29.6	32.7	35.5	38.9	41.4
22	8.64	9.54	11.0	12.3	14.0	17.2	21.3	26.0	30.8	33.9	36.8	40.3	42.8
23	9.26	10.2	11.7	13.1	14.8	18.1	22.3	27.1	32.0	35.2	38.1	41.6	44.2
24	9.89	10.9	12.4	13.8	15.7	19.0	23.3	28.2	33.2	36.4	39.4	43.0	45.6
25	10.5	11.5	13.1	14.6	16.5	19.9	24.3	29.3	34.4	37.7	40.6	44.3	46.9
26	11.2	12.2	13.8	15.4	17.3	20.8	25.3	30.4	35.6	38.9	41.9	45.6	48.3
27	11.8	12.9	14.6	16.2	18.1	21.7	26.3	31.5	36.7	40.1	43.2	47.0	49.6
28	12.5	13.6	15.3	16.9	18.9	22.7	27.3	32.6	37.9	41.3	44.5	48.3	51.0
29	13.1	14.3	16.0	17.7	19.8	23.6	28.3	33.7	39.1	42.6	45.7	49.6	52.3
30	13.8	15.0	16.8	18.5	20.6	24.5	29.3	34.8	40.3	43.8	47.0	50.9	53.7
31	14.5	15.7	17.5	19.3	21.4	25.4	30.3	35.9	41.4	45.0	48.2	52.2	55.0
32	15.1	16.4	18.3	20.1	22.3	26.3	31.3	37.0	42.6	46.2	49.5	53.5	56.3
33	15.8	17.1	19.0	20.9	23.1	27.2	32.3	38.1	43.7	47.4	50.7	54.8	57.6
34	16.5	17.8	19.8	21.7	24.0	28.1	33.3	39.1	44.9	48.6	52.0	56.1	59.0
35	17.2	18.5	20.6	22.5	24.8	29.1	34.3	40.2	46.1	49.8	53.2	57.3	60.3
36	17.9	19.2	21.3	23.3	25.6	30.0	35.3	41.3	47.2	51.0	54.4	58.6	61.6
37	18.6	20.0	22.1	24.1	26.5	30.9	36.3	42.4	48.4	52.2	55.7	59.9	62.9
38	19.3	20.7	22.9	24.9	27.3	31.8	37.3	43.5	49.5	53.4	56.9	61.2	64.2
39	20.0	21.4	23.7	25.7	28.2	32.7	38.3	44.5	50.7	54.6	58.1	62.4	65.5
40	20.7	22.2	24.4	26.5	29.1	33.7	39.3	45.6	51.8	55.8	59.3	63.7	66.8

Cumulative T -Distribution

The table lists the values x of $P[T_\gamma \leq x] = p$ for various values of p .

γ	p					
	0.75	0.90	0.95	0.975	0.99	0.995
1	1.	3.07768	6.31375	12.7062	31.8205	63.6567
2	0.816497	1.88562	2.91999	4.30265	6.96456	9.92484
3	0.764892	1.63774	2.35336	3.18245	4.5407	5.84091
4	0.740697	1.53321	2.13185	2.77645	3.74695	4.60409
5	0.726687	1.47588	2.01505	2.57058	3.36493	4.03214
6	0.717558	1.43976	1.94318	2.44691	3.14267	3.70743
7	0.711142	1.41492	1.89458	2.36462	2.99795	3.49948
8	0.706387	1.39682	1.85955	2.306	2.89646	3.35539
9	0.702722	1.38303	1.83311	2.26216	2.82144	3.24984
10	0.699812	1.37218	1.81246	2.22814	2.76377	3.16927
11	0.697445	1.36343	1.79588	2.20099	2.71808	3.10581
12	0.695483	1.35622	1.78229	2.17881	2.681	3.05454
13	0.693829	1.35017	1.77093	2.16037	2.65031	3.01228
14	0.692417	1.34503	1.76131	2.14479	2.62449	2.97684
15	0.691197	1.34061	1.75305	2.13145	2.60248	2.94671
16	0.690132	1.33676	1.74588	2.11991	2.58349	2.92078
17	0.689195	1.33338	1.73961	2.10982	2.56693	2.89823
18	0.688364	1.33039	1.73406	2.10092	2.55238	2.87844
19	0.687621	1.32773	1.72913	2.09302	2.53948	2.86093
20	0.686954	1.32534	1.72472	2.08596	2.52798	2.84534
21	0.686352	1.32319	1.72074	2.07961	2.51765	2.83136
22	0.685805	1.32124	1.71714	2.07387	2.50832	2.81876
23	0.685306	1.31946	1.71387	2.06866	2.49987	2.80734
24	0.68485	1.31784	1.71088	2.0639	2.49216	2.79694
25	0.68443	1.31635	1.70814	2.05954	2.48511	2.78744
26	0.684043	1.31497	1.70562	2.05553	2.47863	2.77871
27	0.683685	1.3137	1.70329	2.05183	2.47266	2.77068
28	0.683353	1.31253	1.70113	2.04841	2.46714	2.76326
29	0.683044	1.31143	1.69913	2.04523	2.46202	2.75639
30	0.682756	1.31042	1.69726	2.04227	2.45726	2.75
31	0.682486	1.30946	1.69552	2.03951	2.45282	2.74404
32	0.682234	1.30857	1.69389	2.03693	2.44868	2.73848
33	0.681997	1.30774	1.69236	2.03452	2.44479	2.73328
34	0.681774	1.30695	1.69092	2.03224	2.44115	2.72839
35	0.681564	1.30621	1.68957	2.03011	2.43772	2.72381
36	0.681366	1.30551	1.6883	2.02809	2.43449	2.71948
37	0.681178	1.30485	1.68709	2.02619	2.43145	2.71541
38	0.681001	1.30423	1.68595	2.02439	2.42857	2.71156
39	0.680833	1.30364	1.68488	2.02269	2.42584	2.70791
40	0.680673	1.30308	1.68385	2.02108	2.42326	2.70446

Table of 95% Points of the F_{γ_1, γ_2} distribution

The table lists the values of x for which $P[F_{\gamma_1, \gamma_2} \leq x] = 0.95$ for $\gamma_1, \gamma_2 \leq 20$.

γ_2	γ_1																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	161	199	216	225	230	234	237	239	241	242	243	244	245	246	246	247	247	248	248
2	18.5	19.0	19.2	19.2	19.3	19.3	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4
3	10.1	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.76	8.74	8.73	8.71	8.70	8.69	8.68	8.67	8.66
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.94	5.91	5.89	5.87	5.86	5.84	5.83	5.82	5.81
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.70	4.68	4.66	4.64	4.62	4.60	4.59	4.58	4.56
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.03	4.00	3.98	3.96	3.94	3.92	3.91	3.90	3.88
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.60	3.57	3.55	3.53	3.51	3.49	3.48	3.47	3.46
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.31	3.28	3.26	3.24	3.22	3.20	3.19	3.17	3.16
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.10	3.07	3.05	3.03	3.01	2.99	2.97	2.96	2.95
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.94	2.91	2.89	2.86	2.85	2.83	2.81	2.80	2.79
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85	2.82	2.79	2.76	2.74	2.72	2.70	2.69	2.67	2.66
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75	2.72	2.69	2.66	2.64	2.62	2.60	2.58	2.57	2.56
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	2.63	2.60	2.58	2.55	2.53	2.51	2.50	2.48	2.47
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	2.57	2.53	2.51	2.48	2.46	2.44	2.43	2.41	2.40
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.51	2.48	2.45	2.42	2.40	2.38	2.37	2.35	2.34
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	2.46	2.42	2.40	2.37	2.35	2.33	2.32	2.30	2.29
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45	2.41	2.38	2.35	2.33	2.31	2.29	2.27	2.26	2.24
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41	2.37	2.34	2.31	2.29	2.27	2.25	2.23	2.22	2.20
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38	2.34	2.31	2.28	2.26	2.23	2.21	2.20	2.18	2.17
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.31	2.28	2.25	2.22	2.20	2.18	2.17	2.15	2.14

Table for the Sign Test

The values given are those of $P[X \leq k]$, where X follows a binomial distribution with parameters n and $p = 1/2$.

n	k										
	0	1	2	3	4	5	6	7	8	9	10
1	0.5000										
2	0.2500	0.7500									
3	0.1250	0.5000									
4	0.0625	0.3125	0.6875								
5	0.0312	0.1875	0.5000								
6	0.0156	0.1094	0.3438	0.6562							
7	0.0078	0.0625	0.2266	0.5000							
8	0.0039	0.0352	0.1445	0.3633	0.6367						
9	0.0020	0.0195	0.0898	0.2539	0.5000						
10	0.0010	0.0107	0.0547	0.1719	0.3770	0.6230					
11	0.0005	0.0059	0.0327	0.1133	0.2744	0.5000					
12	0.0002	0.0032	0.0193	0.0730	0.1938	0.3872	0.6128				
13	0.0001	0.0017	0.0112	0.0461	0.1334	0.2905	0.5000				
14	0.0001	0.0009	0.0065	0.0287	0.0898	0.2120	0.3953	0.6047			
15	0.0000	0.0005	0.0037	0.0176	0.0592	0.1509	0.3036	0.5000			
16	0.0000	0.0003	0.0021	0.0106	0.0384	0.1051	0.2272	0.4018	0.5982		
17	0.0000	0.0001	0.0012	0.0064	0.0245	0.0717	0.1662	0.3145	0.5000		
18	0.0000	0.0001	0.0007	0.0038	0.0154	0.0481	0.1189	0.2403	0.4073	0.5927	
19	0.0000	0.0000	0.0004	0.0022	0.0096	0.0318	0.0835	0.1796	0.3238	0.5000	
20	0.0000	0.0000	0.0002	0.0013	0.0059	0.0207	0.0577	0.1316	0.2517	0.4119	0.5881

Table for the Wilcoxon Signed-Rank Test

The table gives the critical values for the statistic W for samples of size $5 \leq n \leq 30$. For various values of p the numbers x such that $P[W \leq x] \leq p$ are tabulated.

n	p			
	0.05	0.025	0.01	0.005
5	1			
6	2	1		
7	4	2	0	
8	6	4	2	0
9	8	6	3	2
10	11	8	5	3
11	14	11	7	5
12	17	14	10	7
13	21	17	13	10
14	26	21	16	13
15	30	25	20	16
16	36	30	24	19
17	41	35	28	23

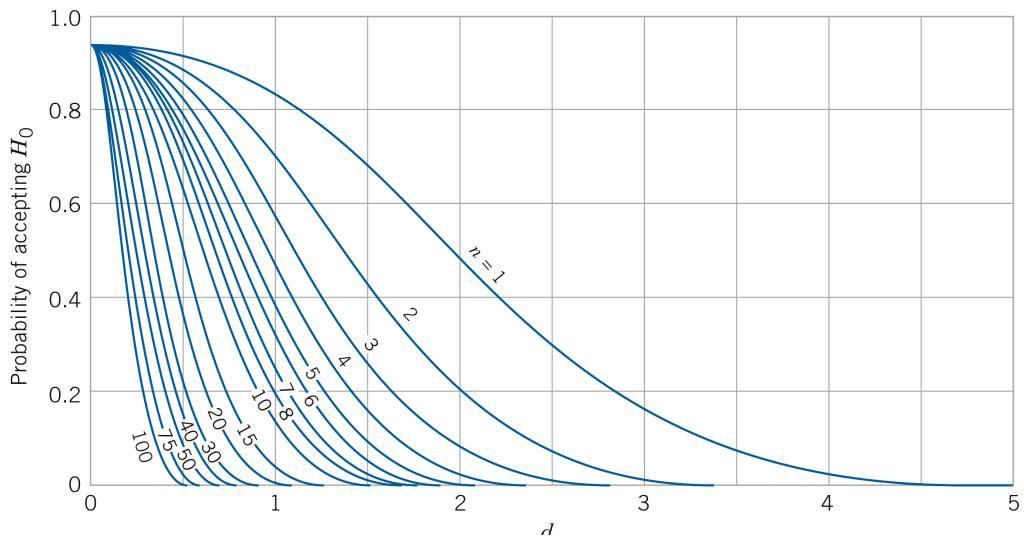
n	p			
	0.05	0.025	0.01	0.005
18	47	40	33	28
19	54	46	38	32
20	60	52	43	37
21	68	59	49	43
22	75	66	56	49
23	83	73	62	55
24	92	81	69	61
25	101	90	77	68
26	110	98	85	76
27	120	107	93	84
28	130	117	102	92
29	141	127	111	100
30	152	137	120	109

Table for the Wilcoxon Rank-Sum Test

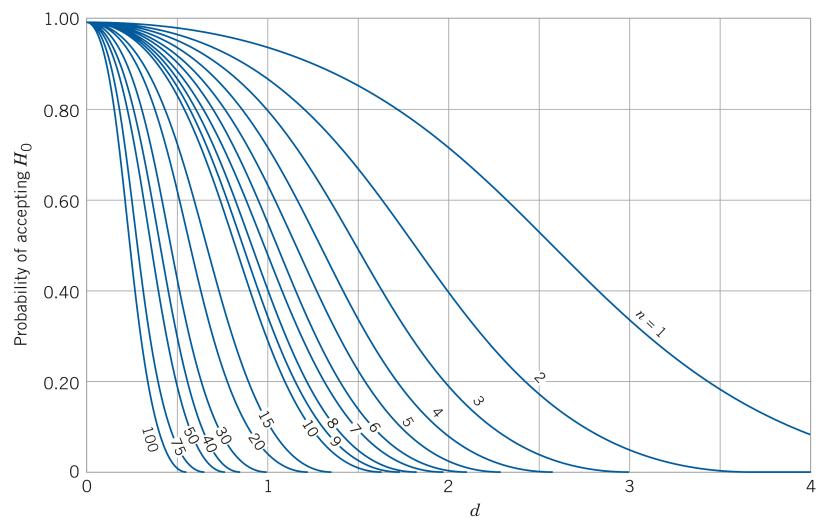
The table gives the critical values for the statistic W_m (the sum of ranks of the smaller sample) for two samples of sizes $m, n \leq 12$. For various values of p the numbers x such that $P[W_m \leq x] \leq p$ (left tail) and $P[W_m \geq x] \leq p$ (right tail) are tabulated.

Sample Size		Left Tail p						Right Tail p					
m	n	0.005	0.01	0.025	0.05	0.10	0.20	0.20	0.10	0.05	0.025	0.01	0.005
4	4	.	.	10	11	13	14	22	23	25	26	.	.
	5	.	10	11	12	14	15	25	26	28	29	30	.
	6	10	11	12	13	15	17	27	29	31	32	33	34
	7	10	11	13	14	16	18	30	32	34	35	37	38
	8	11	12	14	15	17	20	32	35	37	38	40	41
	9	11	13	14	16	19	21	35	37	40	42	43	45
	10	12	13	15	17	20	23	37	40	43	45	47	48
	11	12	14	16	18	21	24	40	43	46	48	50	52
	12	13	15	17	19	22	26	42	46	49	51	53	55
	5	15	16	17	19	20	22	33	35	36	38	39	40
	6	16	17	18	20	22	24	36	38	40	42	43	44
5	7	16	18	20	21	23	26	39	42	44	45	47	49
	8	17	19	21	23	25	28	42	45	47	49	51	53
	9	18	20	22	24	27	30	45	48	51	53	55	57
	10	19	21	23	26	28	32	48	52	54	57	59	61
	11	20	22	24	27	30	34	51	55	58	61	63	65
	12	21	23	26	28	32	36	54	58	62	64	67	69
	6	23	24	26	28	30	33	45	48	50	52	54	55
	7	24	25	27	29	32	35	49	52	55	57	59	60
	8	25	27	29	31	34	37	53	56	59	61	63	65
	9	26	28	31	33	36	40	56	60	63	65	68	70
	10	27	29	32	35	38	42	60	64	67	70	73	75
	11	28	30	34	37	40	44	64	68	71	74	78	80
7	12	30	32	35	38	42	47	67	72	76	79	82	84
	7	32	34	36	39	41	45	60	64	66	69	71	73
	8	34	35	38	41	44	48	64	68	71	74	77	78
	9	35	37	40	43	46	50	69	73	76	79	82	84
	10	37	39	42	45	49	53	73	77	81	84	87	89
8	12	40	42	46	49	54	59	81	86	91	94	98	100
	8	43	45	49	51	55	59	77	81	85	87	91	93
	9	45	47	51	54	58	62	82	86	90	93	97	99
	10	47	49	53	56	60	65	87	92	96	99	103	105
	11	49	51	55	59	63	69	91	97	101	105	109	111
9	12	51	53	58	62	66	72	96	102	106	110	115	117
	9	56	59	62	66	70	75	96	101	105	109	112	115
	10	58	61	65	69	73	78	102	107	111	115	119	122
	11	61	63	68	72	76	82	107	113	117	121	126	128
10	12	63	66	71	75	80	86	112	118	123	127	132	135
	10	71	74	78	82	87	93	117	123	128	132	136	139
	11	73	77	81	86	91	97	123	129	134	139	143	147
	12	76	79	84	89	94	101	129	136	141	146	151	154
11	11	87	91	96	100	106	112	141	147	153	157	162	166
	12	90	94	99	104	110	117	147	154	160	165	170	174
12	12	105	109	115	120	127	134	166	173	180	185	191	195

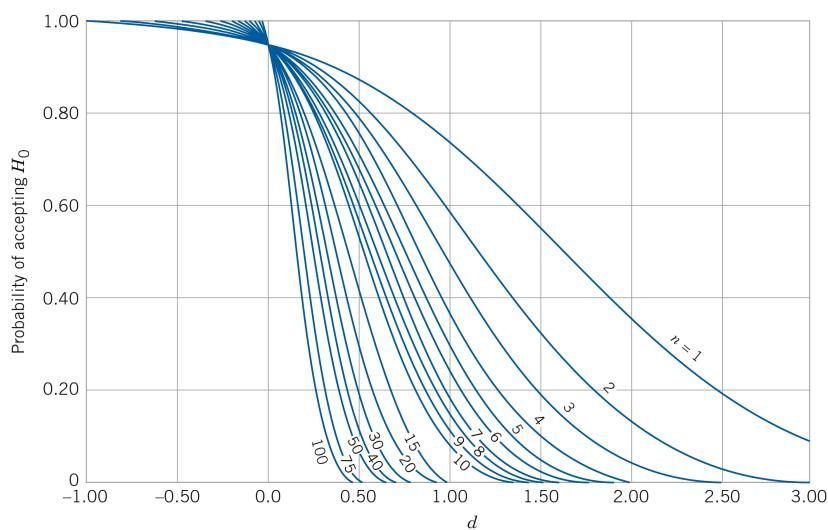
OC Curves for the Normal Distribution



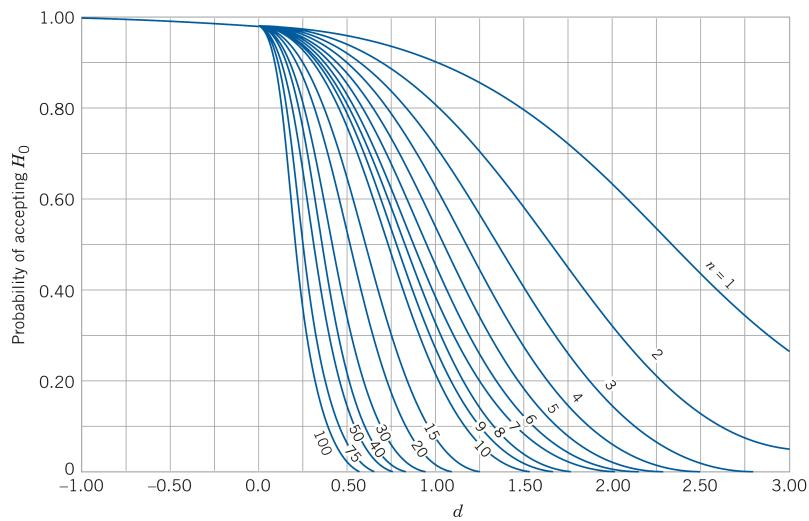
OC Curves for two-sided tests based the normal distribution with $\alpha = 0.05$.



OC Curves for two-sided tests based the normal distribution with $\alpha = 0.01$.

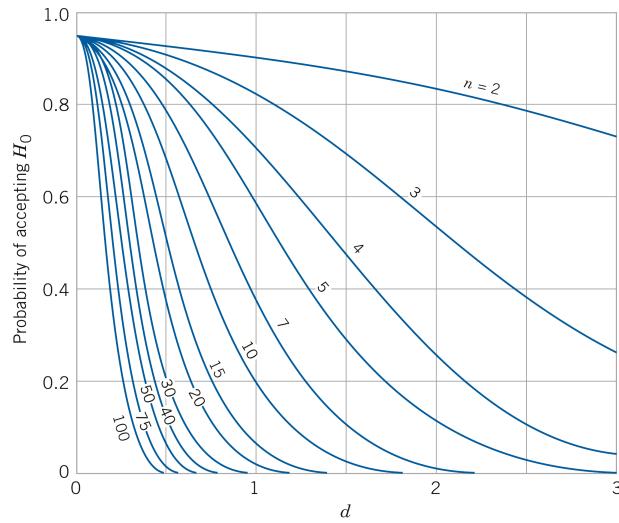


OC Curves for one-sided tests based the normal distribution with $\alpha = 0.05$.

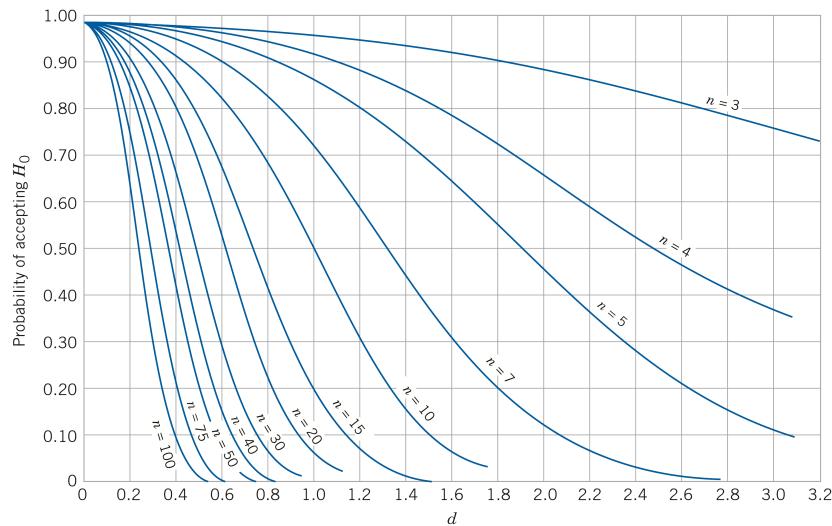


OC Curves for one-sided tests based the normal distribution with $\alpha = 0.01$.

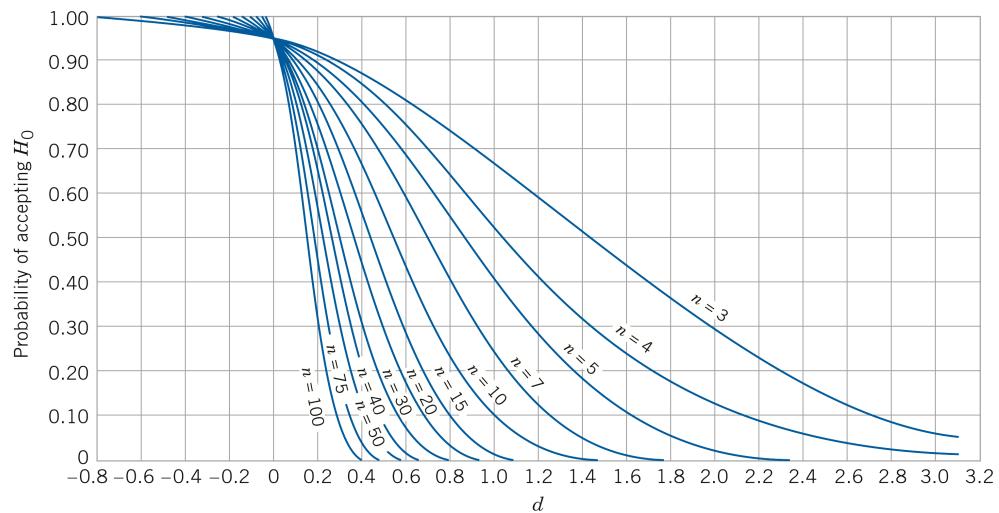
OC Curves for the T -Distribution



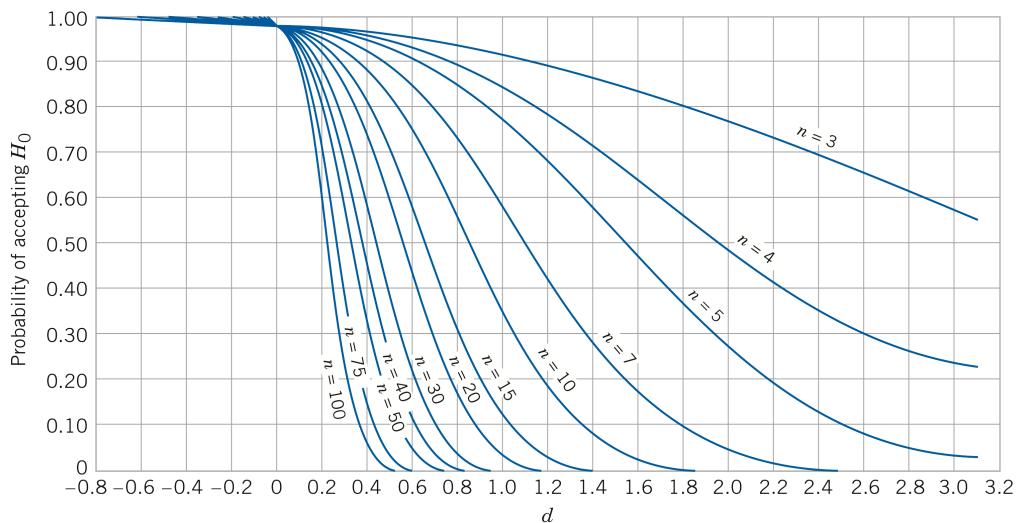
OC Curves for two-sided tests based the T -distribution with $\alpha = 0.05$.



OC Curves for two-sided tests based the T -distribution with $\alpha = 0.01$.

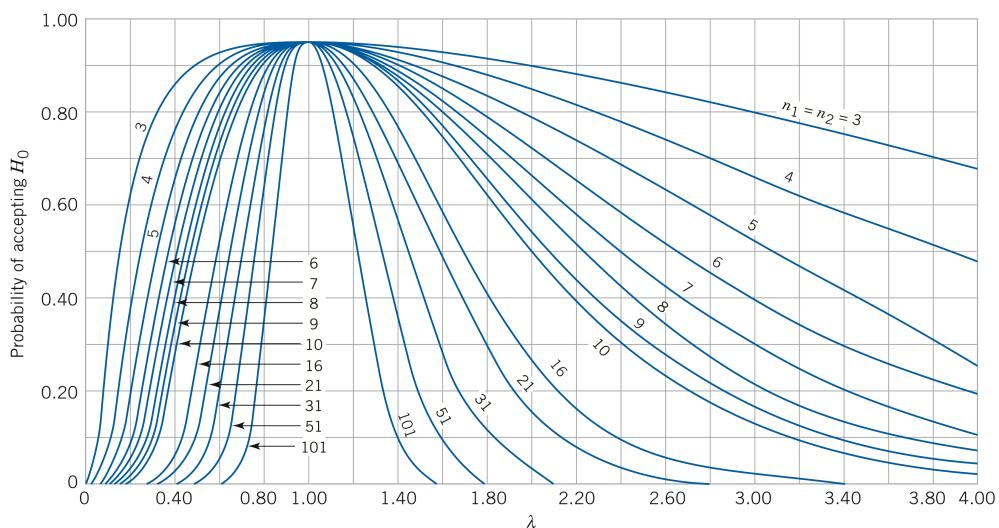


OC Curves for one-sided tests based the T -distribution with $\alpha = 0.05$.

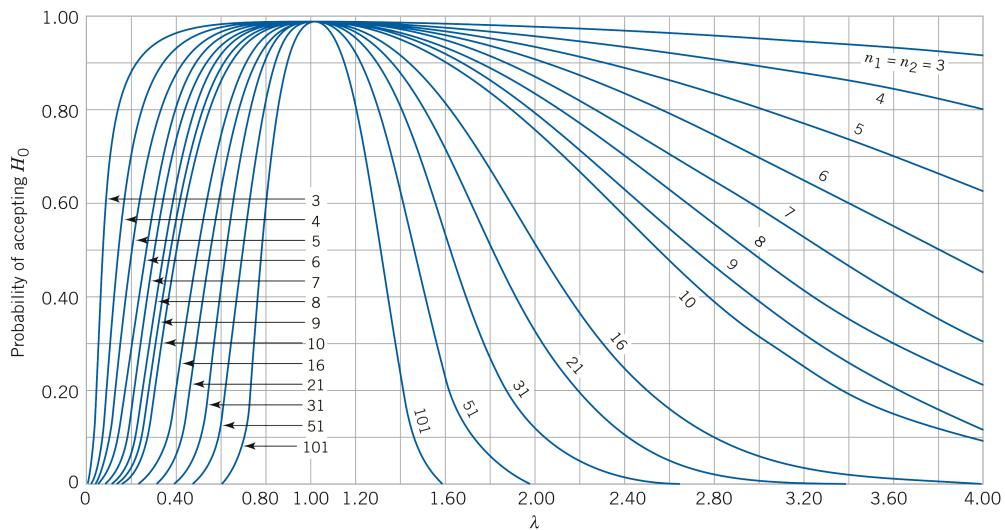


OC Curves for one-sided tests based the T -distribution with $\alpha = 0.01$.

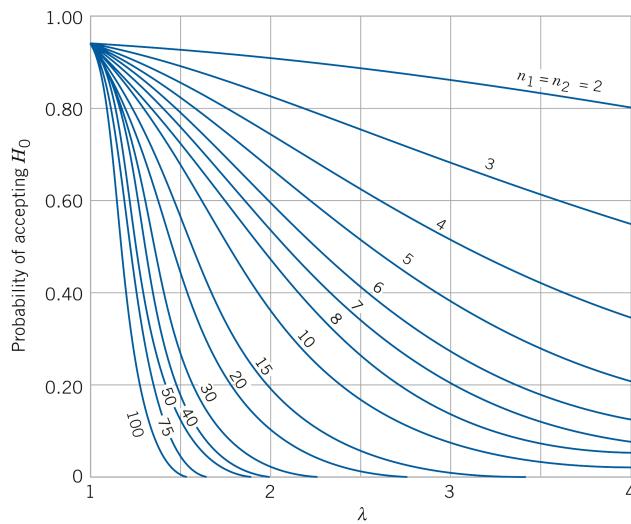
OC Curves for the F -Distribution



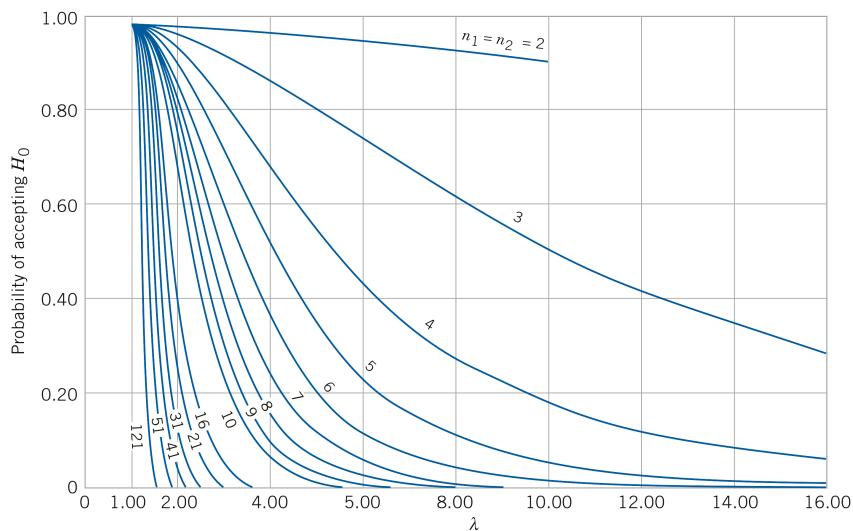
OC Curves for two-sided tests based the F -distribution with $\alpha = 0.05$.



OC Curves for two-sided tests based the F -distribution with $\alpha = 0.01$.

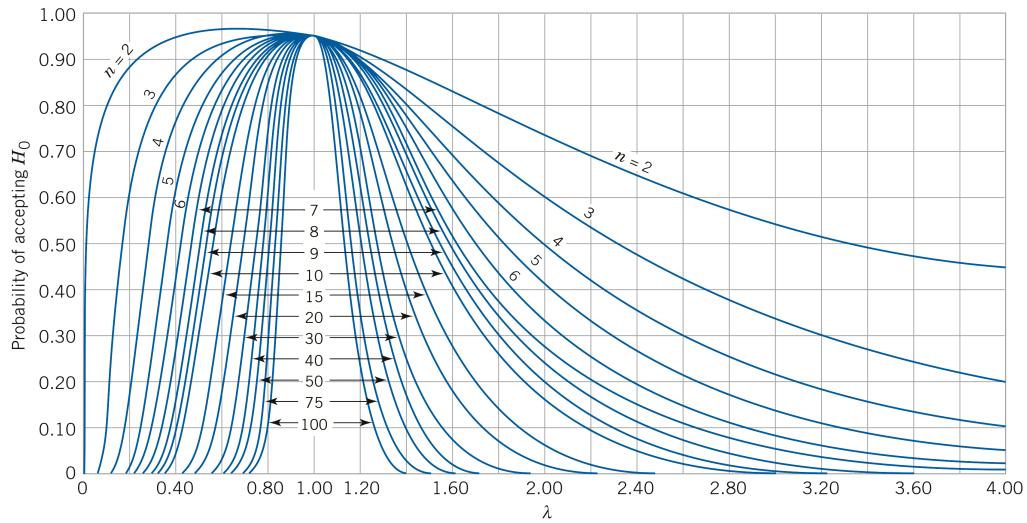


OC Curves for one-sided (upper-tail) tests based the F -distribution with $\alpha = 0.05$.

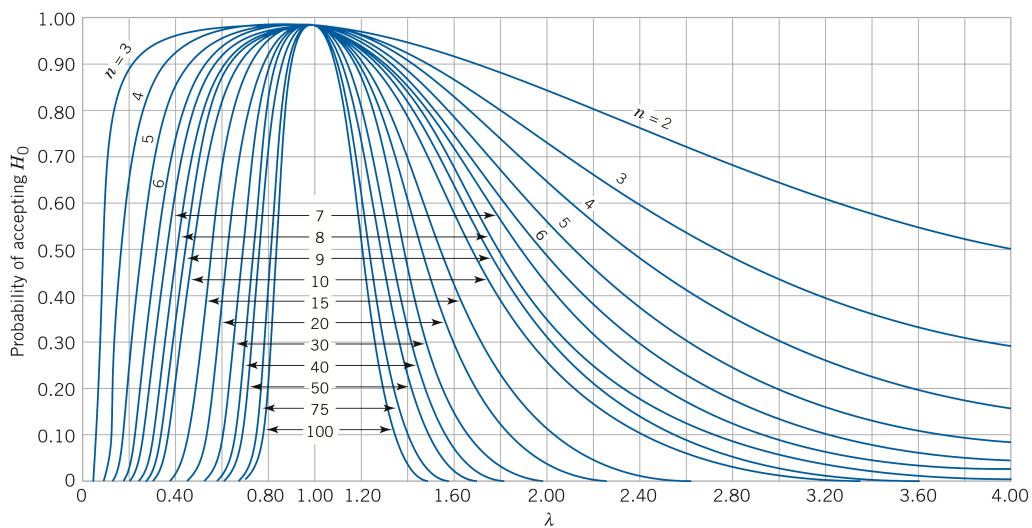


OC Curves for one-sided (upper-tail) tests based the F -distribution with $\alpha = 0.01$.

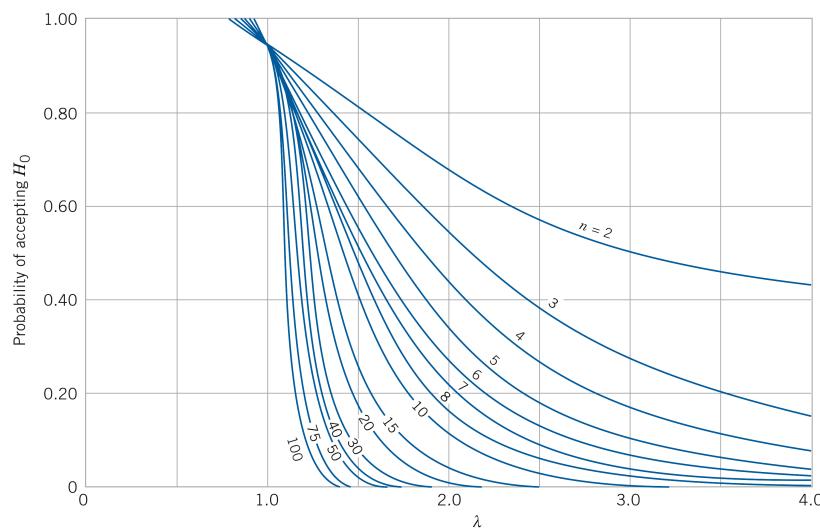
OC Curves for the Chi-Squared-Distribution



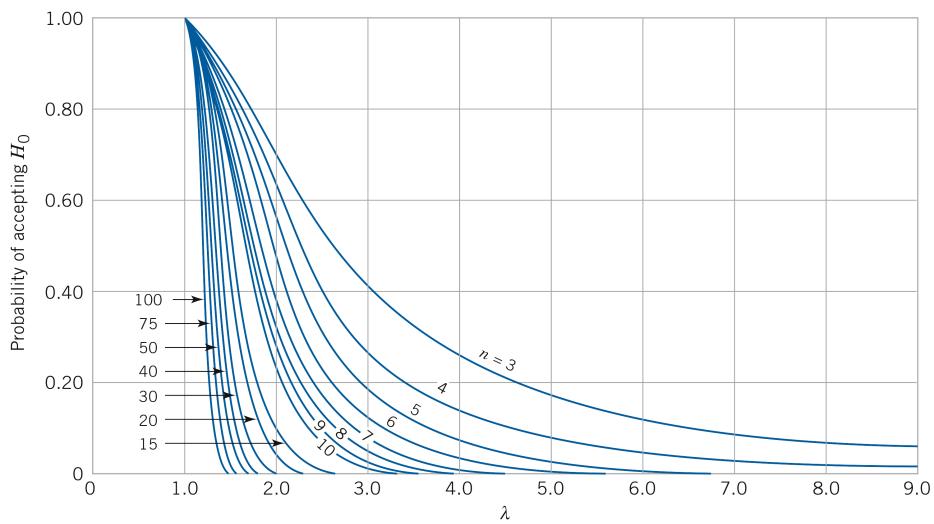
OC Curves for two-sided tests based the chi-squared-distribution with $\alpha = 0.05$.



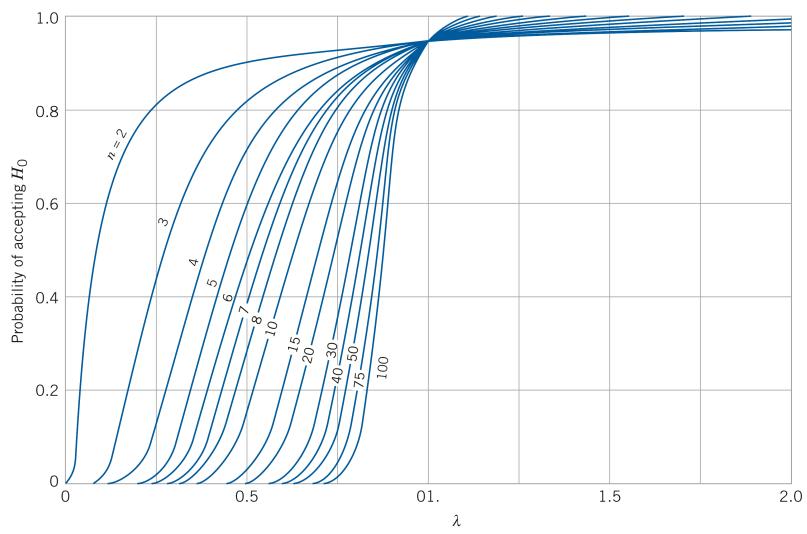
OC Curves for two-sided tests based the chi-squared-distribution with $\alpha = 0.01$.



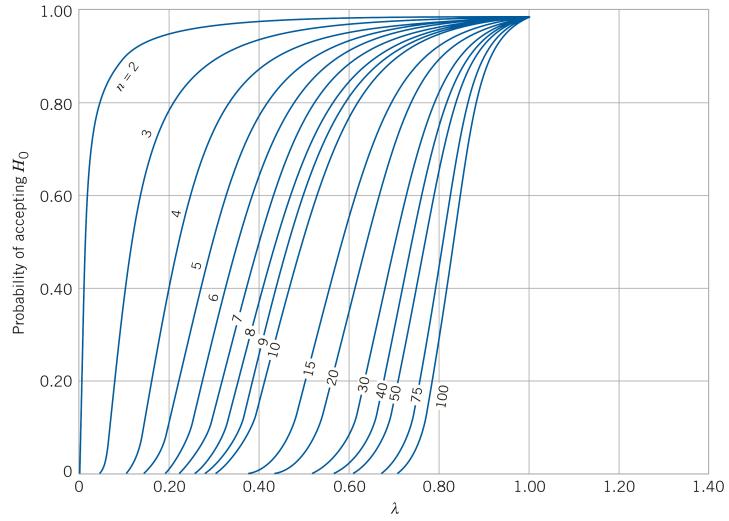
OC Curves for one-sided (upper-tail) tests based on the chi-squared-distribution with $\alpha = 0.05$.



OC Curves for one-sided (upper-tail) tests based on the chi-squared-distribution with $\alpha = 0.01$.



OC Curves for one-sided (lower-tail) tests based on the chi-squared-distribution with $\alpha = 0.05$.



OC Curves for one-sided (lower-tail) tests based on the chi-squared-distribution with $\alpha = 0.01$.