Learning the F-Distribution: A Comprehensive Guide

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The Foundation of F-Statistics: Introducing the F-Distribution

The F-distribution, also widely recognized as the Fisher-Snedecor distribution, is a crucial continuous probability distribution in inferential statistics. It plays a pivotal role primarily in hypothesis testing concerning the comparison of variances. Named after statisticians R.A. Fisher and George W. Snedecor, its mathematical foundation lies in the ratio of two independent chi-squared random variables, each divided by its corresponding Degrees of Freedom. This fundamental relationship makes the F-distribution the theoretical backbone for the F-test, which is essential for determining if two population variances are equivalent or, in a broader context, for assessing the overall significance of regression models and comparing multiple group means within Analysis of Variance (ANOVA).

A distinctive feature of the F-distribution is its inherent positive skewness, meaning that it is defined exclusively over non-negative values. Since the F-statistic is calculated as a ratio of squared quantities (variances), it is mathematically impossible for the result to be zero or negative. Unlike the symmetric bell curve of the normal distribution, the precise shape of the F-distribution is dynamically controlled by two distinct parameters: the numerator degrees of freedom ($strong{df_1}$) and the denominator degrees of freedom ($strong{df_2}$). As these degrees of freedom increase, often reflecting larger sample sizes, the distribution curve gradually becomes less skewed and more compressed, moving toward a more symmetric, albeit still positive, distribution.

For traditional frequentist hypothesis testing, mastering the use of the F-distribution table is non-negotiable. While contemporary statistical software automatically computes precise p-values, these tables furnish the **critical values** necessary for manual hypothesis testing. This manual process is invaluable as it provides deep conceptual insight into statistical decision-making. By requiring the researcher to compare the observed F-statistic against a fixed critical threshold, the tables underscore the relationship between sample variability, sample size, and the required evidentiary standard needed to reject the null hypothesis at a chosen Significance level (α).

The Mechanics of the F-Statistic and the F-Test

The F-statistic is the calculated test statistic central to the F-test. Fundamentally, it expresses the ratio between two independent estimates of population variance. In its most common application within ANOVA, this ratio is specifically defined as the variance observed **between** the sample means (known as the Mean Square Between, or $MS_{Between}$) divided by the variance observed **within** the samples (the Mean Square Error, or MS_{Error}). If the calculated F-statistic hovers near 1, it indicates that the variation separating the groups is comparable to the random variation existing within the groups, offering scant evidence to refute the null hypothesis that all population means are equivalent. Conversely, a significantly large F-statistic signals that the variation between the groups far outweighs the random variation within the groups, strongly suggesting that genuine differences exist among the population means.

The standard null hypothesis tested using the F-distribution typically asserts equality--for instance, that all population means ($\mu_1, \mu_2, \dots, \mu_k$) are identical. Crucially, the F-test is inherently a **one-tailed test** because researchers are solely interested in unusually large F-ratios. A calculated F-statistic that exceeds the critical value obtained from the F-table falls into the critical rejection region defined by the chosen Alpha level (α), mandating the rejection of the null hypothesis. Conversely, F-values less than 1 are non-concerning; they merely affirm that the differences between the group averages are smaller than the expected random variability within those groups, thereby supporting the null hypothesis.

Beyond its utility in comparing group means via ANOVA, the F-test is indispensable in multiple regression analysis. Here, its role is to evaluate the overall explanatory power of the regression model. The test pits the variance explained by the model (the regression sum of squares) against the unexplained variance (the error sum of squares). If the resulting F-statistic is significant, it implies that the set of predictor variables, taken as a whole, meaningfully accounts for the variability in the dependent variable. Historically, determining the critical threshold for this significance would be computationally complex without the pre-calculated reference points offered by the F-distribution tables, emphasizing their foundational importance in statistical history.

The Pivotal Role of Degrees of Freedom

The F-distribution is uniquely parametrized by two independent Degrees of Freedom: df_1 (numerator) and df_2 (denominator). These two parameters are absolutely critical, as they uniquely determine the specific critical value that must be located within the F-table. The numerator degrees of freedom (df_1) typically relate to the number of groups or variables being compared minus one, providing a measure of the flexibility associated with the "between-group" variance estimate.

In contrast, the denominator degrees of freedom (df_2) are strongly linked to the sample size and typically represent the total number of observations minus the number of groups or parameters estimated. This parameter represents the reliability and flexibility of the "within-group" variance estimate, or the error term. When the denominator degrees of freedom are small, the F-distribution is highly dispersed and skewed, reflecting less confidence or precision in the variance estimate. As df_2 increases (a result of larger sample sizes), the distribution tightens, becoming narrower and more peaked, indicating a much more precise estimation of the underlying population variance.

To ensure the F-table is utilized correctly, the researcher must accurately identify both degrees of freedom. The numerator degrees of freedom (df_1) are consistently indexed across the top row of the F-table, while the denominator degrees of freedom (df_2) are found along the far left column. The intersection of the correct row and column yields the exact critical F-value corresponding to the specific Alpha level (α) for that particular table. Any misidentification or transposition of these parameters will inevitably lead to an incorrect critical value and, consequently, a flawed conclusion regarding the statistical hypothesis test, highlighting the necessity for meticulous calculation before consulting the table.

Interpreting Critical Values from the F-Distribution Table

The F-distribution table serves as a comprehensive collection of critical values, compiled for numerous combinations of degrees of freedom (df_1 and df_2) and specific significance thresholds. Since the geometry of the F-distribution is highly sensitive to changes in these two parameters, a single universal table is impractical. For this reason, separate tables are generated for common alpha levels used in scientific methodology, such as 0.10, 0.05, 0.025, 0.01, and 0.001. Every value listed within the table represents the point on the F-distribution curve that demarcates the upper tail area equal to the specified alpha level.

When executing an F-test, the critical value retrieved from the table functions as the definitive decision boundary. If the calculated F-statistic derived from the experimental data is numerically greater than or equal to the critical F-value found in the table, the outcome is designated as **statistically significant**. This implies that the probability of observing such an extreme F-ratio purely by random chance, assuming the null hypothesis is true, is less than the predetermined alpha level. Conversely, if the calculated F-statistic falls below the critical value, the result is deemed non-significant, and the researcher must fail to reject the null hypothesis, concluding that the observed differences are most likely attributable to random sampling variability.

It is essential to recognize that the F-table exclusively provides critical values for the upper (right) tail of the distribution. This is because the F-test is almost always applied as a one-tailed test focused on detecting effects that increase the ratio--i.e., when the variance explained by the effect is substantially larger than the error variance. Researchers must select the appropriate table based on their willingness to accept a Type I error risk (the risk of falsely rejecting a true null hypothesis). For standard scientific rigor, the Alpha level (α) is conventionally set at 0.05. Using a stricter alpha level, such as 0.01, necessitates a much higher critical F-value, demanding more compelling evidence to achieve statistical significance.

Comprehensive F-Tables for Hypothesis Testing

To support accurate and reliable hypothesis testing across various research disciplines, a comprehensive selection of F-distribution tables is provided below. These resources cover the most frequently employed alpha levels, enabling researchers to quickly and accurately determine the critical value required for their specific combination of numerator and denominator degrees of freedom, thereby ensuring a robust decision process for the F-test.

F Table for α **= 0.10** (Click to zoom in)

This table outlines the critical F-values corresponding to a 10% significance level. While employing this table may increase the statistical power of the test, it simultaneously elevates the associated risk of committing a Type I error.

	DF1	α = 0.10																	
DF2	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	Inf
1	39.863	49.5	53.593	55.833	57.24	58.204	58.906	59.439	59.858	60.195	60.705	61.22	61.74	62.002	62.265	62.529	62.794	63.061	63.328
2	8.5263	9	9.1618	9.2434	9.2926	9.3255	9.3491	9.3668	9.3805	9.3916	9.4081	9.4247	9.4413	9.4496	9.4579	9.4662	9.4746	9.4829	9.4912
3	5.5383	5.4624	5.3908	5.3426	5.3092	5.2847	5.2662	5.2517	5.24	5.2304	5.2156	5.2003	5.1845	5.1764	5.1681	5.1597	5.1512	5.1425	5.1337
4	4.5448	4.3246	4.1909	4.1073	4.0506	4.0098	3.979	3.9549	3.9357	3.9199	3.8955	3.8704	3.8443	3.831	3.8174	3.8036	3.7896	3.7753	3.7607
5	4.0604	3.7797	3.6195	3.5202	3.453	3.4045	3.3679	3.3393	3.3163	3.2974	3.2682	3.238	3.2067	3.1905	3.1741	3.1573	3.1402	3.1228	3.105
6	3.776	3.4633	3.2888	3.1808	3.1075	3.0546	3.0145	2.983	2.9577	2.9369	2.9047	2.8712	2.8363	2.8183	2.8	2.7812	2.762	2.7423	2.7222
7	3.5894	3.2574	3.0741	2.9605	2.8833	2.8274	2.7849	2.7516	2.7247	2.7025	2.6681	2.6322	2.5947	2.5753	2.5555	2.5351	2.5142	2.4928	2.4708
8	3.4579	3.1131	2.9238	2.8064	2.7265	2.6683	2.6241	2.5894	2.5612	2.538	2.502	2.4642	2.4246	2.4041	2.383	2.3614	2.3391	2.3162	2.2926
9	3.3603	3.0065	2.8129	2.6927	2.6106	2.5509	2.5053	2.4694	2.4403	2.4163	2.3789	2.3396	2.2983	2.2768	2.2547	2.232	2.2085	2.1843	2.1592
10	3.285	2.9245	2.7277	2.6053	2.5216	2.4606	2.414	2.3772	2.3473	2.3226	2.2841	2.2435	2.2007	2.1784	2.1554	2.1317	2.1072	2.0818	2.0554
11	3.2252	2.8595	2.6602	2.5362	2.4512	2.3891	2.3416	2.304	2.2735	2.2482	2.2087	2.1671	2.1231	2.1	2.0762	2.0516	2.0261	1.9997	1.9721
12	3.1766	2.8068	2.6055	2.4801	2.394	2.331	2.2828	2.2446	2.2135	2.1878	2.1474	2.1049	2.0597	2.036	2.0115	1.9861	1.9597	1.9323	1.9036
13	3.1362	2.7632	2.5603	2.4337	2.3467	2.283	2.2341	2.1954	2.1638	2.1376	2.0966	2.0532	2.007	1.9827	1.9576	1.9315	1.9043	1.8759	1.8462
14	3.1022	2.7265	2.5222	2.3947	2.3069	2.2426	2.1931	2.1539	2.122	2.0954	2.0537	2.0095	1.9625	1.9377	1.9119	1.8852	1.8572	1.828	1.7973
15	3.0732	2.6952	2.4898	2.3614	2.273	2.2081	2.1582	2.1185	2.0862	2.0593	2.0171	1.9722	1.9243	1.899	1.8728	1.8454	1.8168	1.7867	1.7551
16	3.0481	2.6682	2.4618	2.3327	2.2438	2.1783	2.128	2.088	2.0553	2.0282	1.9854	1.9399	1.8913	1.8656	1.8388	1.8108	1.7816	1.7508	1.7182
17	3.0262	2.6446	2.4374	2.3078	2.2183	2.1524	2.1017	2.0613	2.0284	2.0009	1.9577	1.9117	1.8624	1.8362	1.809	1.7805	1.7506	1.7191	1.6856
18	3.007	2.624	2.416	2.2858	2.1958	2.1296	2.0785	2.0379	2.0047	1.977	1.9333	1.8868	1.8369	1.8104	1.7827	1.7537	1.7232	1.691	1.6567
19	2.9899	2.6056	2.397	2.2663	2.176	2.1094	2.058	2.0171	1.9836	1.9557	1.9117	1.8647	1.8142	1.7873	1.7592	1.7298	1.6988	1.6659	1.6308
20	2.9747	2.5893	2.3801	2.2489	2.1582	2.0913	2.0397	1.9985	1.9649	1.9367	1.8924	1.8449	1.7938	1.7667	1.7382	1.7083	1.6768	1.6433	1.6074
21	2.961	2.5746	2.3649	2.2333	2.1423	2.0751	2.0233	1.9819	1.948	1.9197	1.875	1.8272	1.7756	1.7481	1.7193	1.689	1.6569	1.6228	1.5862
22	2.9486	2.5613	2.3512	2.2193	2.1279	2.0605	2.0084	1.9668	1.9327	1.9043	1.8593	1.8111	1.759	1.7312	1.7021	1.6714	1.6389	1.6042	1.5668
23	2.9374	2.5493	2.3387	2.2065	2.1149	2.0472	1.9949	1.9531	1.9189	1.8903	1.845	1.7964	1.7439	1.7159	1.6864	1.6554	1.6224	1.5871	1.549
24	2.9271	2.5383	2.3274	2.1949	2.103	2.0351	1.9826	1.9407	1.9063	1.8775	1.8319	1.7831	1.7302	1.7019	1.6721	1.6407	1.6073	1.5715	1.5327
25	2.9177	2.5283	2.317	2.1842	2.0922	2.0241	1.9714	1.9293	1.8947	1.8658	1.82	1.7708	1.7175	1.689	1.659	1.6272	1.5934	1.557	1.5176
26	2.9091	2.5191	2.3075	2.1745	2.0822	2.0139	1.961	1.9188	1.8841	1.855	1.809	1.7596	1.7059	1.6771	1.6468	1.6147	1.5805	1.5437	1.5036
27	2.9012	2.5106	2.2987	2.1655	2.073	2.0045	1.9515	1.9091	1.8743	1.8451	1.7989	1.7492	1.6951	1.6662	1.6356	1.6032	1.5686	1.5313	1.4906
28	2.8939	2.5028	2.2906	2.1571	2.0645	1.9959	1.9427	1.9001	1.8652	1.8359	1.7895	1.7395	1.6852	1.656	1.6252	1.5925	1.5575	1.5198	1.4784
29	2.887	2.4955	2.2831	2.1494	2.0566	1.9878	1.9345	1.8918	1.8568	1.8274	1.7808	1.7306	1.6759	1.6466	1.6155	1.5825	1.5472	1.509	1.467
30	2.8807	2.4887	2.2761	2.1422	2.0493	1.9803	1.9269	1.8841	1.849	1.8195	1.7727	1.7223	1.6673	1.6377	1.6065	1.5732	1.5376	1.4989	1.4564
40	2.8354	2.4404	2.2261	2.091	1.9968	1.9269	1.8725	1.8289	1.7929	1.7627	1.7146	1.6624	1.6052	1.5741	1.5411	1.5056	1.4672	1.4248	1.3769
60	2.7911	2.3933	2.1774	2.041	1.9457	1.8747	1.8194	1.7748	1.738	1.707	1.6574	1.6034	1.5435	1.5107	1.4755	1.4373	1.3952	1.3476	1.2915
120	2.7478	2.3473	2.13	1.9923	1.8959	1.8238	1.7675	1.722	1.6843	1.6524	1.6012	1.545	1.4821	1.4472	1.4094	1.3676	1.3203	1.2646	1.1926
Inf	2.7055	2.3026	2.0838	1.9449	1.8473	1.7741	1.7167	1.6702	1.6315	1.5987	1.5458	1.4871	1.4206	1.3832	1.3419	1.2951	1.24	1.1686	1

F Table for α **= 0.05** (Click to zoom in)

Serving as the standard convention in the vast majority of scientific literature, this table establishes the critical boundary for accepting a 5% risk of committing a Type I error. It is the most commonly consulted table when performing ANOVA.

	DF1	α = 0.05																	
DF2	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	Inf
1	161.45	199.5	215.71	224.58	230.16	233.99	236.77	238.88	240.54	241.88	243.91	245.95	248.01	249.05	250.1	251.14	252.2	253.25	254.31
2	18.513	19	19.164	19.247	19.296	19.33	19.353	19.371	19.385	19.396	19.413	19.429	19.446	19.454	19.462	19.471	19.479	19.487	19.496
3	10.128	9.5521	9.2766	9.1172	9.0135	8.9406	8.8867	8.8452	8.8123	8.7855	8.7446	8.7029	8.6602	8.6385	8.6166	8.5944	8.572	8.5494	8.5264
4	7.7086	6.9443	6.5914	6.3882	6.2561	6.1631	6.0942	6.041	5.9988	5.9644	5.9117	5.8578	5.8025	5.7744	5.7459	5.717	5.6877	5.6581	5.6281
5	6.6079	5.7861	5.4095	5.1922	5.0503	4.9503	4.8759	4.8183	4.7725	4.7351	4.6777	4.6188	4.5581	4.5272	4.4957	4.4638	4.4314	4.3985	4.365
6	5.9874	5.1433	4.7571	4.5337	4.3874	4.2839	4.2067	4.1468	4.099	4.06	3.9999	3.9381	3.8742	3.8415	3.8082	3.7743	3.7398	3.7047	3.6689
7	5.5914	4.7374	4.3468	4.1203	3.9715	3.866	3.787	3.7257	3.6767	3.6365	3.5747	3.5107	3.4445	3.4105	3.3758	3.3404	3.3043	3.2674	3.2298
8	5.3177	4.459	4.0662	3.8379	3.6875	3.5806	3.5005	3.4381	3.3881	3.3472	3.2839	3.2184	3.1503	3.1152	3.0794	3.0428	3.0053	2.9669	2.9276
9	5.1174	4.2565	3.8625	3.6331	3.4817	3.3738	3.2927	3.2296	3.1789	3.1373	3.0729	3.0061	2.9365	2.9005	2.8637	2.8259	2.7872	2.7475	2.7067
10	4.9646	4.1028	3.7083	3.478	3.3258	3.2172	3.1355	3.0717	3.0204	2.9782	2.913	2.845	2.774	2.7372	2.6996	2.6609	2.6211	2.5801	2.5379
11	4.8443	3.9823	3.5874	3.3567	3.2039	3.0946	3.0123	2.948	2.8962	2.8536	2.7876	2.7186	2.6464	2.609	2.5705	2.5309	2.4901	2.448	2.4045
12	4.7472	3.8853	3.4903	3.2592	3.1059	2.9961	2.9134	2.8486	2.7964	2.7534	2.6866	2.6169	2.5436	2.5055	2.4663	2.4259	2.3842	2.341	2.2962
13	4.6672	3.8056	3.4105	3.1791	3.0254	2.9153	2.8321	2.7669	2.7144	2.671	2.6037	2.5331	2.4589	2.4202	2.3803	2.3392	2.2966	2.2524	2.2064
14	4.6001	3.7389	3.3439	3.1122	2.9582	2.8477	2.7642	2.6987	2.6458	2.6022	2.5342	2.463	2.3879	2.3487	2.3082	2.2664	2.2229	2.1778	2.1307
15	4.5431	3.6823	3.2874	3.0556	2.9013	2.7905	2.7066	2.6408	2.5876	2.5437	2.4753	2.4034	2.3275	2.2878	2.2468	2.2043	2.1601	2.1141	2.0658
16	4.494	3.6337	3.2389	3.0069	2.8524	2.7413	2.6572	2.5911	2.5377	2.4935	2.4247	2.3522	2.2756	2.2354	2.1938	2.1507	2.1058	2.0589	2.0096
17	4.4513	3.5915	3.1968	2.9647	2.81	2.6987	2.6143	2.548	2.4943	2.4499	2.3807	2.3077	2.2304	2.1898	2.1477	2.104	2.0584	2.0107	1.9604
18	4.4139	3.5546	3.1599	2.9277	2.7729	2.6613	2.5767	2.5102	2.4563	2.4117	2.3421	2.2686	2.1906	2.1497	2.1071	2.0629	2.0166	1.9681	1.9168
19	4.3807	3.5219	3.1274	2.8951	2.7401	2.6283	2.5435	2.4768	2.4227	2.3779	2.308	2.2341	2.1555	2.1141	2.0712	2.0264	1.9795	1.9302	1.878
20	4.3512	3.4928	3.0984	2.8661	2.7109	2.599	2.514	2.4471	2.3928	2.3479	2.2776	2.2033	2.1242	2.0825	2.0391	1.9938	1.9464	1.8963	1.8432
21	4.3248	3.4668	3.0725	2.8401	2.6848	2.5727	2.4876	2.4205	2.366	2.321	2.2504	2.1757	2.096	2.054	2.0102	1.9645	1.9165	1.8657	1.8117
22	4.3009	3.4434	3.0491	2.8167	2.6613	2.5491	2.4638	2.3965	2.3419	2.2967	2.2258	2.1508	2.0707	2.0283	1.9842	1.938	1.8894	1.838	1.7831
23	4.2793	3.4221	3.028	2.7955	2.64	2.5277	2.4422	2.3748	2.3201	2.2747	2.2036	2.1282	2.0476	2.005	1.9605	1.9139	1.8648	1.8128	1.757
24	4.2597	3.4028	3.0088	2.7763	2.6207	2.5082	2.4226	2.3551	2.3002	2.2547	2.1834	2.1077	2.0267	1.9838	1.939	1.892	1.8424	1.7896	1.733
25	4.2417	3.3852	2.9912	2.7587	2.603	2.4904	2.4047	2.3371	2.2821	2.2365	2.1649	2.0889	2.0075	1.9643	1.9192	1.8718	1.8217	1.7684	1.711
26	4.2252	3.369	2.9752	2.7426	2.5868	2.4741	2.3883	2.3205	2.2655	2.2197	2.1479	2.0716	1.9898	1.9464	1.901	1.8533	1.8027	1.7488	1.6906
27	4.21	3.3541	2.9604	2.7278	2.5719	2.4591	2.3732	2.3053	2.2501	2.2043	2.1323	2.0558	1.9736	1.9299	1.8842	1.8361	1.7851	1.7306	1.6717
28	4.196	3.3404	2.9467	2.7141	2.5581	2.4453	2.3593	2.2913	2.236	2.19	2.1179	2.0411	1.9586	1.9147	1.8687	1.8203	1.7689	1.7138	1.6541
29	4.183	3.3277	2.934	2.7014	2.5454	2.4324	2.3463	2.2783	2.2229	2.1768	2.1045	2.0275	1.9446	1.9005	1.8543	1.8055	1.7537	1.6981	1.6376
30	4.1709	3.3158	2.9223	2.6896	2.5336	2.4205	2.3343	2.2662	2.2107	2.1646	2.0921	2.0148	1.9317	1.8874	1.8409	1.7918	1.7396	1.6835	1.6223
40	4.0847	3.2317	2.8387	2.606	2.4495	2.3359	2.249	2.1802	2.124	2.0772	2.0035	1.9245	1.8389	1.7929	1.7444	1.6928	1.6373	1.5766	1.5089
60	4.0012	3.1504	2.7581	2.5252	2.3683	2.2541	2.1665	2.097	2.0401	1.9926	1.9174	1.8364	1.748	1.7001	1.6491	1.5943	1.5343	1.4673	1.3893
120	3.9201	3.0718	2.6802	2.4472	2.2899	2.175	2.0868	2.0164	1.9588	1.9105	1.8337	1.7505	1.6587	1.6084	1.5543	1.4952	1.429	1.3519	1.2539
Inf	3.8415	2.9957	2.6049	2.3719	2.2141	2.0986	2.0096	1.9384	1.8799	1.8307	1.7522	1.6664	1.5705	1.5173	1.4591	1.394	1.318	1.2214	1

F Table for α **= 0.025** (Click to zoom in)

This table corresponds to a more stringent 2.5% significance level. It is frequently applied when performing two-tailed comparisons of variance or when a researcher requires a more conservative threshold for the upper tail of the F-distribution.

	DF1	α = 0.025																	
DF2	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	Inf
1	647.79	799.5	864.16	899.58	921.85	937.11	948.22	956.66	963.28	968.63	976.71	984.87	993.1	997.25	1001.4	1005.6	1009.8	1014	1018.3
2	38.506	39	39.166	39.248	39.298	39.332	39.355	39.373	39.387	39.398	39.415	39.431	39.448	39.456	39.465	39.473	39.481	39.49	39.498
3	17.443	16.044	15.439	15.101	14.885	14.735	14.624	14.54	14.473	14.419	14.337	14.253	14.167	14.124	14.081	14.037	13.992	13.947	13.902
4	12.218	10.649	9.9792	9.6045	9.3645	9.1973	9.0741	8.9796	8.9047	8.8439	8.7512	8.6565	8.5599	8.5109	8.461	8.411	8.36	8.309	8.257
5	10.007	8.4336	7.7636	7.3879	7.1464	6.9777	6.8531	6.7572	6.6811	6.6192	6.5245	6.4277	6.3286	6.278	6.227	6.175	6.123	6.069	6.015
6	8.8131	7.2599	6.5988	6.2272	5.9876	5.8198	5.6955	5.5996	5.5234	5.4613	5.3662	5.2687	5.1684	5.1172	5.065	5.012	4.959	4.904	4.849
7	8.0727	6.5415	5.8898	5.5226	5.2852	5.1186	4.9949	4.8993	4.8232	4.7611	4.6658	4.5678	4.4667	4.415	4.362	4.309	4.254	4.199	4.142
8	7.5709	6.0595	5.416	5.0526	4.8173	4.6517	4.5286	4.4333	4.3572	4.2951	4.1997	4.1012	3.9995	3.9472	3.894	3.84	3.784	3.728	3.67
9	7.2093	5.7147	5.0781	4.7181	4.4844	4.3197	4.197	4.102	4.026	3.9639	3.8682	3.7694	3.6669	3.6142	3.56	3.505	3.449	3.392	3.333
10	6.9367	5.4564	4.8256	4.4683	4.2361	4.0721	3.9498	3.8549	3.779	3.7168	3.6209	3.5217	3.4185	3.3654	3.311	3.255	3.198	3.14	3.08
11	6.7241	5.2559	4.63	4.2751	4.044	3.8807	3.7586	3.6638	3.5879	3.5257	3.4296	3.3299	3.2261	3.1725	3.118	3.061	3.004	2.944	2.883
12	6.5538	5.0959	4.4742	4.1212	3.8911	3.7283	3.6065	3.5118	3.4358	3.3736	3.2773	3.1772	3.0728	3.0187	2.963	2.906	2.848	2.787	2.725
13	6.4143	4.9653	4.3472	3.9959	3.7667	3.6043	3.4827	3.388	3.312	3.2497	3.1532	3.0527	2.9477	2.8932	2.837	2.78	2.72	2.659	2.595
14	6.2979	4.8567	4.2417	3.8919	3.6634	3.5014	3.3799	3.2853	3.2093	3.1469	3.0502	2.9493	2.8437	2.7888	2.732	2.674	2.614	2.552	2.487
15	6.1995	4.765	4.1528	3.8043	3.5764	3.4147	3.2934	3.1987	3.1227	3.0602	2.9633	2.8621	2.7559	2.7006	2.644	2.585	2.524	2.461	2.395
16	6.1151	4.6867	4.0768	3.7294	3.5021	3.3406	3.2194	3.1248	3.0488	2.9862	2.889	2.7875	2.6808	2.6252	2.568	2.509	2.447	2.383	2.316
17	6.042	4.6189	4.0112	3.6648	3.4379	3.2767	3.1556	3.061	2.9849	2.9222	2.8249	2.723	2.6158	2.5598	2.502	2.442	2.38	2.315	2.247
18	5.9781	4.5597	3.9539	3.6083	3.382	3.2209	3.0999	3.0053	2.9291	2.8664	2.7689	2.6667	2.559	2.5027	2.445	2.384	2.321	2.256	2.187
19	5.9216	4.5075	3.9034	3.5587	3.3327	3.1718	3.0509	2.9563	2.8801	2.8172	2.7196	2.6171	2.5089	2.4523	2.394	2.333	2.27	2.203	2.133
20	5.8715	4.4613	3.8587	3.5147	3.2891	3.1283	3.0074	2.9128	2.8365	2.7737	2.6758	2.5731	2.4645	2.4076	2.349	2.287	2.223	2.156	2.085
21	5.8266	4.4199	3.8188	3.4754	3.2501	3.0895	2.9686	2.874	2.7977	2.7348	2.6368	2.5338	2.4247	2.3675	2.308	2.246	2.182	2.114	2.042
22	5.7863	4.3828	3.7829	3.4401	3.2151	3.0546	2.9338	2.8392	2.7628	2.6998	2.6017	2.4984	2.389	2.3315	2.272	2.21	2.145	2.076	2.003
23	5.7498	4.3492	3.7505	3.4083	3.1835	3.0232	2.9023	2.8077	2.7313	2.6682	2.5699	2.4665	2.3567	2.2989	2.239	2.176	2.111	2.041	1.968
24	5.7166	4.3187	3.7211	3.3794	3.1548	2.9946	2.8738	2.7791	2.7027	2.6396	2.5411	2.4374	2.3273	2.2693	2.209	2.146	2.08	2.01	1.935
25	5.6864	4.2909	3.6943	3.353	3.1287	2.9685	2.8478	2.7531	2.6766	2.6135	2.5149	2.411	2.3005	2.2422	2.182	2.118	2.052	1.981	1.906
26	5.6586	4.2655	3.6697	3.3289	3.1048	2.9447	2.824	2.7293	2.6528	2.5896	2.4908	2.3867	2.2759	2.2174	2.157	2.093	2.026	1.954	1.878
27	5.6331	4.2421	3.6472	3.3067	3.0828	2.9228	2.8021	2.7074	2.6309	2.5676	2.4688	2.3644	2.2533	2.1946	2.133	2.069	2.002	1.93	1.853
28	5.6096	4.2205	3.6264	3.2863	3.0626	2.9027	2.782	2.6872	2.6106	2.5473	2.4484	2.3438	2.2324	2.1735	2.112	2.048	1.98	1.907	1.829
29	5.5878	4.2006	3.6072	3.2674	3.0438	2.884	2.7633	2.6686	2.5919	2.5286	2.4295	2.3248	2.2131	2.154	2.092	2.028	1.959	1.886	1.807
30	5.5675	4.1821	3.5894	3.2499	3.0265	2.8667	2.746	2.6513	2.5746	2.5112	2.412	2.3072	2.1952	2.1359	2.074	2.009	1.94	1.866	1.787
40	5.4239	4.051	3.4633	3.1261	2.9037	2.7444	2.6238	2.5289	2.4519	2.3882	2.2882	2.1819	2.0677	2.0069	1.943	1.875	1.803	1.724	1.637
60	5.2856	3.9253	3.3425	3.0077	2.7863	2.6274	2.5068	2.4117	2.3344	2.2702	2.1692	2.0613	1.9445	1.8817	1.815	1.744	1.667	1.581	1.482
120	5.1523	3.8046	3.2269	2.8943	2.674	2.5154	2.3948	2.2994	2.2217	2.157	2.0548	1.945	1.8249	1.7597	1.69	1.614	1.53	1.433	1.31
Inf	5.0239	3.6889	3.1161	2.7858	2.5665	2.4082	2.2875	2.1918	2.1136	2.0483	1.9447	1.8326	1.7085	1.6402	1.566	1.484	1.388	1.268	1

F Table for α **= 0.01** (Click to zoom in)

This resource provides the critical values for a highly rigorous 1% significance level. This table is typically reserved for studies where the consequences of a Type I error are serious, demanding overwhelming statistical evidence before the null hypothesis can be rejected.

	DF1	α = 0.01																	
DF2	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	Inf
1	4052.2	4999.5	5403.4	5624.6	5763.7	5859	5928.4	5981.1	6022.5	6055.8	6106.3	6157.3	6208.7	6234.6	6260.6	6286.8	6313	6339.4	6365.9
2	98.503	99	99.166	99.249	99.299	99.333	99.356	99.374	99.388	99.399	99.416	99.433	99.449	99.458	99.466	99.474	99.482	99.491	99.499
3	34.116	30.817	29.457	28.71	28.237	27.911	27.672	27.489	27.345	27.229	27.052	26.872	26.69	26.598	26.505	26.411	26.316	26.221	26.125
4	21.198	18	16.694	15.977	15.522	15.207	14.976	14.799	14.659	14.546	14.374	14.198	14.02	13.929	13.838	13.745	13.652	13.558	13.463
5	16.258	13.274	12.06	11.392	10.967	10.672	10.456	10.289	10.158	10.051	9.888	9.722	9.553	9.466	9.379	9.291	9.202	9.112	9.02
6	13.745	10.925	9.78	9.148	8.746	8.466	8.26	8.102	7.976	7.874	7.718	7.559	7.396	7.313	7.229	7.143	7.057	6.969	6.88
7	12.246	9.547	8.451	7.847	7.46	7.191	6.993	6.84	6.719	6.62	6.469	6.314	6.155	6.074	5.992	5.908	5.824	5.737	5.65
8	11.259	8.649	7.591	7.006	6.632	6.371	6.178	6.029	5.911	5.814	5.667	5.515	5.359	5.279	5.198	5.116	5.032	4.946	4.859
9	10.561	8.022	6.992	6.422	6.057	5.802	5.613	5.467	5.351	5.257	5.111	4.962	4.808	4.729	4.649	4.567	4.483	4.398	4.311
10	10.044	7.559	6.552	5.994	5.636	5.386	5.2	5.057	4.942	4.849	4.706	4.558	4.405	4.327	4.247	4.165	4.082	3.996	3.909
11	9.646	7.206	6.217	5.668	5.316	5.069	4.886	4.744	4.632	4.539	4.397	4.251	4.099	4.021	3.941	3.86	3.776	3.69	3.602
12	9.33	6.927	5.953	5.412	5.064	4.821	4.64	4.499	4.388	4.296	4.155	4.01	3.858	3.78	3.701	3.619	3.535	3.449	3.361
13	9.074	6.701	5.739	5.205	4.862	4.62	4.441	4.302	4.191	4.1	3.96	3.815	3.665	3.587	3.507	3.425	3.341	3.255	3.165
14	8.862	6.515	5.564	5.035	4.695	4.456	4.278	4.14	4.03	3.939	3.8	3.656	3.505	3.427	3.348	3.266	3.181	3.094	3.004
15	8.683	6.359	5.417	4.893	4.556	4.318	4.142	4.004	3.895	3.805	3.666	3.522	3.372	3.294	3.214	3.132	3.047	2.959	2.868
16	8.531	6.226	5.292	4.773	4.437	4.202	4.026	3.89	3.78	3.691	3.553	3.409	3.259	3.181	3.101	3.018	2.933	2.845	2.753
17	8.4	6.112	5.185	4.669	4.336	4.102	3.927	3.791	3.682	3.593	3.455	3.312	3.162	3.084	3.003	2.92	2.835	2.746	2.653
18	8.285	6.013	5.092	4.579	4.248	4.015	3.841	3.705	3.597	3.508	3.371	3.227	3.077	2.999	2.919	2.835	2.749	2.66	2.566
19	8.185	5.926	5.01	4.5	4.171	3.939	3.765	3.631	3.523	3.434	3.297	3.153	3.003	2.925	2.844	2.761	2.674	2.584	2.489
20	8.096	5.849	4.938	4.431	4.103	3.871	3.699	3.564	3.457	3.368	3.231	3.088	2.938	2.859	2.778	2.695	2.608	2.517	2.421
21	8.017	5.78	4.874	4.369	4.042	3.812	3.64	3.506	3.398	3.31	3.173	3.03	2.88	2.801	2.72	2.636	2.548	2.457	2.36
22	7.945	5.719	4.817	4.313	3.988	3.758	3.587	3.453	3.346	3.258	3.121	2.978	2.827	2.749	2.667	2.583	2.495	2.403	2.305
23	7.881	5.664	4.765	4.264	3.939	3.71	3.539	3.406	3.299	3.211	3.074	2.931	2.781	2.702	2.62	2.535	2.447	2.354	2.256
24	7.823	5.614	4.718	4.218	3.895	3.667	3.496	3.363	3.256	3.168	3.032	2.889	2.738	2.659	2.577	2.492	2.403	2.31	2.211
25	7.77	5.568	4.675	4.177	3.855	3.627	3.457	3.324	3.217	3.129	2.993	2.85	2.699	2.62	2.538	2.453	2.364	2.27	2.169
26	7.721	5.526	4.637	4.14	3.818	3.591	3.421	3.288	3.182	3.094	2.958	2.815	2.664	2.585	2.503	2.417	2.327	2.233	2.131
27	7.677	5.488	4.601	4.106	3.785	3.558	3.388	3.256	3.149	3.062	2.926	2.783	2.632	2.552	2.47	2.384	2.294	2.198	2.097
28	7.636	5.453	4.568	4.074	3.754	3.528	3.358	3.226	3.12	3.032	2.896	2.753	2.602	2.522	2.44	2.354	2.263	2.167	2.064
29	7.598	5.42	4.538	4.045	3.725	3.499	3.33	3.198	3.092	3.005	2.868	2.726	2.574	2.495	2.412	2.325	2.234	2.138	2.034
30	7.562	5.39	4.51	4.018	3.699	3.473	3.304	3.173	3.067	2.979	2.843	2.7	2.549	2.469	2.386	2.299	2.208	2.111	2.006
40	7.314	5.179	4.313	3.828	3.514	3.291	3.124	2.993	2.888	2.801	2.665	2.522	2.369	2.288	2.203	2.114	2.019	1.917	1.805
60	7.077	4.977	4.126	3.649	3.339	3.119	2.953	2.823	2.718	2.632	2.496	2.352	2.198	2.115	2.028	1.936	1.836	1.726	1.601
120	6.851	4.787	3.949	3.48	3.174	2.956	2.792	2.663	2.559	2.472	2.336	2.192	2.035	1.95	1.86	1.763	1.656	1.533	1.381
Inf	6.635	4.605	3.782	3.319	3.017	2.802	2.639	2.511	2.407	2.321	2.185	2.039	1.878	1.791	1.696	1.592	1.473	1.325	1

F Table for α **= 0.001** (Click to zoom in)

Representing an extremely conservative 0.1% significance level, this table requires the highest calculated F-statistic to achieve significance, demanding near certainty that the observed effect is genuine and not merely the result of chance variation.

	DF1	α = 0.001																	
DF2	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	Inf
1	405284	500000	540379	562500	576405	585937	592873	598144	602284	605621	610668	615764	620908	623497	626099	628712	631337	633972	636619
2	998.5	999	999.17	999.25	999.3	999.33	999.36	999.37	999.39	999.4	999.42	999.43	999.45	999.46	999.47	999.47	999.48	999.49	999.5
3	167.03	148.5	141.11	137.1	134.58	132.85	131.58	130.62	129.86	129.25	128.32	127.37	126.42	125.93	125.45	124.96	124.47	123.97	123.47
4	74.137	61.246	56.177	53.436	51.712	50.525	49.658	48.996	48.475	48.053	47.412	46.761	46.1	45.766	45.429	45.089	44.746	44.4	44.051
5	47.181	37.122	33.202	31.085	29.752	28.834	28.163	27.649	27.244	26.917	26.418	25.911	25.395	25.133	24.869	24.602	24.333	24.06	23.785
6	35.507	27	23.703	21.924	20.803	20.03	19.463	19.03	18.688	18.411	17.989	17.559	17.12	16.897	16.672	16.445	16.214	15.981	15.745
7	29.245	21.689	18.772	17.198	16.206	15.521	15.019	14.634	14.33	14.083	13.707	13.324	12.932	12.732	12.53	12.326	12.119	11.909	11.696
8	25.415	18.494	15.829	14.392	13.485	12.858	12.398	12.046	11.767	11.54	11.194	10.841	10.48	10.295	10.109	9.9194	9.7272	9.5321	9.3337
9	22.857	16.387	13.902	12.56	11.714	11.128	10.698	10.368	10.107	9.8943	9.57	9.2381	8.8976	8.7239	8.5476	8.3685	8.1865	8.0014	7.8128
10	21.04	14.905	12.553	11.283	10.481	9.9256	9.5175	9.2041	8.9558	8.7539	8.4452	8.1288	7.8037	7.6376	7.4688	7.2971	7.1224	6.9443	6.7625
11	19.687	13.812	11.561	10.346	9.5784	9.0466	8.6553	8.3548	8.1163	7.9224	7.6256	7.321	7.0076	6.8471	6.6839	6.5178	6.3483	6.1753	5.9983
12	18.643	12.974	10.804	9.6327	8.8921	8.3788	8.0009	7.7104	7.4797	7.292	7.0046	6.7092	6.4048	6.2488	6.0898	5.9278	5.7623	5.5931	5.4195
13	17.815	12.313	10.209	9.0727	8.3541	7.8557	7.4886	7.2061	6.9818	6.7992	6.5192	6.2312	5.934	5.7814	5.6258	5.467	5.3046	5.1381	4.9671
14	17.143	11.779	9.7294	8.6223	7.9218	7.4358	7.0775	6.8017	6.5826	6.4041	6.1302	5.8483	5.5568	5.407	5.2542	5.0979	4.9378	4.7735	4.6042
15	16.587	11.339	9.3353	8.2527	7.5674	7.0917	6.7408	6.4707	6.2559	6.0808	5.8121	5.5351	5.2484	5.1009	4.9502	4.7959	4.6377	4.475	4.307
16	16.12	10.971	9.0059	7.9442	7.2719	6.8049	6.4604	6.195	5.9839	5.8117	5.5473	5.2745	4.9918	4.8462	4.6972	4.5446	4.3878	4.2263	4.0592
17	15.722	10.658	8.7269	7.6831	7.0219	6.5625	6.2234	5.962	5.7541	5.5844	5.3237	5.0544	4.7751	4.6311	4.4836	4.3323	4.1767	4.016	3.8496
18	15.379	10.39	8.4875	7.4593	6.8078	6.355	6.0206	5.7628	5.5575	5.39	5.1324	4.8663	4.5899	4.4471	4.3009	4.1507	3.996	3.836	3.6698
19	15.081	10.157	8.2799	7.2655	6.6225	6.1754	5.8452	5.5904	5.3876	5.2219	4.9672	4.7037	4.4297	4.2881	4.1429	3.9936	3.8396	3.6801	3.5141
20	14.819	9.9526	8.0984	7.096	6.4606	6.0186	5.692	5.44	5.2392	5.0752	4.8229	4.5618	4.29	4.1493	4.005	3.8564	3.703	3.5438	3.3778
21	14.587	9.7723	7.9383	6.9467	6.3179	5.8805	5.5571	5.3076	5.1087	4.9462	4.696	4.4369	4.167	4.0272	3.8836	3.7357	3.5827	3.4237	3.2575
22	14.38	9.612	7.796	6.8142	6.1914	5.758	5.4376	5.1901	4.9929	4.8317	4.5835	4.3262	4.0579	3.9189	3.7759	3.6285	3.4759	3.317	3.1505
23	14.195	9.4685	7.6688	6.6957	6.0783	5.6486	5.3308	5.0853	4.8896	4.7296	4.4831	4.2274	3.9606	3.8222	3.6798	3.5328	3.3804	3.2216	3.0548
24	14.028	9.3394	7.5545	6.5892	5.9768	5.5504	5.2349	4.9912	4.7968	4.6379	4.3929	4.1387	3.8732	3.7354	3.5935	3.4468	3.2946	3.1357	2.9685
25	13.877	9.2225	7.4511	6.4931	5.8851	5.4617	5.1484	4.9063	4.7131	4.5551	4.3116	4.0587	3.7944	3.657	3.5155	3.3692	3.2171	3.0581	2.8904
26	13.739	9.1163	7.3572	6.4057	5.8018	5.3812	5.0698	4.8292	4.6372	4.4801	4.2378	3.9861	3.7228	3.5859	3.4448	3.2987	3.1467	2.9875	2.8193
27	13.613	9.0194	7.2715	6.3261	5.7259	5.3078	4.9983	4.759	4.568	4.4117	4.1706	3.92	3.6576	3.5211	3.3803	3.2344	3.0825	2.9231	2.7543
28	13.498	8.9305	7.1931	6.2532	5.6565	5.2407	4.9328	4.6947	4.5047	4.3491	4.1091	3.8595	3.598	3.4618	3.3213	3.1755	3.0236	2.864	2.6947
29	13.391	8.8488	7.121	6.1863	5.5927	5.1791	4.8727	4.6358	4.4466	4.2917	4.0526	3.8039	3.5432	3.4074	3.2671	3.1215	2.9695	2.8097	2.6397
30	13.293	8.7734	7.0545	6.1245	5.5339	5.1223	4.8173	4.5814	4.393	4.2388	4.0006	3.7527	3.4928	3.3572	3.2171	3.0716	2.9196	2.7595	2.5889
40	12.609	8.2508	6.5945	5.6981	5.1283	4.7306	4.4355	4.207	4.0243	3.8744	3.6425	3.4003	3.145	3.0111	2.8721	2.7268	2.5737	2.4103	2.2326
60	11.973	7.7678	6.1712	5.3067	4.7565	4.3721	4.0864	3.8648	3.6873	3.5415	3.3153	3.0781	2.8266	2.6938	2.5549	2.4086	2.2523	2.0821	1.8905
120	11.38	7.3211	5.7814	4.9472	4.4157	4.0437	3.767	3.5519	3.3792	3.2372	3.0162	2.7833	2.5344	2.4019	2.2621	2.1128	1.9502	1.7667	1.5433
Inf	10.828	6.9078	5.4221	4.6167	4.103	3.743	3.4746	3.2656	3.0975	2.9588	2.7425	2.5132	2.2657	2.1324	1.9901	1.835	1.6601	1.4468	1

A Practical Example: Utilizing the F-Table in ANOVA

To illustrate the practical application of the F-table, consider a research scenario where an educator investigates the effectiveness of three distinct teaching methodologies (Groups A, B, and C) on student performance metrics. The researcher gathers data from a total of 40 students ($N=40$), divided across the three groups ($k=3$). The initial step is calculating the necessary Degrees of Freedom. The numerator degrees of freedom (df_1) is calculated as $k-1 = 3-1 = strong{2}$. The denominator degrees of freedom (df_2) is calculated as $N-k = 40-3 = strong{37}$. Assuming the researcher adopts the standard Alpha level (α) of 0.05, they must consult the $alpha = 0.05$ table using $df_1 = 2$ and $df_2 = 37$.

A common challenge when using printed F-tables is that they often omit values for every possible denominator degree of freedom. Consequently, researchers frequently need to use interpolation or conservatively round down to the closest available value (e.g., $df_2 = 35$ or $df_2 = 30$). If, after consulting the table or approximating, the critical F-value for $df_1=2$ and the closest available df_2 is found to be $strong{3.25}$, this value establishes the necessary threshold for the decision-making process. If the researcher's calculated F-statistic from the data analysis is $strong{4.10}$, then the comparison $4.10 > 3.25$ reveals that the calculated statistic falls into the critical rejection region. In this case, the researcher must reject the null hypothesis, concluding that a statistically significant difference exists among the average test scores produced by the three teaching methods.

Conversely, had the calculated F-statistic been only $strong{2.50}$, the result would be non-significant because $2.50 < 3.25$. In this second scenario, the researcher would fail to reject the null hypothesis, concluding that the observed differences in mean test scores are not statistically large enough to confidently rule out random chance as the primary causal factor. The precision afforded by the F-table, when combined with the accurate calculation of the Degrees of Freedom, is absolutely paramount for drawing correct inferences about population characteristics based on sample observations.

Limitations of Tables and the Rise of Modern Alternatives

Although the F-distribution tables have served as the bedrock of statistical inference for many decades, relying exclusively on them introduces certain limitations into the analytical process. The main drawback stems from the discrete nature of the tables: they provide critical values only for a finite set of pre-selected alpha levels and specific degree of freedom combinations. This constraint often necessitates rounding of the denominator degrees of freedom (df_2) or employing interpolation, which can introduce minor inaccuracies, particularly when high precision is required or when experimental designs are non-standard. Furthermore, the tables only offer the critical boundary, requiring a subsequent comparison, rather than providing the exact p-value directly.

The widespread adoption of high-powered computing technology has fundamentally shifted modern statistical practice toward the calculation of exact p-values. Specialized software packages, including R, Python (via libraries like SciPy), SPSS, and SAS, employ sophisticated algorithms to compute the precise area under the F-distribution curve corresponding to the observed F-statistic and the given degrees of freedom. For example, if a program calculates an F-statistic of 4.10 with $df_1=2$ and $df_2=37$, it can instantly return an exact p-value (e.g., p = 0.024), effectively eliminating the ambiguity and approximation inherent in table lookups and interpolation procedures.

Despite the prevalence of computational tools, maintaining a conceptual mastery of the F-table structure and interpretation remains an indispensable skill for any proficient statistician or researcher. The tables provide a necessary conceptual framework, offering a clear visual representation of how the critical boundary dramatically shifts based on the Degrees of Freedom and the chosen Alpha level (α). Ultimately, regardless of whether a table or software is used, the core principle of the F-test--comparing the ratio of explained variance to unexplained variance--remains constant, forming the essential basis for rigorous statistical conclusions across diverse fields such as engineering, psychology, economics, and biology.