

11.4.1: Table of Critical F-Scores

F Distribution

The tables following Figure 11.4.1.1 show the critical t-score. If the your calculated F-score is bigger (more extreme) than the critical F-score, then you reject the null hypothesis. Similarly, if the calculated F-score is to the right (in the shaded area), then the null hypothesis should be rejected. This means that there is a small probability (less than 5%, $p < .05$) that all of the means are similar (suggesting that at least one mean is different from one other mean). In contrast, if the calculated F-score is smaller than the critical value (to the right of the shaded area), then the null hypothesis is retained; there is a large probability (larger than 5%, $p > .05$) that the group means are similar.


 Sample F-distribution that is a line graph that leans to the left, with the extreme section to the right of an F-score at the right tail labeled "Probability p" shaded to show the Rejection Region.

Figure 11.4.1.1- Critical Values for F (F^*) with probability p to its right. (CC-BY by [Barbara Illowsky & Susan Dean \(De Anza College\)](#) from [OpenStax](#)).

Note

Remember:

(Critical < Calculated) = Reject null = At least one mean is different from at least one other mean. = $p < .05$

(Critical > Calculated) = Retain null = All of the means are similar. = $p > .05$

Tables of Critical Values of F (ANOVA)

The critical values table for ANOVA is a little different than other tables of critical values because ANOVA is a ratio of variances between groups and variances within each group. This means that there are two degrees of freedom, one for the numerator and one for the denominator. Below the tables are the formulas for calculating the degrees of freedom for each (numerator and denominator) for each type of ANOVA. Because there are so many options with the combination of two degrees of freedom, there are two critical value tables.

Both tables show degrees of freedom of the numerator (which is based on the number of groups) in the columns; the options are from 1 to 10. If you have 11 or more groups (or combinations), use the column for 10. But honestly, if you have more than 10 groups, you should be using statistical software that will provide the probability so that you wouldn't have to use a table of critical values!

The p column, in italics in both tables, shows three different alphas (α), or probabilities. This textbook will always use the 5% alpha ($p = 0.05$, but your professor or your circumstances might indicate another alpha level is preferred.

Denominator 5 to 29

The first table (Table 11.4.1.1) has degrees of freedom of the denominator for every degree of freedom 5 to 29. The degrees of freedom of the denominator are based on the sample size and the number of groups being compared.

Table 11.4.1.1- Critical Values of F for Denominator DF's from 5 to 29

Degrees of Freedom for Denominator (Error)	Degrees of Freedom for Numerator										
	<i>p</i>	1	2	3	4	5	6	7	8	9	10
5	<i>0.10</i>	4.06	3.78	3.62	3.52	3.45	3.40	3.37	3.34	3.32	3.30
5	<i>0.05</i>	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74

Degrees of Freedom	Degrees of Freedom for Numerator											
5	0.01	16.26	13.27	12.06	11.39	10.97	10.67	10.46	10.29	10.16	10.05	
6	0.10	3.78	3.46	3.29	3.18	3.11	3.05	3.01	2.98	2.96	2.94	
6	0.05	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	
6	0.01	13.75	10.92	9.78	9.15	8.75	8.47	8.26	8.10	7.98	7.87	
7	0.10	3.59	3.26	3.07	2.96	2.88	2.83	2.78	2.75	2.72	2.70	
7	0.05	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	
7	0.01	12.25	9.55	8.45	7.85	7.46	7.19	6.99	6.84	6.72	6.62	
8	0.10	3.46	3.11	2.92	2.81	2.73	2.67	2.62	2.59	2.56	2.54	
8	0.05	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	
8	0.01	11.26	8.65	7.59	7.01	6.63	6.37	6.18	6.03	5.91	5.81	
9	0.10	3.36	3.01	2.81	2.69	2.61	2.55	2.51	2.47	2.44	2.42	
9	0.05	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	
9	0.01	10.56	8.02	6.99	6.42	6.06	5.80	5.61	5.47	5.35	5.26	
10	0.10	3.29	2.92	2.73	2.61	2.52	2.46	2.41	2.38	2.35	2.32	
10	0.05	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	
10	0.01	10.04	7.56	6.55	5.99	5.64	5.39	5.20	5.06	4.94	4.85	
11	0.10	3.23	2.86	2.66	2.54	2.45	2.39	2.34	2.30	2.27	2.25	
11	0.05	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85	
11	0.01	9.65	7.21	6.22	5.67	5.32	5.07	4.89	4.74	4.63	4.54	
12	0.10	3.18	2.81	2.61	2.48	2.39	2.33	2.28	2.24	2.21	2.19	
12	0.05	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75	
12	0.01	9.33	6.93	5.95	5.41	5.06	4.82	4.64	4.50	4.39	4.30	
13	0.10	3.14	2.76	2.56	2.43	2.35	2.28	2.23	2.20	2.16	2.14	
13	0.05	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	
13	0.01	9.07	6.70	5.74	5.21	4.86	4.62	4.44	4.30	4.19	4.10	
14	0.10	3.10	2.73	2.52	2.39	2.31	2.24	2.19	2.15	2.12	2.10	
14	0.05	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	
14	0.01	8.86	6.51	5.56	5.04	4.69	4.46	4.28	4.14	4.03	3.94	
15	0.10	3.07	2.70	2.49	2.36	2.27	2.21	2.16	2.12	2.09	2.06	
15	0.05	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	
15	0.01	8.68	6.36	5.42	4.89	4.56	4.32	4.14	4.00	3.89	3.80	
16	0.10	3.05	2.67	2.46	2.33	2.24	2.18	2.13	2.09	2.06	2.03	
16	0.05	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	

Degrees of Freedom	Degrees of Freedom for Numerator											
16	0.01	8.53	6.23	5.29	4.77	4.44	4.20	4.03	3.89	3.78	3.69	
17	0.10	3.03	2.64	2.44	2.31	2.22	2.15	2.10	2.06	2.03	2.00	
17	0.05	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45	
17	0.01	8.40	6.11	5.19	4.67	4.34	4.10	3.93	3.79	3.68	3.59	
18	0.10	3.01	2.62	2.42	2.29	2.20	2.13	2.08	2.04	2.00	1.98	
18	0.05	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41	
18	0.01	8.29	6.01	5.09	4.58	4.25	4.01	3.84	3.71	3.60	3.51	
19	0.10	3.36	3.01	2.81	2.69	2.61	2.55	2.51	2.47	2.44	1.96	
19	0.05	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	2.38	
19	0.01	10.56	8.02	6.99	6.42	6.06	5.80	5.61	5.47	5.35	3.43	
20	0.10	2.97	2.59	2.38	2.25	2.16	2.09	2.04	2.00	1.96	1.94	
20	0.05	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	
20	0.01	8.10	5.85	4.94	4.43	4.10	3.87	3.70	3.56	3.46	3.37	
21	0.10	2.96	2.57	2.36	2.23	2.14	2.08	2.02	1.98	1.95	1.92	
21	0.05	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37	2.32	
21	0.01	8.02	5.78	4.87	4.37	4.04	3.81	3.64	3.51	3.40	3.31	
22	0.10	2.95	2.56	2.35	2.22	2.13	2.06	2.01	1.97	1.93	1.90	
22	0.05	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30	
22	0.01	7.95	5.72	4.82	4.31	3.99	3.76	3.59	3.45	3.35	3.26	
23	0.10	2.94	2.55	2.34	2.21	2.11	2.05	1.99	1.95	1.92	1.89	
23	0.05	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32	2.27	
23	0.01	7.88	5.66	4.76	4.26	3.94	3.71	3.54	3.41	3.30	3.21	
24	0.10	2.93	2.54	2.33	2.19	2.10	2.04	1.98	1.94	1.91	1.88	
24	0.05	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.25	
24	0.01	7.82	5.61	4.72	4.22	3.90	3.67	3.50	3.36	3.26	3.17	
25	0.10	2.92	2.53	2.32	2.18	2.09	2.02	1.97	1.93	1.89	1.87	
25	0.05	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28	2.24	
25	0.01	7.77	5.57	4.68	4.18	3.85	3.63	3.46	3.32	3.22	3.13	
26	0.10	2.91	2.52	2.31	2.17	2.08	2.01	1.96	1.92	1.88	1.86	
26	0.05	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27	2.22	
26	0.01	7.72	5.53	4.64	4.14	3.82	3.59	3.42	3.29	3.18	3.09	
27	0.10	2.90	2.51	2.30	2.17	2.07	2.00	1.95	1.91	1.87	1.85	
27	0.05	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25	2.20	

Degrees of Freedom	Degrees of Freedom for Numerator										
27	0.01	7.68	5.49	4.60	4.11	3.78	3.56	3.39	3.26	3.15	3.06
28	0.10	2.89	2.50	2.29	2.16	2.06	2.00	1.94	1.90	1.87	1.84
28	0.05	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24	2.19
28	0.01	7.64	5.45	4.57	4.07	3.75	3.53	3.36	3.23	3.12	3.03
29	0.10	2.89	2.50	2.28	2.15	2.06	1.99	1.93	1.89	1.86	1.83
29	0.05	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22	2.18
29	0.01	7.60	5.42	4.54	4.04	3.73	3.50	3.33	3.20	3.09	3.00

Denominator 30 and Above

The second table (Table 11.4.1.2) has degrees of freedom of the denominator for every tenth degree of freedom from 30 to 60, then 100, 200, and 1,000. The degrees of freedom of the denominator are based on the sample size and the number of groups being compared.

Table 11.4.1.2- Critical Values of F for Denominator DF's 30, 40, 50, 60, 100, 200, and 1,000

Degrees of Freedom	Degrees of Freedom for Numerator										
Degrees of Freedom for Denominator (Error)	p	1	2	3	4	5	6	7	8	9	10
30	0.10	2.88	2.49	2.28	2.14	2.05	1.98	1.93	1.88	1.85	1.82
30	0.05	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16
30	0.01	7.56	5.39	4.51	4.02	3.70	3.47	3.30	3.17	3.07	2.98
40	0.10	2.84	2.44	2.23	2.09	2.00	1.93	1.87	1.83	1.79	1.76
40	0.05	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08
40	0.01	7.31	5.18	4.31	3.83	3.51	3.29	3.12	2.99	2.89	2.80
50	0.10	2.81	2.41	2.20	2.06	1.97	1.90	1.84	1.80	1.76	1.73
50	0.05	4.03	3.18	2.79	2.56	2.40	2.29	2.20	2.13	2.07	2.03
50	0.01	7.17	5.06	4.20	3.72	3.41	3.19	3.02	2.89	2.78	2.70
60	0.10	2.79	2.39	2.18	2.04	1.95	1.87	1.82	1.77	1.74	1.71
60	0.05	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99
60	0.01	7.08	4.98	4.13	3.65	3.34	3.12	2.95	2.82	2.72	2.63
100	0.10	2.76	2.36	2.14	2.00	1.91	1.83	1.78	1.73	1.69	1.66
100	0.05	3.94	3.09	2.70	2.46	2.31	2.19	2.10	2.03	1.97	1.93

Degrees of Freedom		Degrees of Freedom for Numerator										
100	0.01	6.90	4.82	3.98	3.51	3.21	2.99	2.82	2.69	2.59	2.50	
200	0.10	2.73	2.33	2.11	1.97	1.88	1.80	1.75	1.70	1.66	1.63	
200	0.05	3.89	3.04	2.65	2.42	2.26	2.14	2.06	1.98	1.93	1.88	
200	0.01	6.76	4.71	3.88	3.41	3.11	2.89	2.73	2.60	2.50	2.41	
1000	0.10	2.71	2.31	2.09	1.95	1.85	1.78	1.72	1.68	1.64	1.61	
1000	0.05	3.85	3.00	2.61	2.38	2.22	2.11	2.02	1.95	1.89	1.84	
1000	0.01	6.66	4.63	3.80	3.34	3.04	2.82	2.66	2.53	2.43	2.34	

Because tables are limited by size, not all critical t-scores are listed. For example, if you had $F(2, 49)$, then the degrees of freedom of the numerator would be 2 ($DF_N = 2$) and the degrees of freedom for the denominator would be 49 ($df_D = 49$). However, the DF for the denominator jumps from 40 to 50. There are a couple of options when your Degrees of Freedom is not listed on the table.

- One option is to use the Degrees of Freedom that is *closest* to your sample's Degrees of Freedom. For our example of $F(2, 49)$, that would mean that we would use the df_D of 50 because 50 is closer to 49 than 40 is. That would mean that the critical F-score for $F(2, 49)$ would be 3.18.
- Another option is to always we round down. For our example of $F(2, 49)$, we use the df_D of 40 because it is the next lowest df_D listed. That would mean that the critical F-score for $F(2, 49)$ would be 3.23. This option avoids inflating Type I Error (false positives).

Ask your professor which option you should use!

Whichever option you choose, your statistical sentence should include the actual degrees of freedom for the numerator and for the denominator, regardless of which number is listed in the table; the table is used to decide if the null hypothesis should be rejected or retained.

Degrees of Freedom

Between Groups ANOVA (independent groups)

- Numerator (effect of IV): $k-1$
- Denominator (error): $N-k$

Repeated Measures ANOVA (dependent groups)

- Numerator (effect of IV Between Groups): $k-1$
- Denominator (Within Groups or Error): $(k-1) \times (P-1)$
- Participants: $P-1$

Factorial ANOVA (2+ IVs)

1. Cells: $(k_1 \times k_2) - 1$

1. Remembering that “k” is the number of groups, k_1 is the number of levels of the first IV and , k_2 is the number of levels of the other IV.

2. Between group for one variable (IV_1): $k_1 - 1$

3. Between group for the other variable (IV_2): $k_2 - 1$

4. Interaction: $df_1 \times df_2$

5. Within group: $df_{Total} - df_{Cells}$

6. Total: $N - 1$

1. With N being the number of scores.

Regression

- Model (numerator): 1
- Error (denominator): $N-2$
- Total: $N-1$

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