Examination Number:____________

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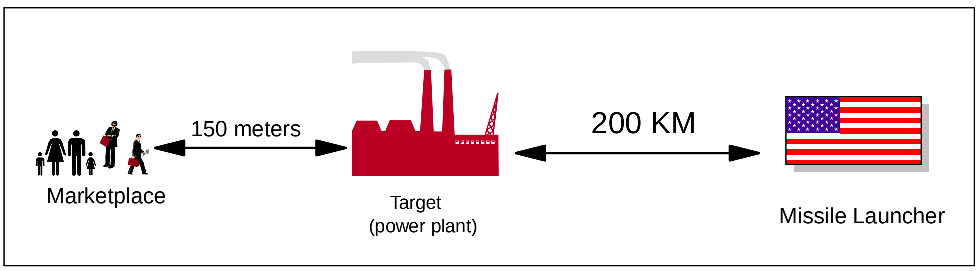
University of North Carolina
Economics 400: Economic Statistics & Econometrics
Practice Second Midterm Examination

Prof. B. Turchi   Spring 2019

General Instructions: Answer all five (5) questions on this examination, writing your answers on the exam paper itself. Use the back of the pages for any extra work, if necessary. Sign the Honor Pledge above. Express all answers to a precision of at least 3 decimal points. Show your work to be eligible for partial credit. **Be sure to note that tables and formulas are on the last pages of the exam.**

1. **(32 points total)** Last week a bomb exploded in a crowded Baghdad market place killing and wounding a number of civilians. The Iraqi government blamed American cruise missiles for the attack; however, the U.S. forces spokesman in Qatar raised doubts, saying that the U.S. does not target civilian areas and that the accuracy of the missiles is so good that the Iraqi claim is doubtful. The market was about 150 meters *beyond* the most likely target, a power plant and the missiles were fired from a distance of 200 km . (see picture below) from the target.



Suppose that the U. S. government supplies you with the following test data on the accuracy of cruise missiles fired from a distance of 200 km:

-272.54 5.80 71.43 25.10 270.30 20.25 82.95 32.72 -209.31 -5.17 -65.80 -15.92 53.30 121.90 -53.78 40.85

These data show the number of meters short or long of the target resulting from the test firing of 16 cruise missiles in tests in the Nevada desert. *Assume that a missile must actually hit the target to damage it.* Answer the following questions.

(a) (5 points) Compute the sample mean of these data.

$$\bar{x} = \frac{\sum_{i=1}^{16} x_i}{16} = \frac{102.08}{16} = 6.38$$

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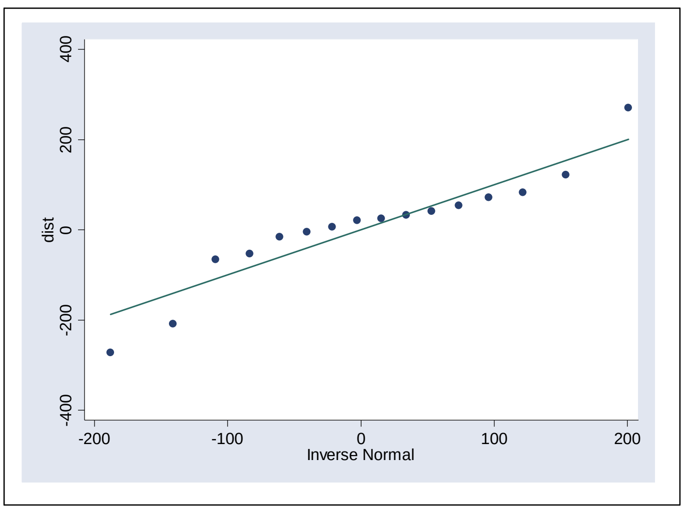
(b) (5 points) Compute the sample standard deviation of these data

$$s^2 = \frac{\sum_{i=1}^{16}\left(x_i - \overline{x}\right)^2}{16-1} = \frac{231498.0}{15} = 15433.2 \Rightarrow s = 124.23$$

(c) (10 points) Compute the 95 percent confidence interval for the sample mean. Is *zero* included in the confidence interval***?_Yes_***

$$\overline{x} \pm t_{\alpha/2} s_{\overline{x}} = \overline{x} \pm t_{0.025} s_{\overline{x}} = 6.38 \pm 2.131 \times 31.0576 = 6.38 \pm 66.184 \Rightarrow \left[-59.817, 72.578\right]$$

(d) (2 points) Here is the normal probability plot for these data. Do the data look normally distributed***?____Yes_____*** Is it likely that they come from a normally distributed population of targeting errors***?___Yes____***



(e) (10 points) If the errors are, in fact, normally distributed with a mean = 0, what is the probability (based on this sample) that a missile could have reached the market *or beyond?* (You can assume that the sample standard deviation, *s*, equals the population standard deviation, σ.

Now we're dealing with the *probability distribution* of the random variable *x:* the distance in meters long or short. The first thing we do is compute the *z-value* for a distance of +150 meters:

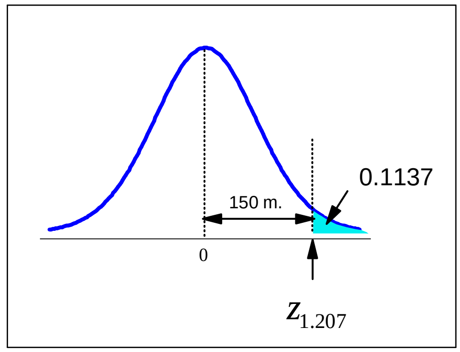
$$z = 150 \ meters$$
$$z = \frac{150 - 0}{124.2299} = 1.207$$

Note that this assumes that the underlying population mean = 0. I do this because the confidence interval contains zero and any reasonable hypothesis test could not reject the null hypothesis that $\mu = 0$. I'm sure that many students will use the sample mean instead of zero. I do not consider this as correct; however, they should only receive a small penalty for computing a z-value using $\mu = 6.38$. I'll show that calculation below.

Then, to compute the probability of being *at least* 150 meters long, we have:

$$z_{1.200} = 0.3849$$
$$z_{1.210} = 0.3869$$
$$z_{1.200} - z_{1.210} = -0.002 \Rightarrow 0.7 \times 0.002 = 0.0014$$
$$z_{1.200} + 0.0014 = 0.3863 \Rightarrow 0.5000 - 0.3863 = 0.1137$$

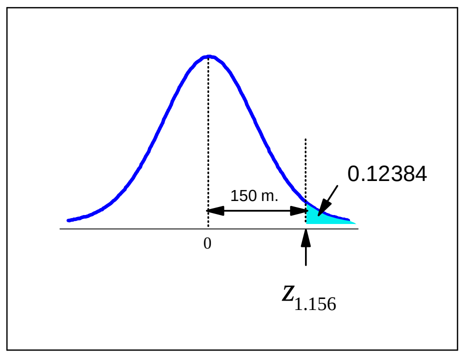
$$\therefore \Pr(x \geq 150) = 0.1137$$



Alternate calculation:

Alternate using sample mean:

$$z = \frac{150 - 6.38}{124.2299} = 1.156$$
$$z_{1.156} = 0.37616$$
$$\Pr(x \geq 150) = 0.5000 - 0.37616 = 0.12384$$



Grading Standard: One point should be deducted if the student did the entire calculation correctly but used 6.38 instead of 0

2. **(18 points total)** Husbands and wives often disagree about how much housework the husband does around the house in a given 2-week period. Below you will find a table containing data from 2 independent samples of husbands and wives. Each sample contains 12 respondents. Sample 1 is husbands who report on their housework in a typical 2-week period. Sample 2 is wives (not necessarily married to the husbands in sample 1) who report on the housework performed by *their* husbands in the same two week period. At the $\alpha = 0.10$ level can you reject the null hypothesis that, on average husbands and wives report the same number of hours versus the alternative that husbands report *more* hours? **(a)** perform this hypothesis test assuming equal population variances; then **(b)** perform the test assuming unequal population variances. Do your results differ depending upon which assumption you make about the respective population variances? For parts (a) and (b) be sure to show your calculations of test statistic, critical values and degrees of freedom. Show all your work including all relevant information for performing the significance test.

Husbands	Wives
19.8	14.0
19.2	9.2
18.3	15.2
16.9	16.2
16.3	16.0
16.0	16.2
14.8	12.5
14.6	15.4
14.0	13.4
12.7	14.8
11.6	13.4
11.5	15.3

This problem asks the student to test the hypothesis that sample means from two populations are the same vs. the alternative that the husbands' estimates of housework are greater. Because the husbands and wives are not necessarily married to each other, the samples are independent and we can use the *t-test for independent samples:* However, since we are unsure as to whether the underlying standard deviations from the two populations are the same, part (a) asks for the calculation using *pooled variances* (assumed equal) and part (b) asks for the same test assuming *unequal variances.*

(a) The proper formulas are:

$$t = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{s_p\sqrt{(1/n_1) + (1/n_2)}}$$

$$df = n_1 + n_2 - 2.$$

$$s_p = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}}$$

t= 1.1849

df = 22

sp = 2.429

critical t(0.1)= 1.321
Cannot reject Ho

(b) For the unequal variance t-test, the proper formulas are:

t = 1.1849
delta (df) = 19.9933~19
critical t(0.1) = 1.328
cannot reject Ho

$$t = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{\sqrt{(s_1^2/n_1) + (s_2^2/n_2)}}$$

$$\Delta = \frac{\left[(s_1^2/n_1) + (s_2^2/n_2)\right]^2}{\frac{(s_1^2/n_1)^2}{n_1 - 1} + \frac{(s_2^2/n_2)^2}{n_2 - 1}} \text{ rounded down.}$$

While the results are slightly different, we cannot reject the null hypothesis in either case.

3. **(28 points total)** Provide definitions for:

a) Simple random sampling:

Simple random sampling: A sampling procedure for which each possible sample of a given size is equally likely to be the one obtained

b) Sampling error:

Sampling Error: Sampling error is the error resulting from using a sample to estimate a population characteristic.

c) The difference between **probability distributions** and **sampling distributions:**

A probability distribution of a random variable gives, for each value of the random variable, the probability that a given value of the random variable will be obtained.

The Sampling Distribution of a Sample Statistic shows, for a sample statistic computed from a given sample size, the probability distribution of all possible values of the sample statistic that can be computed from samples of that size. So, for a variable x-bar and a given sample size n, the distribution of the variable that is, the distribution of all possible sample means -- is called the sampling distribution of the sample mean.

d) The Power of a Hypothesis Test:

The probability of not making a type II error (i.e., it is the probability of rejecting a false null hypothesis)

e) Unbiasedness of an estimator:

✓**Unbiasedness:** An estimator is said to be unbiased if the expected value of the estimator is equal to the parameter being estimated, or

$$E\left[\hat{\Theta}\right] = \Theta.$$

f) Efficiency of an estimator

Efficiency: The most efficient estimator among a group of unbiased estimators is the one with the smallest variance.

g) *p-value* of a hypothesis test:

Definition: The P-value of a hypothesis test equals the smallest significance level at which the null hypothesis can be rejected, that is, the smallest level for which the observed sampled data results in rejection of Ho.

(Problem #4 on the next page)

4. (10 points total) Suppose the Carolina Poll wants to gauge student opinion regarding the resignation of Matt Doherty as UNC's men's basketball coach.

a) To obtain an estimate of the proportion favoring the resignation, how many students would have to be sampled if the maximum error is to be 0.05 at an $\alpha = 0.05$ level?

a) We can use the formula $n = \dfrac{z_{\alpha/2}^2}{4D^2}$ with *D=0.05:*

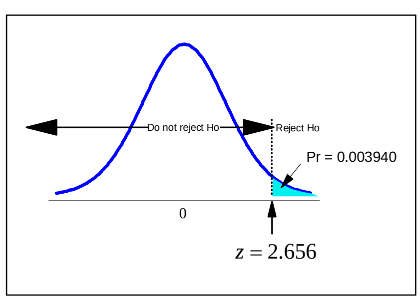
$$n = \frac{z_{\alpha/2}^2}{4D^2} = \frac{1.96^2}{4\times(0.05)^2} = 384.16 \Rightarrow 384 \sim 385$$

b) Suppose the sample is taken with 250 randomly selected respondents. If 146 respondents said that they are opposed to the resignation at what level can we reject the null hypothesis that a majority favor the resignation in favor of the alternative that a majority are against the resignation?

$$H_0 : p = 0.5 \text{ where } p = \text{ proportion against resignation}$$
$$H_a : p > 0.5$$

$$z = \frac{\hat{p} - p_0}{\sqrt{\dfrac{p_0(1-p_0)}{n}}} = \frac{0.584 - 0.50}{\sqrt{\dfrac{0.5(0.5)}{250}}} = \frac{0.084}{0.032} = 2.656 \Rightarrow \alpha = .5 - .49606 = 0.003940$$

Therefore, we can reject the null hypothesis that a majority are in favor of the resignation at the $\alpha = 0.003940$ level.



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5. (12 points) The following Stata output shows the regression model:

$AvgWaterUse = \alpha + \beta \cdot AvgRainFall + \varepsilon$. Answer the following questions using these results as a basis for your answers.

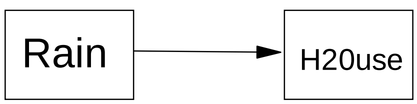
```
. regress  h2ouse rain

      Source |       SS       df       MS              Number of obs =     137
-------------+------------------------------           F(  1,   135) =    1.57
       Model |  .296179057     1  .296179057           Prob > F      =  0.2117
    Residual |  25.3931185   135  .188097174           R-squared     =  0.0115
-------------+------------------------------           Adj R-squared =  0.0042
       Total |  25.6892976   136  .188891894           Root MSE      =   .4337

------------------------------------------------------------------------------
      h2ouse |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        rain |  -.0319033   .0254243    -1.25   0.212    -.0821848    .0183782
       _cons |   4.331621   .0854821    50.67   0.000     4.162564    4.500679
------------------------------------------------------------------------------
```

(a) Draw a causal diagram and explain what this regression is attempting to discover.

(a) The causal diagram would look like:



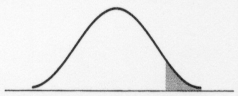
This regression is attempting to determine if there is a causal relationship between average rainfall and water use by households.

(b) What proportion of the total variation in water use does rainfall explain?

(b) The $R^2 = 0.0115$, which says that only about 1.1% of the variation in water use is accounted for by the regression.

(c) Does rainfall have a significant impact on the level of water use? Why/Why Not?

(c) No, rainfall appears not to have a significant effect on water use. The coefficient on "rain" is small (-0.0319033) and it has a small t-statistic, which allows us to reject the null hypothesis at only the 21.2% level.



d.f.	$t_{.100}$	$t_{.050}$	$t_{.025}$	$t_{.010}$	$t_{.005}$	d.f.
1	3.078	6.314	12.706	31.821	63.657	1
2	1.886	2.920	4.303	6.965	9.925	2
3	1.638	2.353	3.182	4.541	5.841	3
4	1.533	2.132	2.776	3.747	4.604	4
5	1.476	2.015	2.571	3.365	4.032	5
6	1.440	1.943	2.447	3.143	3.707	6
7	1.415	1.895	2.365	2.998	3.499	7
8	1.397	1.860	2.306	2.896	3.355	8
9	1.383	1.833	2.262	2.821	3.250	9
10	1.372	1.812	2.228	2.764	3.169	10
11	1.363	1.796	2.201	2.718	3.106	11
12	1.356	1.782	2.179	2.681	3.055	12
13	1.350	1.771	2.160	2.650	3.012	13
14	1.345	1.761	2.145	2.624	2.977	14
15	1.341	1.753	2.131	2.602	2.947	15
16	1.337	1.746	2.120	2.583	2.921	16
17	1.333	1.740	2.110	2.567	2.898	17
18	1.330	1.734	2.101	2.552	2.878	18
19	1.328	1.729	2.093	2.539	2.861	19
20	1.325	1.725	2.086	2.528	2.845	20
21	1.323	1.721	2.080	2.518	2.831	21
22	1.321	1.717	2.074	2.508	2.819	22
23	1.319	1.714	2.069	2.500	2.807	23
24	1.318	1.711	2.064	2.492	2.797	24
25	1.316	1.708	2.060	2.485	2.787	25
26	1.315	1.706	2.056	2.479	2.779	26
27	1.314	1.703	2.052	2.473	2.771	27
28	1.313	1.701	2.048	2.467	2.763	28
29	1.311	1.699	2.045	2.462	2.756	29
inf.	1.282	1.645	1.960	2.326	2.576	inf.

Source: From "Table of Percentage Points of the *t*-Distribution." *Biometrika*, Vol. 32 (1941), p. 300. Reproduced by permission of the Biometrika Trustees.

$$\Pr\left(-t_{\alpha/2} < \frac{\bar{x}-\mu}{s/\sqrt{n}} < t_{\alpha/2}\right) = 1-\alpha$$

$$t = \frac{\left(\bar{x}_1-\bar{x}_2\right)-\left(\mu_1-\mu_2\right)}{s_p\sqrt{\left(1/n_1\right)+\left(1/n_2\right)}}$$

$$df = n_1+n_2-2.$$

$$s_p = \sqrt{\frac{\left(n_1-1\right)s_1^2+\left(n_2-1\right)s_2^2}{n_1+n_2-2}}$$

$$\mathrm{t} = \frac{\left(\bar{x}_1-\bar{x}_2\right)-\left(\mu_1-\mu_2\right)}{\sqrt{\left(s_1^2/n_1\right)+\left(s_2^2/n_2\right)}}$$

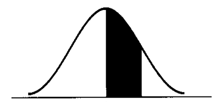
$$\Delta = \frac{\left[\left(s_1^2/n_1\right)+\left(s_2^2/n_2\right)\right]^2}{\frac{\left(s_1^2/n_1\right)^2}{n_1-1}+\frac{\left(s_2^2/n_2\right)^2}{n_2-1}} \text{ rounded down.}$$

$$\hat{p}_p = \frac{x_1+x_2}{n_1+n_2}$$

$$z = \frac{\hat{p}-p_0}{\sqrt{\frac{p_0\left(1-p_0\right)}{n}}}$$

$$z = \frac{\hat{p}_1-\hat{p}_2}{\sqrt{\hat{p}_p\left(1-\hat{p}_p\right)}\bullet\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}}$$

Normal Curve Areas



z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.0359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0753
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2257	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2517	.2549
0.7	.2580	.2611	.2642	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2995	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

Source: This table is abridged from Table 1 of *Statistical Tables and Formulas*, by A. Hald (New York: John Wiley & Sons, Inc., 1952). Reproduced by permission of A. Hald and the publishers, John Wiley & Sons, Inc.

$$n = \frac{z_{\alpha/2}^2\sigma^2}{D^2}. \qquad n = \frac{z_{\alpha/2}^2}{4D^2}$$

Binomial Coefficients

n	$\binom{n}{0}$	$\binom{n}{1}$	$\binom{n}{2}$	$\binom{n}{3}$	$\binom{n}{4}$	$\binom{n}{5}$	$\binom{n}{6}$	$\binom{n}{7}$	$\binom{n}{8}$	$\binom{n}{9}$	$\binom{n}{10}$
0	1										
1	1	1									
2	1	2	1								
3	1	3	3	1							
4	1	4	6	4	1						
5	1	5	10	10	5	1					
0	1	6	15	20	15	6	1				
7	1	7	21	35	35	21	7	1			
8	1	8	28	56	70	56	28	8	1		
9	1	9	36	84	126	126	84	36	9	1	
10	1	10	45	120	210	252	210	120	45	10	1
11	1	11	55	165	330	462	462	330	165	55	11
12	1	12	66	220	405	792	924	792	495	220	66
13	1	13	78	286	715	1287	1716	1716	1287	715	286
14	1	14	91	364	1001	2002	3003	3432	3003	2002	1001
15	1	15	105	455	1365	3003	5005	6435	6435	5005	3003
16	1	16	120	560	1820	4368	8008	11440	12870	11440	8008
17	1	17	136	680	2380	6188	12376	19448	24310	24310	19448
18	1	18	153	816	3060	8568	18564	31824	43758	48620	43758
19	1	19	171	969	3876	11628	27132	50388	75582	92378	92378
20	1	20	190	1140	4845	15304	38760	77520	125970	167960	184756

If necessary, use the identity $\binom{n}{k} = \binom{n}{n-k}$.

$$f(\tilde{x}) = \frac{1}{\sigma\sqrt{2\pi}} e^{-(x-\mu)^2/2\sigma^2} \quad -\infty < x < \infty$$

$$\sigma^2 = \frac{\sum_{i=1}^{N}(x_i-\mu)^2}{N}$$

$$p(x) = \frac{C_x^r C_{n-x}^{N-r}}{C_n^N} = \frac{\binom{r}{x}\binom{N-r}{n-x}}{\binom{N}{n}}$$

Mean: $\mu = n\left(\frac{r}{N}\right)$

Variance: $\sigma^2 = n\left(\frac{r}{N}\right)\left(\frac{N-r}{N}\right)\left(\frac{N-n}{N-1}\right)$

Standard deviation: $\sigma = \sqrt{\sigma^2}$

$$f(x) = \begin{cases} \frac{1}{(b-a)}, & a \le x \le b \\ 0, & \text{otherwise} \end{cases}$$

$$\mu = \frac{1}{2}(b+a) \text{ and } \sigma = \frac{(b-a)}{\sqrt{12}}$$

$$f(x) = \begin{cases} \lambda e^{-\lambda x}, & \lambda > 0, x \ge 0 \\ 0, & \text{otherwise} \end{cases}$$

$$\mu = \frac{1}{\lambda} \text{ and } \sigma = \frac{1}{\lambda}$$

$$P(x \ge a) = e^{-\lambda a}, a \ge 0 \text{ and } \lambda > 0$$

$$P(A_i|B) = \frac{P(B|A_i)P(A_i)}{\sum_{\text{all } k} P(B|A_k)P(A_k)}$$

$$F_{(n_A-1;n_B-1)} = \frac{s_A^2/\sigma_A^2}{s_B^2/\sigma_B^2}$$

$$\chi^2_{(n-1)} = \frac{n-1}{\sigma_0^2}s^2$$

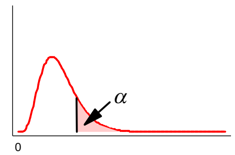
$$P(x) = \begin{cases} \frac{e^{-\lambda t}(\lambda t)^x}{x!}, & \text{for } x = 0,1,2,,,\infty, \quad \lambda > 0, \\ 0, & \text{otherwise.} \end{cases}$$

λ = the mean number of events in a given segment of time $(t=1)$

t = the length of a particular subsegment $(t \le 1)$

$E[x] = \mu_x = \lambda t$ = the expected number of events in one subsegment length t

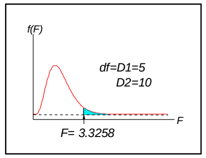
Critical values of χ^2_α



df	$\chi^2_{0.995}$	$\chi^2_{0.99}$	$\chi^2_{0.975}$	$\chi^2_{0.95}$	$\chi^2_{0.90}$
1	0.000	0.000	0.001	0.004	0.016
2	0.010	0.020	0.051	0.103	0.211
3	0.072	0.115	0.216	0.352	0.584
4	0.207	0.297	0.484	0.711	1.064
5	0.412	0.554	0.831	1.145	1.610
6	0.676	0.872	1.237	1.635	2.204
7	0.989	1.239	1.690	2.167	2.833
8	1.344	1.646	2.180	2.733	3.490
9	1.735	2.088	2.700	3.325	4.168
10	2.156	2.558	3.247	3.940	4.865
11	2.603	3.053	3.816	4.575	5.578
12	3.074	3.571	4.404	5.226	6.304
13	3.565	4.107	5.009	5.892	7.042
14	4.075	4.660	5.629	6.571	7.790
15	4.601	5.229	6.262	7.261	8.547
16	5.142	5.812	6.908	7.962	9.312
17	5.697	6.408	7.564	8.672	10.085
18	6.265	7.015	8.231	9.390	10.865
19	6.844	7.633	8.907	10.117	11.651
20	7.434	8.260	9.591	10.851	12.443
21	8.034	8.897	10.283	11.591	13.240
22	8.643	9.542	10.982	12.338	14.041
23	9.260	10.196	11.689	13.091	14.848
24	9.886	10.856	12.401	13.848	15.659
25	10.520	11.524	13.120	14.611	16.473
26	11.160	12.198	13.844	15.379	17.292
27	11.808	12.879	14.573	16.151	18.114
28	12.461	13.565	15.308	16.928	18.939
29	13.121	14.256	16.047	17.708	19.768
30	13.787	14.953	16.791	18.493	20.599
40	20.707	22.164	24.433	26.509	29.051
50	27.991	29.707	32.357	34.764	37.689
60	35.534	37.485	40.482	43.188	46.459
70	43.275	45.442	48.758	51.739	55.329
80	51.172	53.540	57.153	60.391	64.278
90	59.196	61.754	65.647	69.126	73.291
100	67.328	70.065	74.222	77.930	82.358

$\chi^2_{0.10}$	$\chi^2_{0.05}$	$\chi^2_{0.025}$	$\chi^2_{0.001}$	$\chi^2_{0.005}$	df
2.706	3.841	5.024	6.635	7.879	1
4.605	5.991	7.378	9.210	10.597	2
6.251	7.815	9.348	11.345	12.838	3
7.779	9.488	11.143	13.277	14.860	4
9.236	11.070	12.833	15.086	16.750	5
10.645	12.592	14.449	16.812	18.548	6
12.017	14.067	16.013	18.475	20.278	7
13.362	15.507	17.535	20.090	21.955	8
14.684	16.919	19.023	21.666	23.589	9
15.987	18.307	20.483	23.209	25.188	10
17.275	19.675	21.920	24.725	26.757	11
18.549	21.026	23.337	26.217	28.300	12
19.812	22.362	24.736	27.688	29.819	13
21.064	23.685	26.119	29.141	31.319	14
22.307	24.996	27.488	30.578	32.801	15
23.542	26.296	28.845	32.000	34.267	16
24.769	27.587	30.191	33.409	35.718	17
25.989	28.869	31.526	34.805	37.156	18
27.204	30.143	32.852	36.191	38.582	19
28.412	31.410	34.170	37.566	39.997	20
29.615	32.671	35.479	38.932	41.401	21
30.813	33.924	36.781	40.290	42.796	22
32.007	35.172	38.076	41.638	44.181	23
33.196	36.415	39.364	42.980	45.559	24
34.382	37.653	40.647	44.314	46.928	25
35.563	38.885	41.923	45.642	48.290	26
36.741	40.113	43.195	46.963	49.645	27
37.916	41.337	44.461	48.278	50.994	28
39.087	42.557	45.722	49.588	52.336	29
40.256	43.773	46.979	50.892	53.672	30
51.805	55.759	59.342	63.691	66.767	40
63.167	67.505	71.420	76.154	79.490	50
74.397	79.082	83.298	88.381	91.955	60
85.527	90.531	95.023	100.424	104.213	70
96.578	101.879	106.628	112.328	116.320	80
107.565	113.145	118.135	124.115	128.296	90
118.499	124.343	129.563	135.811	140.177	100

F-Distribution Table: Upper 5% Probability (or 5% Area) under F-distribution Curve



			F-Table for alpha = 0.05																
/	df1=1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	inf
df2=1	161.4476	199.5	215.7073	224.5832	230.1619	233.986	236.7684	238.8827	240.5433	241.8817	243.906	245.9499	248.0131	249.0518	250.0951	251.1432	252.1957	253.2529	254.3144
2	18.5128	19	19.1643	19.2468	19.2964	19.3295	19.3532	19.371	19.3848	19.3959	19.4125	19.4291	19.4458	19.4541	19.4624	19.4707	19.4791	19.4874	19.4957
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