NAME:

STUDENT #:

EMAIL:

ECO220Y1Y, Test #3, Prof. Murdock

February 7, 2025, 8:10 am – 10:00 am

Instructions:

- **Keep ALL pages closed and face up on your desk until we announce the start.**
- There are 8 test pages with 7 questions, with varying numbers of parts, worth a total of 95 points.
- **Questions (1) and (2) have no supplementary material. The rest require the *Supplement*, which will be distributed after the test has begun. You already have the aids sheets, with formulae and statistical tables.**
- You have 110 minutes. You must stay for a minimum of 60 minutes.
- For each question referencing the *Supplement*, carefully review *all* materials. The ***Supplement and aid sheets are NOT collected:*** write your answers on the test papers. At the end, hand in only your Crowdmark test papers.
- Write your answers clearly, completely, and concisely in the designated space provided immediately after each question. An answer guide ends each question to let you know what is expected. For example, a quantitative analysis, a fully labelled graph, and/or sentences. Any answer guide asking for a quantitative analysis *always* automatically means that you must show your work and make your reasoning clear.
    - Marking TAs are instructed to accept all reasonable rounding.
- ***Your entire answer must fit in the designated space provided immediately after each question.*** No extra space/pages are possible. You *cannot* use blank space for other questions, nor can you write answers on the *Supplement*. ***Write in PENCIL and use an ERASER as needed*** so that you can fit your final answer (including work and reasoning) in the appropriate space. We give more blank space than is needed for each answer (with typical handwriting) worth full marks. ***Follow the answer guides and avoid excessively long answers.***

(1) [4 pts] We wish to make an inference about how access to health insurance and primary care affects people's use of hospital emergency departments. In this context, describe an example of *paired data.* Answer with 1 – 2 sentences.

(2) An application process requires written materials and a passport photo. Among all white applicants, 10% are offered jobs. To test for bias against black applicants, 1,000 real submissions by white applicants are altered by changing only the name and the photo to reflect a black applicant pool. This sample of 1,000 altered applications are then submitted.

(a) [9 pts] To prove bias against black applicants at a 1% significance level, how low must the percent offered jobs in the sample be? Answer with hypotheses in formal notation, a quantitative analysis & 1 sentence.

(b) [3 pts] Without doing any further quantitative analysis, *explain* how the answer to Part **(a)** would change if instead of 1,000 applications there were 250. Explain conceptually, *not* mathematically. Answer with 1 sentence.

(3) See ***Supplement for Question (3)***: *Forecasting the directional effects of macroeconomic shocks.*

(a) [5 pts] Among ECO220Y students, compute the 90% CI about the belief that a rise in government spending leads to a rise in inflation. Answer with a quantitative analysis.

(b) [8 pts] Compute and *interpret* a 99% CI about the difference between experts and the general population in the belief that a rise in government spending leads to a rise in inflation. Answer with a quantitative analysis & 1 sentence.

(4) [9 pts] See ***Supplement for Questions (4), (5) and (6)***: *Declining fertility.* For a certain population of women, researchers wish to prove that fertility supports population growth (i.e. exceeds the *adequate replacement rate*). Write the hypotheses. In this context and in plain English, what would a Type I error be? In this context and in plain English, what would a Type II error be? <u>Answer with hypotheses in formal notation & 2 sentences.</u>

(5) See ***Supplement for Questions (4), (5) and (6)***: *Declining fertility.* A research team studies how socioeconomic status and demographics interact with fertility. They make inferences about subgroups. For example, women whose highest level of education is a high school degree and are aged 50 to 55.

(a) [5 pts] The tabulation to the right summarizes a random sample from a population subgroup. The sample standard deviation is 1.3474759. Compute the standardized test statistic to test if the population subgroup has fertility exceeding the U.S. <u>Answer with a quantitative analysis.</u> (*Note:* It does *not* ask you to do the test, just to compute the test statistic.)

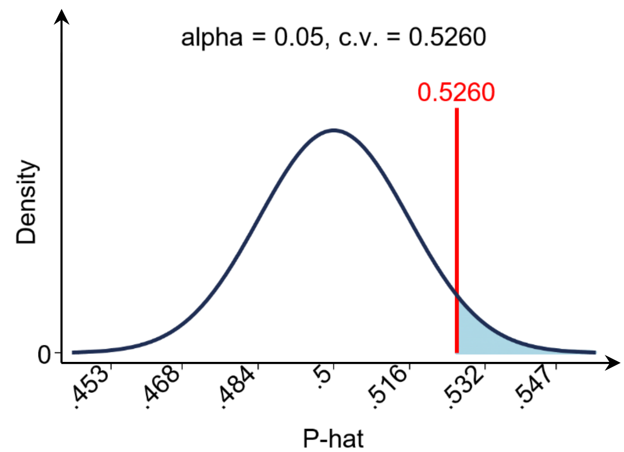
num_child	Freq.	Percent	Cum.
0	277	22.78	22.78
1	211	17.35	40.13
2	412	33.88	74.01
3	195	16.04	90.05
4	91	7.48	97.53
5	15	1.23	98.77
6	13	1.07	99.84
7	2	0.16	100.00
Total	1,216	100.00	

(b) [10 pts] For another subgroup – women aged 50 to 55 who completed law school – a random sample of 54 has average births of 1.2 and a standard deviation of 1.1. Can this sample prove *ultralow fertility*? Compute the P-value. *Interpret* the results. <u>Answer with hypotheses in formal notation, a quantitative analysis & 2 – 3 sentences.</u>

(c) [6 pts] Using a sample for another subgroup – women aged 50 to 55 with a PhD – researchers seek to prove fertility is below South Korea. The P-value comes out to 0.961. *Explain* and *interpret* the results. <u>Answer with 2 – 3 sentences.</u>

(6) [12 pts] See ***Supplement for Questions (4), (5) and (6)***: *Declining fertility.* Fertility can decline because fewer women choose to bear children and/or because an increasing fraction choose to stop after a small number (e.g. one child). Focusing on the latter, consider trying to prove at a 5% significance level that a majority of a population subgroup have only one child. What is the *power* of the test if we have a random sample of 1,000 women and 54% of the entire population subgroup have one child? <u>Answer with hypotheses in formal notation, a quantitative analysis, a second fully labeled graph & 1 – 2 sentences *interpreting* your answer.</u>

(*Note:* The first required graph is *already* drawn for you. Do *not* redo the quantitative analysis required to draw it.)



(7) See ***Supplement for Question (7)***: *Valuing Solar Subsidies.*

(a) [4 pts] Give an example of a *specific question* – in PLAIN ENGLISH (like an interpretation) – that would require using the formula below from our aid sheets. Your question should be answerable using the formula below and the numbers in Table 1, but you should *not* answer it *nor* plug into the formula. Answer with **ONE** *specific question*.

$$z = \frac{\hat{P}_2 - \hat{P}_1}{\sqrt{\frac{\bar{P}(1-\bar{P})}{n_1} + \frac{\bar{P}(1-\bar{P})}{n_2}}}$$

(b) [4 pts] Give an example of a *specific question* – in PLAIN ENGLISH (like an interpretation) – that would require using the formula below from our aid sheets. Your question should be answerable using the formula below and the numbers in Table 1, but you should *not* answer it *nor* plug into the formula. Answer with **ONE** *specific question*.

$$(\bar{X}_1 - \bar{X}_2) \pm t_{\alpha/2}\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$$

(c) [6 pts] Compute the standard error for **5.51** (near the bottom of Table 1). How will it compare to the standard error for **5.29**? *Explain* if the standard error for **5.51** will be bigger, smaller, or about the same as the standard error for **5.29**. Answer with a quantitative analysis & 1 – 2 sentences.

(d) [10 pts] Is there a *significant* difference in house size between those who adopt rooftop solar systems compared to those who do not? Justify and explain your answer. Answer with the relevant quantitative analysis & 2 – 3 sentences.

Supplement for Question (1): N/A (all information given with the question)

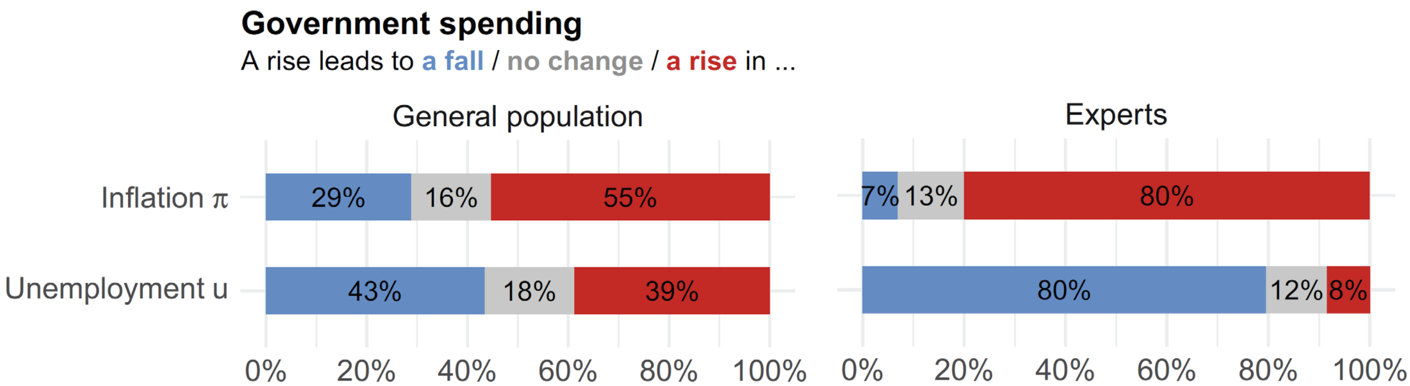
Supplement for Question (2): N/A (all information given with the question)

Supplement for Question (3): From Workshop 14, recall the 2022 paper “Subjective Models of the Macroeconomy: Evidence from Experts and Representative Samples” published in the *Review of Economic Studies*.

Figure 1 is titled “Forecasts of the directional effects of macroeconomic shocks” and an excerpt is below.

Figure 1 shows when the macroeconomic shock is a rise in government spending. A note below Figure 1 says “This figure presents the forecasts of the directional effects of macroeconomic shocks on the inflation rate and the unemployment rate. It compares the forecasts of the general population (left column) to those of experts (right column).”

The researchers use replies to a 2019 survey administered to representative random samples. For the general population, they have a sample of about 2,200 respondents living in the United States. For economic experts, they have a sample of about 1,100 respondents from around the world.



> ***NOTE to help you read the screenshot above:*** It shows that in response to a rise in government spending, 29% of the general population think that leads to a fall in inflation, 16% think no change in inflation, and 55% think a rise in inflation, whereas among economic experts those numbers are 7%, 13%, and 80%, respectively.

During class in ECO220Y in January 2025, 83 students said a rise in government spending leads to a fall in inflation, 32 said no change in inflation, and 240 said a rise in inflation. Treat this as a representative random sample of typical students in ECO220Y.

Supplement for Questions (4), (5) and (6): Consider an opinion piece by Ezra Klein titled “Now is the Time of Monsters” published on January 12, 2025 in the *New York Times*.

> **Excerpt:** *In April, the Centers for Disease Control and Prevention announced that the U.S. fertility rate had fallen to a new low of around 1.6 births per woman — well below the 2.1 that is broadly considered an adequate replacement rate. The European Union average is closer to 1.5, with Germany recently falling below the U.N.’s “ultralow fertility” line of 1.4. South Korea is down to 0.78 births per woman, a rate at which the country will sharply contract over a few generations. The only wealthy country with a fertility rate above the replacement rate is Israel.*
>
> *It is harder for societies to remain stable as they shrink; South Korea’s demographic crisis has contributed to its recent political turmoil. Growth becomes elusive when populations decline. Fewer adults supporting more retirees is a recipe for discontent.*

Supplement for Question (7): Consider a 2025 *NBER Working Paper* titled "Valuing Solar Subsidies."

Excerpts (pp. 7 – 9): For 28 zip codes in west-central California, we assemble a detailed household-level data set on solar adoptions, home characteristics, and household characteristics covering the period 2014 to 2016.

Our first data source contains address-level data on home characteristics from CoreLogic. We focus on all single-family detached owner-occupied non-mobile home residences that were built before 2014 in the 28 zip codes. The data include the year built, heated square footage, and number of stories. This provides the set of potentially adopting households.

Our second data source is publicly available voter registration data from the California Secretary of State. For each address, we categorize households to be Democrat, Republican, or mixed. We merge in household characteristics data from InfoUSA, including the number of children, race, home-ownership status, the length of time at the residence, the number of open lines of credit, and the calculated wealth of the household, inclusive of equity in the home.

Our installation-level dataset of solar adopters is a restricted-access version of the Lawrence Berkeley National Laboratories "Tracking the Sun" (TTS) database which contains the address of the installation, application date, installation date, system size (in watts).

Table 1 shows summary statistics for the homes and households in the sample by adopter status. The wealth variable includes the estimated value of the home. Solar adopters tend to be middle- and high-wealth, are more likely to have children, and have larger homes. Adopters are only slightly more likely to be all-Democratic in voter registration and have shorter length of residence. [Two numbers are in **boldface** in Table 1 for easy reference.]

Table 1: Sample Summary Statistics

	All		Adopters		Non-adopters	
	Mean	Std. dev	Mean	Std. dev	Mean	Std. dev
Variables						
Wealth ($1,000's)	2500.09	1017.81	2624.27	909.25	2494.99	1021.70
1(Low wealth bin)	0.33	0.47	0.24	0.43	0.34	0.47
1(Medium wealth bin)	0.33	0.47	0.42	0.49	0.33	0.47
1(High wealth bin)	0.33	0.47	0.34	0.47	0.33	0.47
Lines of credit (count)	0.67	1.41	0.75	1.53	0.66	1.40
1(Children present)	0.32	0.47	0.41	0.49	0.31	0.46
Length of residence (years)	15.56	12.26	13.42	10.65	15.65	12.31
Square Footage (1,000 sq. ft.)	1.79	0.75	2.16	0.81	1.77	0.75
1(Single story)	0.32	0.47	0.45	0.50	0.32	0.47
1(Dem voter registration)	0.43	0.49	0.45	0.50	0.43	0.49
1(Possible non-owner)	0.18	0.39	0.06	0.24	0.19	0.39
Number of households (n)	183,667		7,244		176,423	
Adopted System Size (n = 7,244)			Mean	Std. dev		
System Size (kW)			**5.29**	2.36		
Low-Wealth Adopter Sys. Size (kW)			4.91	2.23		
Med-Wealth Adopter Sys. Size (kW)			**5.51**	2.34		
High-Wealth Adopter Sys. Size (kW)			5.29	2.45		

Sample mean: $\bar{X} = \frac{\sum_{i=1}^{n} x_i}{n}$ **Sample variance:** $s^2 = \frac{\sum_{i=1}^{n}(x_i-\bar{X})^2}{n-1} = \frac{\sum_{i=1}^{n} x_i^2}{n-1} - \frac{\left(\sum_{i=1}^{n} x_i\right)^2}{n(n-1)}$ **Sample s.d.:** $s = \sqrt{s^2}$

Sample coefficient of variation: $CV = \frac{s}{\bar{X}}$ **Sample covariance:** $s_{xy} = \frac{\sum_{i=1}^{n}(x_i-\bar{X})(y_i-\bar{Y})}{n-1} = \frac{\sum_{i=1}^{n} x_i y_i}{n-1} - \frac{(\sum_{i=1}^{n} x_i)(\sum_{i=1}^{n} y_i)}{n(n-1)}$

Sample interquartile range: $IQR = Q3 - Q1$ **Sample coefficient of correlation:** $r = \frac{s_{xy}}{s_x s_y} = \frac{\sum_{i=1}^{n} z_{x_i} z_{y_i}}{n-1}$

Addition rule: $P(A\ or\ B) = P(A) + P(B) - P(A\ and\ B)$ **Conditional probability:** $P(A|B) = \frac{P(A\ and\ B)}{P(B)}$

Complement rules: $P(A^C) = P(A') = 1 - P(A)$ $P(A^C|B) = P(A'|B) = 1 - P(A|B)$

Multiplication rule: $P(A\ and\ B) = P(A|B)P(B) = P(B|A)P(A)$

Expected value: $E[X] = \mu = \sum_{all\ x} xp(x)$ **Variance:** $V[X] = E[(X-\mu)^2] = \sigma^2 = \sum_{all\ x}(x-\mu)^2 p(x)$

Covariance: $COV[X,Y] = E[(X-\mu_X)(Y-\mu_Y)] = \sigma_{XY} = \sum_{all\ x}\sum_{all\ y}(x-\mu_X)(y-\mu_Y)p(x,y)$

<u>Laws of expected value</u>:

$E[c] = c$

$E[X + c] = E[X] + c$

$E[cX] = cE[X]$

$E[a + bX + cY] = a + bE[X] + cE[Y]$

<u>Laws of variance</u>:

$V[c] = 0$

$V[X + c] = V[X]$

$V[cX] = c^2V[X]$

$V[a + bX + cY] = b^2V[X] + c^2V[Y] + 2bc * COV[X,Y]$

$V[a + bX + cY] = b^2V[X] + c^2V[Y] + 2bc * SD(X) * SD(Y) * \rho$

where $\rho = CORRELATION[X,Y]$

<u>Laws of covariance</u>:

$COV[X,c] = 0$

$COV[a + bX, c + dY] = bd * COV[X,Y]$

Combinatorial formula: $C_x^n = \frac{n!}{x!(n-x)!}$ **Binomial probability:** $p(x) = \frac{n!}{x!(n-x)!}p^x(1-p)^{n-x}$ for $x = 0,1,2,\ldots,n$

If X is Binomial $(X \sim B(n,p))$ **then** $E[X] = np$ **and** $V[X] = np(1-p)$

If X is Uniform $(X \sim U[a,b])$ **then** $f(x) = \frac{1}{b-a}$ **and** $E[X] = \frac{a+b}{2}$ **and** $V[X] = \frac{(b-a)^2}{12}$

<u>Sampling distribution of $\bar{X}$</u>:

$\mu_{\bar{X}} = E[\bar{X}] = \mu$

$\sigma_{\bar{X}}^2 = V[\bar{X}] = \frac{\sigma^2}{n}$

$\sigma_{\bar{X}} = SD[\bar{X}] = \frac{\sigma}{\sqrt{n}}$

<u>Sampling distribution of $\hat{P}$</u>:

$\mu_{\hat{P}} = E[\hat{P}] = p$

$\sigma_{\hat{P}}^2 = V[\hat{P}] = \frac{p(1-p)}{n}$

$\sigma_{\hat{P}} = SD[\hat{P}] = \sqrt{\frac{p(1-p)}{n}}$

<u>Sampling distribution of $(\hat{P}_2 - \hat{P}_1)$</u>:

$\mu_{\hat{P}_2-\hat{P}_1} = E[\hat{P}_2 - \hat{P}_1] = p_2 - p_1$

$\sigma_{\hat{P}_2-\hat{P}_1}^2 = V[\hat{P}_2 - \hat{P}_1] = \frac{p_2(1-p_2)}{n_2} + \frac{p_1(1-p_1)}{n_1}$

$\sigma_{\hat{P}_2-\hat{P}_1} = SD[\hat{P}_2 - \hat{P}_1] = \sqrt{\frac{p_2(1-p_2)}{n_2} + \frac{p_1(1-p_1)}{n_1}}$

<u>Sampling distribution of $(\bar{X}_1 - \bar{X}_2)$, independent samples</u>:

$\mu_{\bar{X}_1-\bar{X}_2} = E[\bar{X}_1 - \bar{X}_2] = \mu_1 - \mu_2$

$\sigma_{\bar{X}_1-\bar{X}_2}^2 = V[\bar{X}_1 - \bar{X}_2] = \frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}$

$\sigma_{\bar{X}_1-\bar{X}_2} = SD[\bar{X}_1 - \bar{X}_2] = \sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}$

<u>Sampling distribution of $(\bar{X}_d)$, paired $(d = X_1 - X_2)$</u>:

$\mu_{\bar{X}_d} = E[\bar{X}_d] = \mu_1 - \mu_2$

$\sigma_{\bar{X}_d}^2 = V[\bar{X}_d] = \frac{\sigma_d^2}{n} = \frac{\sigma_1^2+\sigma_2^2-2*\rho*\sigma_1*\sigma_2}{n}$

$\sigma_{\bar{X}_d} = SD[\bar{X}_d] = \frac{\sigma_d}{\sqrt{n}} = \sqrt{\frac{\sigma_1^2+\sigma_2^2-2*\rho*\sigma_1*\sigma_2}{n}}$

<u>Inference about a population proportion</u>:

***z* test statistic:** $z = \frac{\hat{P} - p_0}{\sqrt{\frac{p_0(1-p_0)}{n}}}$ **CI estimator:** $\hat{P} \pm z_{\alpha/2} \sqrt{\frac{\hat{P}(1-\hat{P})}{n}}$

<u>Inference about comparing two population proportions</u>:

***z* test statistic under Null hypothesis of no difference:** $z = \frac{\hat{P}_2 - \hat{P}_1}{\sqrt{\frac{\bar{P}(1-\bar{P})}{n_1} + \frac{\bar{P}(1-\bar{P})}{n_2}}}$ **Pooled proportion:** $\bar{P} = \frac{X_1 + X_2}{n_1 + n_2}$

CI estimator: $(\hat{P}_2 - \hat{P}_1) \pm z_{\alpha/2} \sqrt{\frac{\hat{P}_2(1-\hat{P}_2)}{n_2} + \frac{\hat{P}_1(1-\hat{P}_1)}{n_1}}$

<u>Inference about the population mean</u>:

***t* test statistic:** $t = \frac{\bar{X} - \mu_0}{s/\sqrt{n}}$ **CI estimator:** $\bar{X} \pm t_{\alpha/2} \frac{s}{\sqrt{n}}$ **Degrees of freedom:** $\nu = n - 1$

<u>Inference about a comparing two population means, independent samples, unequal variances</u>:

***t* test statistic:** $t = \frac{(\bar{X}_1 - \bar{X}_2) - \Delta_0}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$ **CI estimator:** $(\bar{X}_1 - \bar{X}_2) \pm t_{\alpha/2} \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$

Degrees of freedom: $\nu = \frac{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)^2}{\frac{1}{n_1 - 1}\left(\frac{s_1^2}{n_1}\right)^2 + \frac{1}{n_2 - 1}\left(\frac{s_2^2}{n_2}\right)^2}$

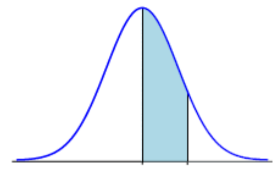
<u>Inference about a comparing two population means, independent samples, assuming equal variances</u>:

***t* test statistic:** $t = \frac{(\bar{X}_1 - \bar{X}_2) - \Delta_0}{\sqrt{\frac{s_p^2}{n_1} + \frac{s_p^2}{n_2}}}$ **CI estimator:** $(\bar{X}_1 - \bar{X}_2) \pm t_{\alpha/2} \sqrt{\frac{s_p^2}{n_1} + \frac{s_p^2}{n_2}}$ **Degrees of freedom:** $\nu = n_1 + n_2 - 2$

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

<u>Inference about a comparing two population means, paired data:</u> (n is number of pairs and $d = X_1 - X_2$)

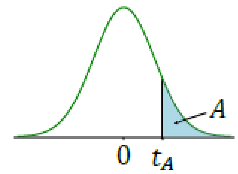
***t* test statistic:** $t = \frac{\bar{d} - \Delta_0}{s_d/\sqrt{n}}$ **CI estimator:** $\bar{X}_d \pm t_{\alpha/2} \frac{s_d}{\sqrt{n}}$ **Degrees of freedom:** $\nu = n - 1$



The Standard Normal Distribution:

	Second decimal place in z									
z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.4767
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.4981
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.4990
3.1	0.4990	0.4991	0.4991	0.4991	0.4992	0.4992	0.4992	0.4992	0.4993	0.4993
3.2	0.4993	0.4993	0.4994	0.4994	0.4994	0.4994	0.4994	0.4995	0.4995	0.4995
3.3	0.4995	0.4995	0.4995	0.4996	0.4996	0.4996	0.4996	0.4996	0.4996	0.4997
3.4	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4998
3.5	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998
3.6	0.4998	0.4998	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999

Aid sheets will *NOT* be collected or graded: write your answers on the test papers.



Critical Values of Student t Distribution:

ν	$t_{0.10}$	$t_{0.05}$	$t_{0.025}$	$t_{0.01}$	$t_{0.005}$	$t_{0.001}$	$t_{0.0005}$	ν	$t_{0.10}$	$t_{0.05}$	$t_{0.025}$	$t_{0.01}$	$t_{0.005}$	$t_{0.001}$	$t_{0.0005}$
1	3.078	6.314	12.71	31.82	63.66	318.3	636.6	38	1.304	1.686	2.024	2.429	2.712	3.319	3.566
2	1.886	2.920	4.303	6.965	9.925	22.33	31.60	39	1.304	1.685	2.023	2.426	2.708	3.313	3.558
3	1.638	2.353	3.182	4.541	5.841	10.21	12.92	40	1.303	1.684	2.021	2.423	2.704	3.307	3.551
4	1.533	2.132	2.776	3.747	4.604	7.173	8.610	41	1.303	1.683	2.020	2.421	2.701	3.301	3.544
5	1.476	2.015	2.571	3.365	4.032	5.893	6.869	42	1.302	1.682	2.018	2.418	2.698	3.296	3.538
6	1.440	1.943	2.447	3.143	3.707	5.208	5.959	43	1.302	1.681	2.017	2.416	2.695	3.291	3.532
7	1.415	1.895	2.365	2.998	3.499	4.785	5.408	44	1.301	1.680	2.015	2.414	2.692	3.286	3.526
8	1.397	1.860	2.306	2.896	3.355	4.501	5.041	45	1.301	1.679	2.014	2.412	2.690	3.281	3.520
9	1.383	1.833	2.262	2.821	3.250	4.297	4.781	46	1.300	1.679	2.013	2.410	2.687	3.277	3.515
10	1.372	1.812	2.228	2.764	3.169	4.144	4.587	47	1.300	1.678	2.012	2.408	2.685	3.273	3.510
11	1.363	1.796	2.201	2.718	3.106	4.025	4.437	48	1.299	1.677	2.011	2.407	2.682	3.269	3.505
12	1.356	1.782	2.179	2.681	3.055	3.930	4.318	49	1.299	1.677	2.010	2.405	2.680	3.265	3.500
13	1.350	1.771	2.160	2.650	3.012	3.852	4.221	50	1.299	1.676	2.009	2.403	2.678	3.261	3.496
14	1.345	1.761	2.145	2.624	2.977	3.787	4.140	51	1.298	1.675	2.008	2.402	2.676	3.258	3.492
15	1.341	1.753	2.131	2.602	2.947	3.733	4.073	52	1.298	1.675	2.007	2.400	2.674	3.255	3.488
16	1.337	1.746	2.120	2.583	2.921	3.686	4.015	53	1.298	1.674	2.006	2.399	2.672	3.251	3.484
17	1.333	1.740	2.110	2.567	2.898	3.646	3.965	54	1.297	1.674	2.005	2.397	2.670	3.248	3.480
18	1.330	1.734	2.101	2.552	2.878	3.610	3.922	55	1.297	1.673	2.004	2.396	2.668	3.245	3.476
19	1.328	1.729	2.093	2.539	2.861	3.579	3.883	60	1.296	1.671	2.000	2.390	2.660	3.232	3.460
20	1.325	1.725	2.086	2.528	2.845	3.552	3.850	65	1.295	1.669	1.997	2.385	2.654	3.220	3.447
21	1.323	1.721	2.080	2.518	2.831	3.527	3.819	70	1.294	1.667	1.994	2.381	2.648	3.211	3.435
22	1.321	1.717	2.074	2.508	2.819	3.505	3.792	75	1.293	1.665	1.992	2.377	2.643	3.202	3.425
23	1.319	1.714	2.069	2.500	2.807	3.485	3.768	80	1.292	1.664	1.990	2.374	2.639	3.195	3.416
24	1.318	1.711	2.064	2.492	2.797	3.467	3.745	90	1.291	1.662	1.987	2.368	2.632	3.183	3.402
25	1.316	1.708	2.060	2.485	2.787	3.450	3.725	100	1.290	1.660	1.984	2.364	2.626	3.174	3.390
26	1.315	1.706	2.056	2.479	2.779	3.435	3.707	120	1.289	1.658	1.980	2.358	2.617	3.160	3.373
27	1.314	1.703	2.052	2.473	2.771	3.421	3.690	140	1.288	1.656	1.977	2.353	2.611	3.149	3.361
28	1.313	1.701	2.048	2.467	2.763	3.408	3.674	160	1.287	1.654	1.975	2.350	2.607	3.142	3.352
29	1.311	1.699	2.045	2.462	2.756	3.396	3.659	180	1.286	1.653	1.973	2.347	2.603	3.136	3.345
30	1.310	1.697	2.042	2.457	2.750	3.385	3.646	200	1.286	1.653	1.972	2.345	2.601	3.131	3.340
31	1.309	1.696	2.040	2.453	2.744	3.375	3.633	250	1.285	1.651	1.969	2.341	2.596	3.123	3.330
32	1.309	1.694	2.037	2.449	2.738	3.365	3.622	300	1.284	1.650	1.968	2.339	2.592	3.118	3.323
33	1.308	1.692	2.035	2.445	2.733	3.356	3.611	400	1.284	1.649	1.966	2.336	2.588	3.111	3.315
34	1.307	1.691	2.032	2.441	2.728	3.348	3.601	500	1.283	1.648	1.965	2.334	2.586	3.107	3.310
35	1.306	1.690	2.030	2.438	2.724	3.340	3.591	750	1.283	1.647	1.963	2.331	2.582	3.101	3.304
36	1.306	1.688	2.028	2.434	2.719	3.333	3.582	1000	1.282	1.646	1.962	2.330	2.581	3.098	3.300
37	1.305	1.687	2.026	2.431	2.715	3.326	3.574	∞	1.282	1.645	1.960	2.326	2.576	3.090	3.291

Degrees of freedom: ν