Read Carefully. Give an answer in the form of a number or numeric expression where possible. Show all calculations. Use a value of 0.05 for any tests if α is not specified. Tables are provided. All multiple choice questions have one correct response unless "circle all that apply" is specified.

1) 2 points each — Indicate the following statements to be (T) or false (F) by **circling** the appropriate letter.

a) T (F) Trial and error are part of the scientific method.

b) T (F) The length of a fish and the height of a tree are examples of qualitative variables.

c) T (F) For a variable Y_i, the sum of the squares is the same as the square of the sum.

d) T (F) Percentiles and quartiles are measures of dispersion.

e) (T) F The midrange is a measure of location or central tendency.

f) (T) F Geometric means and harmonic means result from variable transformations that are back-transformed to the original scale.

g) T (F) All distributions have two separate and independent parameters, the mean and the variance.

h) (T) F For a distribution with a positive skew the mean will be greater than the median.

i) (T) F Deviations of sample observations from the sample mean (e.g. $Y_i - \bar{Y}$) should always sum to zero.

j) T (F) The units on the coefficient of variation (CV) are the units of the first variable per each unit of the second variable.

k) (T) F In “back-transforming” or “detransforming” a transformed variable (e.g. like the Z transformation) the order in which the operations are performed is important.

l) (T) F the units of the standard deviation are the same as for the units on the mean. (eg. if the units are “inches" for the mean they will be “inches” for the standard deviation).

m) T (F) Testing an hypothesis about a population mean by employing a sample (for example, n = 12) involves deductive reasoning.

n) (T) F Although both the Z and t distributions are bell shaped the Z distribution is a normal distribution but the t distribution is not a normal distribution.

All multiple choice questions have **one correct response** unless "circle all that apply" is specified. Indicate your choice by **circling** the letter preceding that response.

2) 4 points — When every individual in the population has an equal chance of being sampled the sample is then termed which of the following?

a) a biased sample

b) a random sample

c) a complete sample

d) a census

3) 4 points — If this question has one correct answer and you randomly choose a response to this question from the 5 options below, what is the probability that you will get the correct answer?

a) 0.01

b) 0.05

c) 0.10

d) 0.20

e) 0.40

4) 4 points — The outcome of tossing a coin is an example of which of the following?

a) a null hypothesis (H_0)

b) a test of hypothesis

c) a Bernoulli trial

d) power

5) 4 points — The knowledge that the sample means will be more nearly normal than the parent distribution comes from which of the following?

a) the null hypothesis (H_0)

b) the central limit theorem

c) the robustness of parametric statistics

d) deductive reasoning

6) 4 points — Which one of the following is NOT true of a Z test of a sample mean if the sample size is increased?

a) we expect the standard deviation to decrease

b) we expect the standard error to decrease

c) we expect the power to increase

d) we expect the probability of a Type I error (α) to decrease

7) 2 points each — Find the probabilities (**to 4 decimal places**) or critical limit values (**to at least 2 decimal places**) indicated by the expressions below. The first problems are Z distribution problems.

a) $P(0.50 \le Z \le 0.96) = ?$ Probability = 0.1400

b) $P(|Z| \le 1.11) = ?$ Probability = 0.7330

c) $P(|Z| \le Z_0) = 0.7960$ Z_0 = 1.27

d) $P(|Z| \ge Z_0) = 0.4840$ Z_0 = 0.70

e) $P(Z \ge Z_0) = 0.7580$ Z_0 = -0.70

f) $P(Z \ge 1.82) = ?$ Probability = 0.0344

g) $P(Z \le -0.81) = ?$ Probability = 0.2090

h) $P(-0.22 \le Z \le 1.22) = ?$ Probability = 0.4759

i) $P(Z \ge -1.645) = ?$ Probability = 0.95

j) $P(Z \le -1.96) = ?$ Probability = 0.025

k) $P(-1.96 \le Z \le Z_0) = 0.9500$ Z_0 = 1.96

t distribution problems follow; find probabilities (**to 3 decimal places**) or critical limit values (**to at least 3 decimal places**)

l) $P(t \leq -1.356) = ?$ d.f. = 12 P value = 0.100

m) $P(|t| \leq 2.921) = ?$ d.f. = 16 P value = 0.99

n) $P(t \geq t_0) = 0.75$ d.f. = 15 t_0 = -0.691

o) $P(t \leq t_0) = 0.20$ d.f. = 100 t_0 = -0.845

p) $P(-t_0 \leq t \leq t_0) = 0.90$ d.f. = 5 t_0 = 2.015

q) $P(-1.093 \leq t \leq t_0) = 0.75$ d.f. = 10 t_0 = 1.372

8) 2 points each — Find the indicated probability or value of Y_0 for the following statements.
Let $\mu = 80$, $\sigma^2 = 36$ and $\sigma = 6$. Where (or if) applicable, n = 36.

a) $P(62 \leq Y \leq 86) = ?$ Probability 0.84

b) $P(Y_0 \leq Y \leq 92) = 0.2515$ Y_0 = 83.6

c) $P(79 \leq \bar{Y} \leq 81) = ?$ Probability 0.6826

The annual maximum rainfall in Sydney, Australia, is said to be equal to 110 mm in published literature. A researcher wants to test the hypothesis ($\alpha = 0.05$) that the maximum rainfall in a given year does indeed average 110 mm (H_0: $\mu_{RAINFALL} = 110$) or determine that it is actually different from 110. He has data for 47 years of observed annual maximum rainfall events and uses two SAS procedures to analyze the data; a proc univariate analysis on the adjusted rainfall value (observed rainfall – 110) and a proc ttest on the unadjusted rainfall value and specifying a hypothesized value of 110.

9) 3 points each — Fill in the blanks to answer the questions below.

a) What is the alternative hypotheses for the test of hypothesis?

H_1: $\mu \neq 110$

b) What are the results of the test of the hypothesis of "no difference"? State a P value for your answer as closely as possible.

P = 0.0107

c) What are the conclusions for this analysis? Circle the number corresponding to the best choice.

(1) Fail to reject the null hypothesis (H_0) and conclude the results are consistent with the null hypothesis

(2) Reject H_0 in favor of the alternative and conclude that rainfall is less than 110 mm.

(3) Reject H_0 in favor of the alternative and conclude that rainfall is greater than 110 mm.

Note: you do not need to know how to write a SAS program for this problem and you do not need to answer any questions about the SAS program. I am giving you the program below in case it may help you to understand the output that follows.

```
TITLE1 'Study of Annual Maximums of Daily Rainfall in Sydney in mm';

DATA Rainfall; INFILE CARDS MISSOVER;
   INPUT Rainfall;
   RainMinus110 = rainfall - 110;
CARDS; RUN;
. . .
;
PROC univariate DATA=Rainfall plot normal; var RainMinus110; RUN;

proc ttest data=Rainfall H0=110; var Rainfall;
   TITLE2 'Proc TTEST on Sidney rainfall';
run;
```

Put your name on this page and be sure to return it with the rest of your exam.

The first part of the output is a partial PROC UNIVARIATE run on the variable RAINFALL – 110;

```
Study of Annual Maximums of Daily Rainfall in Sydney in mm

The UNIVARIATE Procedure
Variable:  RainMinus110

                            Moments
N                         47    Sum Weights                47
Mean              26.9106383    Sum Observations       1264.8
Std Deviation     69.3670177    Variance           4811.78315
Skewness           1.2952471    Kurtosis           2.32593553
Uncorrected SS      255378.6    Corrected SS       221342.025
Coeff Variation   257.768013    Std Error Mean     10.1182194

              Basic Statistical Measures
    Location                    Variability
Mean      26.9106     Std Deviation            69.36702
Median    23.1000     Variance                     4812
Mode     -19.1000     Range                   337.80000
                      Interquartile Range      88.70000

           Tests for Location: Mu0=0
Test           -Statistic-    -----p Value------
Student's t    t  2.659622    Pr > |t|    0.0107
Sign           M       4.5    Pr >= |M|   0.2430
Signed Rank    S     211.5    Pr >= |S|   0.0235
```

The second part of the output is a PROC TTEST run on the raw data variable RAINFALL;

```
Study of Annual Maximums of Daily Rainfall in Sydney in mm
Proc TTEST on Sidney rainfall

The TTEST Procedure

Variable:  Rainfall

  N        Mean     Std Dev     Std Err     Minimum     Maximum
 47       136.9     69.3670     10.1182     45.2000       383.0

  Mean        95% CL Mean       Std Dev      95% CL Std Dev
 136.9        116.5    157.3    69.3670     57.6423  87.1240

  DF    t Value    Pr > |t|
  46       2.66      0.0107
```

Z-tables : Probability of a larger value

	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.00	0.5000	0.4960	0.4920	0.4880	0.4840	0.4801	0.4761	0.4721	0.4681	0.4641
0.10	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
0.20	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
0.30	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
0.40	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
0.50	**0.3085**	**0.3050**	**0.3015**	**0.2981**	**0.2946**	**0.2912**	**0.2877**	**0.2843**	**0.2810**	**0.2776**
0.60	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2483	0.2451
0.70	0.2420	0.2389	0.2358	0.2327	0.2296	0.2266	0.2236	0.2206	0.2177	0.2148
0.80	0.2119	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
0.90	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
1.00	**0.1587**	**0.1562**	**0.1539**	**0.1515**	**0.1492**	**0.1469**	**0.1446**	**0.1423**	**0.1401**	**0.1379**
1.10	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
1.20	0.1151	0.1131	0.1112	0.1093	0.1075	0.1056	0.1038	0.1020	0.1003	0.0985
1.30	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
1.40	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0721	0.0708	0.0694	0.0681
1.50	**0.0668**	**0.0655**	**0.0643**	**0.0630**	**0.0618**	**0.0606**	**0.0594**	**0.0582**	**0.0571**	**0.0559**
1.60	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
1.70	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
1.80	0.0359	0.0351	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
1.90	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
2.00	**0.0228**	**0.0222**	**0.0217**	**0.0212**	**0.0207**	**0.0202**	**0.0197**	**0.0192**	**0.0188**	**0.0183**
2.10	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
2.20	0.0139	0.0136	0.0132	0.0129	0.0125	0.0122	0.0119	0.0116	0.0113	0.0110
2.30	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
2.40	0.0082	0.0080	0.0078	0.0075	0.0073	0.0071	0.0069	0.0068	0.0066	0.0064
2.50	**0.0062**	**0.0060**	**0.0059**	**0.0057**	**0.0055**	**0.0054**	**0.0052**	**0.0051**	**0.0049**	**0.0048**
2.60	0.0047	0.0045	0.0044	0.0043	0.0041	0.0040	0.0039	0.0038	0.0037	0.0036
2.70	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
2.80	0.0026	0.0025	0.0024	0.0023	0.0023	0.0022	0.0021	0.0021	0.0020	0.0019
2.90	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
3.00	**0.0013**	**0.0013**	**0.0013**	**0.0012**	**0.0012**	**0.0011**	**0.0011**	**0.0011**	**0.0010**	**0.0010**
3.10	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
3.20	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
3.30	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
3.40	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002
3.50	**0.0002**	**0.0002**	**0.0002**	**0.0002**	**0.0002**	**0.0002**	**0.0002**	**0.0002**	**0.0002**	**0.0002**
3.60	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
3.70	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
3.80	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
3.90	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4.00	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**

t - tables : Probability of a larger absolute value (two tailed test)

d.f.	***0.500***	***0.400***	***0.300***	***0.200***	***0.100***	***0.050***	***0.020***	***0.010***	***0.002***	***0.001***	***d.f.***
1	1.000	1.376	1.963	3.078	6.314	**12.706**	31.821	**63.656**	318.289	636.578	**1**
2	0.816	1.061	1.386	1.886	2.920	**4.303**	6.965	**9.925**	22.328	31.600	**2**
3	0.765	0.978	1.250	1.638	2.353	**3.182**	4.541	**5.841**	10.214	12.924	**3**
4	0.741	0.941	1.190	1.533	2.132	**2.776**	3.747	**4.604**	7.173	8.610	**4**
5	**0.727**	**0.920**	**1.156**	**1.476**	**2.015**	**2.571**	**3.365**	**4.032**	**5.894**	**6.869**	**5**
6	0.718	0.906	1.134	1.440	1.943	**2.447**	3.143	**3.707**	5.208	5.959	**6**
7	0.711	0.896	1.119	1.415	1.895	**2.365**	2.998	**3.499**	4.785	5.408	**7**
8	0.706	0.889	1.108	1.397	1.860	**2.306**	2.896	**3.355**	4.501	5.041	**8**
9	0.703	0.883	1.100	1.383	1.833	**2.262**	2.821	**3.250**	4.297	4.781	**9**
10	**0.700**	**0.879**	**1.093**	**1.372**	**1.812**	**2.228**	**2.764**	**3.169**	**4.144**	**4.587**	**10**
11	0.697	0.876	1.088	1.363	1.796	**2.201**	2.718	**3.106**	4.025	4.437	**11**
12	0.695	0.873	1.083	1.356	1.782	**2.179**	2.681	**3.055**	3.930	4.318	**12**
13	0.694	0.870	1.079	1.350	1.771	**2.160**	2.650	**3.012**	3.852	4.221	**13**
14	0.692	0.868	1.076	1.345	1.761	**2.145**	2.624	**2.977**	3.787	4.140	**14**
15	**0.691**	**0.866**	**1.074**	**1.341**	**1.753**	**2.131**	**2.602**	**2.947**	**3.733**	**4.073**	**15**
16	0.690	0.865	1.071	1.337	1.746	**2.120**	2.583	**2.921**	3.686	4.015	**16**
17	0.689	0.863	1.069	1.333	1.740	**2.110**	2.567	**2.898**	3.646	3.965	**17**
18	0.688	0.862	1.067	1.330	1.734	**2.101**	2.552	**2.878**	3.610	3.922	**18**
19	0.688	0.861	1.066	1.328	1.729	**2.093**	2.539	**2.861**	3.579	3.883	**19**
20	**0.687**	**0.860**	**1.064**	**1.325**	**1.725**	**2.086**	**2.528**	**2.845**	**3.552**	**3.850**	**20**
21	0.686	0.859	1.063	1.323	1.721	**2.080**	2.518	**2.831**	3.527	3.819	**21**
22	0.686	0.858	1.061	1.321	1.717	**2.074**	2.508	**2.819**	3.505	3.792	**22**
23	0.685	0.858	1.060	1.319	1.714	**2.069**	2.500	**2.807**	3.485	3.768	**23**
24	0.685	0.857	1.059	1.318	1.711	**2.064**	2.492	**2.797**	3.467	3.745	**24**
25	**0.684**	**0.856**	**1.058**	**1.316**	**1.708**	**2.060**	**2.485**	**2.787**	**3.450**	**3.725**	**25**
26	0.684	0.856	1.058	1.315	1.706	**2.056**	2.479	**2.779**	3.435	3.707	**26**
27	0.684	0.855	1.057	1.314	1.703	**2.052**	2.473	**2.771**	3.421	3.689	**27**
28	0.683	0.855	1.056	1.313	1.701	**2.048**	2.467	**2.763**	3.408	3.674	**28**
29	0.683	0.854	1.055	1.311	1.699	**2.045**	2.462	**2.756**	3.396	3.660	**29**
30	**0.683**	**0.854**	**1.055**	**1.310**	**1.697**	**2.042**	**2.457**	**2.750**	**3.385**	**3.646**	**30**
32	0.682	0.853	1.054	1.309	1.694	**2.037**	2.449	**2.738**	3.365	3.622	**32**
34	0.682	0.852	1.052	1.307	1.691	**2.032**	2.441	**2.728**	3.348	3.601	**34**
36	0.681	0.852	1.052	1.306	1.688	**2.028**	2.434	**2.719**	3.333	3.582	**36**
38	0.681	0.851	1.051	1.304	1.686	**2.024**	2.429	**2.712**	3.319	3.566	**38**
40	**0.681**	**0.851**	**1.050**	**1.303**	**1.684**	**2.021**	**2.423**	**2.704**	**3.307**	**3.551**	**40**
45	0.680	0.850	1.049	1.301	1.679	**2.014**	2.412	**2.690**	3.281	3.520	**45**
50	0.679	0.849	1.047	1.299	1.676	**2.009**	2.403	**2.678**	3.261	3.496	**50**
75	0.678	0.846	1.044	1.293	1.665	**1.992**	2.377	**2.643**	3.202	3.425	**75**
100	0.677	0.845	1.042	1.290	1.660	**1.984**	2.364	**2.626**	3.174	3.390	**100**
∞	**0.674**	**0.842**	**1.036**	**1.282**	**1.645**	**1.960**	**2.326**	**2.576**	**3.090**	**3.290**	∞
d.f.	***0.250***	***0.200***	***0.150***	***0.100***	***0.050***	***0.025***	***0.010***	***0.005***	***0.001***	***0.0005***	***d.f.***

t - tables : Probability of a larger value (one tailed test)