

++ADM 2304 – Final Examination
APPLIED STATISTICAL METHODS IN BUSINESS
29 April 2010

NAME (please print): _____

STUDENT NUMBER: _____

SECTION (please circle one): M N P Q R

Time allowed: 3 hours

Question booklet: 10 pages (including front cover)

Appendices: 5 pages of appendices and 5 pages of statistical tables

Instructions:

1. *Complete all tests with hypotheses, test statistic, critical value, decision, and conclusion. Use the .05 level of significance unless otherwise indicated.*
2. Calculators and one sheet of notes (8.5 x 14 in.) are allowed.
3. You must hand back all exam materials (exam question booklet, appendices and tables), but please keep your personal sheet of notes for future use.

Question	Value	Mark
1	8	
2	5	
3	6	
4	13	
5	14	
6	14	
Total	60	

Statement of Academic Integrity

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I have read the text on academic integrity and I pledge not to have committed or attempted to commit academic fraud in this examination.

Signed: _____

Question 2. [5 marks]

The CCAC also decided to look at the client choice of type of bed or room in the long-term facility. Clients are categorized based on if they choose a private bed, a ward bed or are willing to take either. The CCAC hypothesized that there should be no difference between the three hospitals (MON, QCH and TOH) in terms of these choices. The breakdown of data is as follows:

	Private	Ward	Either	Total
MON	216	175	83	474
QCH	275	241	147	663
TOH	444	778	657	1879
Total	935	1194	887	3016

Expected counts are printed below observed counts
 Chi-Square contributions are printed below expected counts

	Private	Ward	Either	Total
1	216	175	83	474
	_____	187.65	139.40	
	_____	0.853	22.821	
2	275	241	147	663
	205.54	262.47	194.99	
	23.474	1.757	11.810	
3	444	778	657	1879
	_____	743.87	_____	
	_____	1.566	_____	
Total	935	1194	887	3016

Determine whether client choice differs by hospital. What is the approximate p-value?

Question 3 [6 marks]

Finally, the CCAC decided to look at preferences among the 28 long-term facilities in the Ottawa region.

The five largest facilities have the following relative capacities, with the 23 smaller facilities sharing the remaining 61% capacity.

PR	11%
GR	8%
SA	8%
PC	6%
GA	6%

The facility preference data were as follows:

Facility	Preference
PR	422
GR	304
SA	293
PC	239
GA	233
Other	2036

- a) Test whether or not the relative preference for each facility is consistent with the relative capacity.

[5]

- b) Is there anything about the relative capacity data to suggest that your conclusion above might be suspect?

[1]

Question 4. [13 marks]

The leading digits of numbers occurring in real life were carefully observed and an empirical law was discovered by a physicist named Benford. For example, the numbers 123, 1056, 12967, 130546 all have ‘1’ as the leading digit.

According to this law, the leading digit ‘1’ occurs 30.6% (and not 11.11% as expected) of the times in numbers occurring in real life. The other digits also have different percentage values according to this law. In this question only the leading digit ‘1’ is considered.

Forensic auditors use Benford’s law to flag tax returns which **could** be fraudulent. In a comparison of two samples of tax returns, the following data were obtained. Sample#1 was a simple random sample of typical high income tax returns and Sample#2 was a simple random sample of typical middle income tax returns. Suspected frauds are the returns which need auditing and in this example are based on the relative frequency of leading digit ‘1’ being other than $0.306 \pm .030$.

	Sample #1 (high income)	Sample #2 (middle income)
X- Suspected number of frauds:	60	30
n - Total number Tax Returns:	450	500

- a) From the above data, test the hypothesis that the population proportion of suspected fraudulent high income tax returns is greater than 11.5%. Use a level of significance of 5%.

[3]

- b) For the above test, we assume that _____ is normally distributed. To determine whether this is valid, we check if

_____ .

[2] (Fill in the blanks above.)

c) Calculate a one-sided 95% confidence interval or the 'bound' for the population proportion which is appropriate for the test in (a).
[2]

d) How big a sample of middle income returns would we need if we wanted to calculate a 95% confidence interval with a margin of error of plus-or-minus 1%?
[2]

e) Now test the hypothesis that the two population proportions are different. Use a 5% level of significance.
[4]

Question 5. [14 marks]

A large electronic service company collected data on the 'Training Time' (in days) given to its technicians and the 'Time' (in minutes) required to repair different types of defective equipment. The equipment types are 'E1:Fax Machines', 'E2:Photo-Copiers', 'E3: Computers', and 'E4: Televisions'.

The relevant data and Minitab output are given in Appendix B. Perform all tests using the .05 level of significance.

- a) Complete the ANOVA table up to the 'MS' Column.

[3]

Source	DF	SS	MS
TrainingTime		593.06	
Equipment		2396.53	
Interaction		418.06	
Error	24	1683.33	70.139
Total		5090.97	

- b) What is the estimated standard deviation "s" of the error terms?

[1]

- c) Calculate the adjusted R^2 .

[1]

- d) Comment on the presence or absence of interaction, based on the plot. Explain briefly.

[1]

e) Test whether the effect of training time on service time depends on the equipment type.
[3]

f) Calculate the margin of error for comparing average service times on different equipment types, using the Bonferroni method of multiple comparisons. Use the closest critical value on the appropriate table.
[3]

g) Explain if there is a real difference in the average service time comparing technicians working on TVs with those working on computers, or between fax machines and photocopiers.
[2]

Question 6. [14 marks]

The objective of the Study on the Efficacy of Nosocomial Infection Control (SENIC Project, **American Journal of Epidemiology** 111 (1980), p. 465-653) was to determine whether infection surveillance and control programs have reduced the rates of nosocomial (hospital-acquired) infection in hospitals. The analyses are found in Appendix C.

The variables are:

ID	Identification number of hospital
LoS	Average Length of Stay (days)
Age	Average age of patients (years)
InfectRisk	Average estimated probability of acquiring infection in hospital (percentage)
CultRat	Ratio of number of cultures to number of patients without hospital-acquired infection (percentage)
XrayRat	Ratio of number of X-rays to number of patients without pneumonia (percentage)
NumBeds	Average number of beds
MedSch	1 – if hospital is associated with a medical school, 0 -- otherwise
West	1 – if hospital is in the West Region, 0 -- otherwise
AvgCens	Average number of patients per day during study period
NumbNurses	Average number of nurses
Available	Percentage of 35 potential services and services provided by hospital

- a) Looking at the residual plot from Model 1, what potential problem do you see with the regression model assumptions? What assumption might be violated?

[1]

- b) Has this problem been solved in Model 2? Explain briefly.

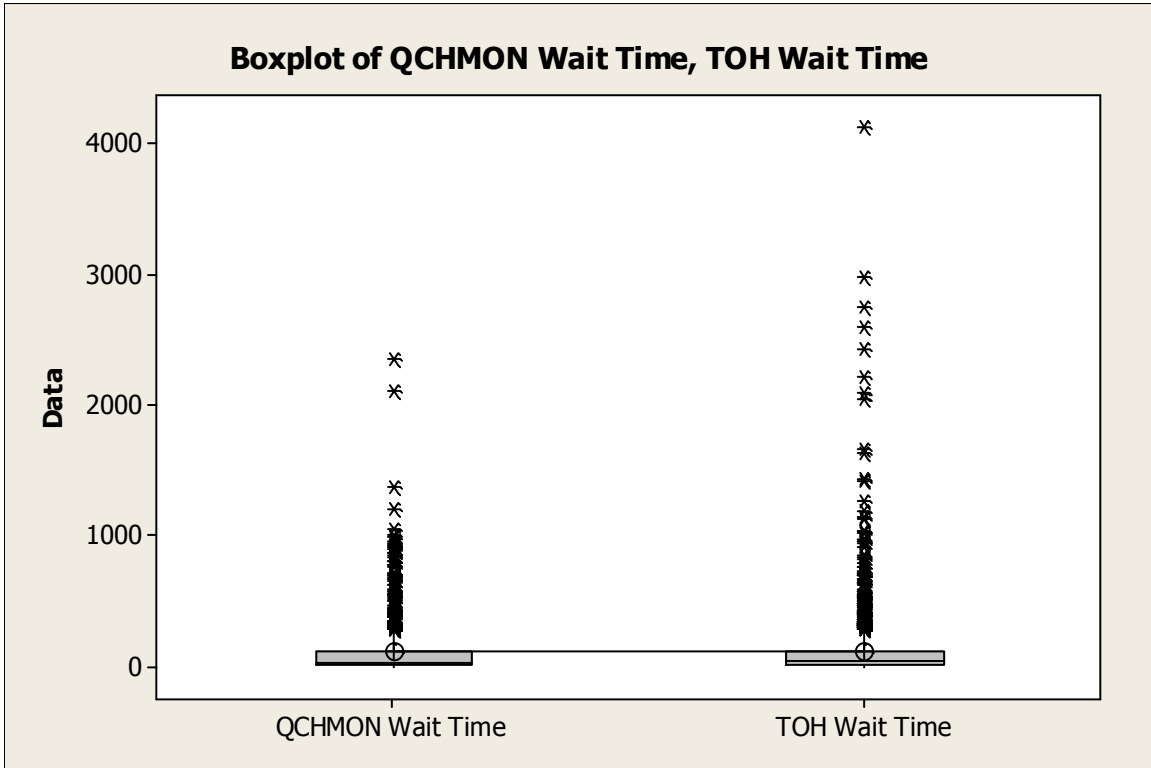
[1]

- c) Test whether Model 2 is helpful for predicting the Infection Risk.

[3]

- d) Test whether the ratio of the number of cultures to the number of patients without hospital-acquired infection has an effect on the Infection Risk.
[3]
- e) How would you interpret the value of the coefficient of the West variable?
[2]
- f) Why might the interpretation of the number of beds coefficient be problematic?
[1]
- g) Using Model 2, calculate the **99%** interval for predicting the infection rate for the outlying hospital that was dropped from Model 1 to Model 2. Does this interval cover the actual infection rate for this hospital?
[3]

Appendix A



Two-Sample T-Test and CI: QCHMON Wait Time, TOH Wait Time

Two-sample T for QCHMON Wait Time vs TOH Wait Time

	N	Mean	StDev	SE Mean
QCHMON Wait Time	783	115	217	7.8
TOH Wait Time	1374	124	270	7.3

Mann-Whitney Test and CI: QCHMON Wait Time, TOH Wait Time

	N	Median
QCHMON Wait Time	783	33.00
TOH Wait Time	1374	41.00

Point estimate for ETA1-ETA2 is -2.00

95.0 Percent CI for ETA1-ETA2 is (-4.00,1.01)

W = 827270.0

Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.2061

The test is significant at 0.2061 (adjusted for ties)

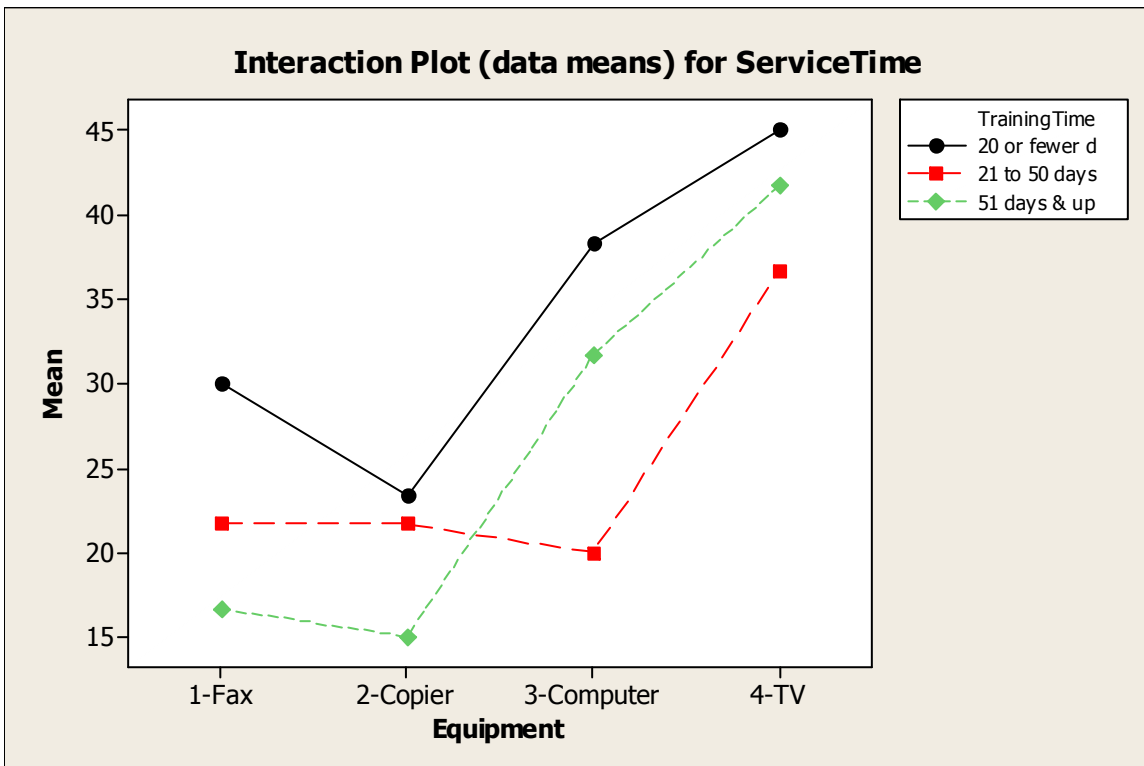
Appendix B

Tabulated statistics: TrainingTime, Equipment

Rows: TrainingTime Columns: Equipment

	1-Fax	2-Copier	3-Computer	4-TV	All
20 or fewer d	30.00	23.33	38.33	45.00	34.17
	25	20	30	50	
	30	20	45	45	
	35	30	40	40	
21 to 50 days	21.67	21.67	20.00	36.67	25.00
	20	10	20	15	
	25	30	10	50	
	20	25	30	45	
51 days & up	16.67	15.00	31.67	41.67	26.25
	25	10	25	40	
	10	15	35	40	
	15	20	35	45	
All	22.78	20.00	30.00	41.11	28.47

Cell Contents: ServiceTime : Mean
 ServiceTime : DATA



Appendix C

The following table shows an extract of the data:

ID	Infect Risk	Culture Rat	Xray Rat	Num Beds	Med Sch	Avg Cens	Numb Nurses	Avail-able	LoS	Age	West
51	5.6	20.3	82	252	0	207	251	51.4	11.48	57.6	0
52	4.3	11.6	42.6	620	0	413	420	71.4	9.23	51.6	0
53	7.6	16.6	97.9	535	0	330	273	51.4	11.41	61.1	0
54	7.8	52.4	105.3	157	0	115	76	31.4	12.07	43.7	0
55	3.1	8.4	56.2	76	0	39	44	31.4	8.63	54	0

Model 1.

Regression Analysis: InfectRisk versus CultRat, XrayRat, ...

The regression equation is

$$\text{InfectRisk} = -0.93 + 0.0514 \text{ CultRat} + 0.0113 \text{ XrayRat} - 0.00249 \text{ NumBeds} - 0.618 \text{ MedSch} + 0.00317 \text{ AvgCens} + 0.00148 \text{ NumbNurses} + 0.0180 \text{ Available} + 0.215 \text{ LoS} + 0.0084 \text{ Age} + 0.811 \text{ West}$$

Predictor	Coef	SE Coef	T	P	VIF
Constant	-0.931	1.159	-0.80	0.424	
CultRat	0.05136	0.01042			1.5
XrayRat	0.011322	0.005251	2.16	0.033	1.4
NumBeds	-0.002492	0.002619	-0.95	0.344	34.0
MedSch	-0.6181	0.3199	-1.93	0.056	1.8
AvgCens	0.003169	0.003424	0.93	0.357	36.9
NumbNurses	0.001477	0.001690	0.87	0.384	7.4
Available	0.017974	0.009784	1.84	0.069	2.9
LoS	0.21457	0.06748	3.18	0.002	2.2
Age	0.00843	0.02143	0.39	0.695	1.2
West	0.8107	0.2678	3.03	0.003	1.2

S = 0.917301 R-Sq = 57.4% R-Sq(adj) = 53.2%

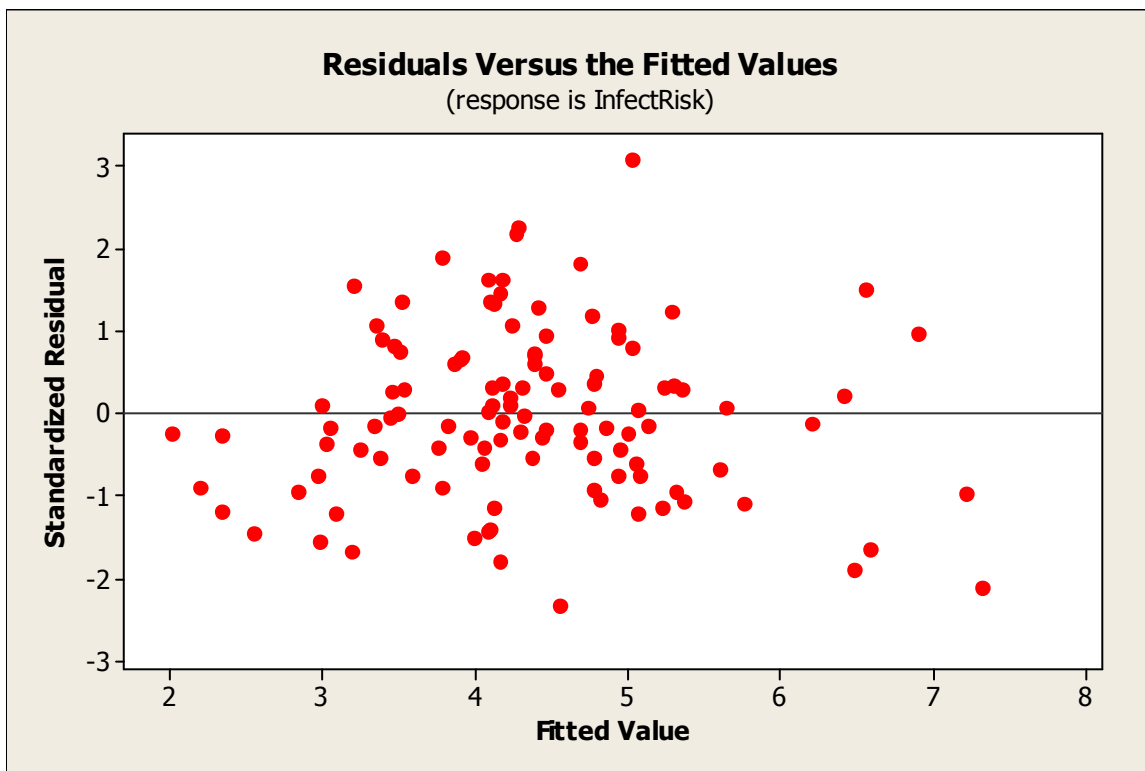
Analysis of Variance

Source	DF	SS	MS	F	P
Regression	10	115.553	11.555	13.73	
Residual Error	102	85.827	0.841		
Total	112	201.380			

Unusual Observations

Obs	CultRat	InfectRisk	Fit	SE Fit	Residual	St Resid
8	60.5	5.4000	6.5935	0.5612	-1.1935	-1.64 X
35	11.4	6.3000	4.2827	0.1733	2.0173	2.24R
47	17.2	6.5000	7.2222	0.5407	-0.7222	-0.97 X
53	16.6	7.6000	5.0330	0.3757	2.5670	3.07R
96	27.0	2.5000	4.5638	0.2312	-2.0638	-2.32R
100	16.4	6.2000	4.2744	0.2592	1.9256	2.19R
112	26.4	5.9000	7.3268	0.6214	-1.4268	-2.11RX

R denotes an observation with a large standardized residual.
 X denotes an observation whose X value gives it large influence.



Model 2.

Regression Analysis: InfectRisk versus CultRat, XrayRat, ...

The regression equation is

$$\begin{aligned} \text{InfectRisk} = & -0.22 + 0.0513 \text{ CultRat} + 0.00993 \text{ XrayRat} - 0.00534 \text{ NumBeds} \\ & - 0.563 \text{ MedSch} + 0.00599 \text{ AvgCens} + 0.00183 \text{ NumbNurses} \\ & + 0.0210 \text{ Available} + 0.203 \text{ LoS} - 0.0016 \text{ Age} + 0.840 \text{ West} \end{aligned}$$

112 cases used, 1 cases contain missing values

Predictor	Coef	SE Coef	T	P	VIF
Constant	-0.220	1.132	-0.19	0.846	
CultRat	0.051314	0.009979			1.5
XrayRat	0.009931	0.005047	1.97	0.052	1.4
NumBeds	-0.005342	0.002661	-2.01	0.047	37.5
MedSch	-0.5627	0.3067	-1.83	0.070	1.8
AvgCens	0.005991	0.003395	1.76	0.081	39.3
NumbNurses	0.001828	0.001622	1.13	0.263	7.4
Available	0.020985	0.009415	2.23	0.028	3.0
LoS	0.20277	0.06471	3.13	0.002	2.2
Age	-0.00162	0.02076	-0.08	0.938	1.2
West	0.8405	0.2566	3.28	0.001	1.2

S = 0.878282 R-Sq = 59.2% R-Sq(adj) = 55.1%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	10	112.846	11.285	14.63	_____
Residual Error	101	77.909	0.771		
Total	111	190.755			

Unusual Observations

Obs	CultRat	InfectRisk	Fit	SE Fit	Residual	St Resid
8	60.5	5.4000	6.2556	0.5475	-0.8556	-1.25 X
35	11.4	6.3000	4.2996	0.1660	2.0004	2.32R
47	17.2	6.5000	7.0551	0.5203	-0.5551	-0.78 X
96	27.0	2.5000	4.5399	0.2215	-2.0399	-2.40R
100	16.4	6.2000	4.2927	0.2483	1.9073	2.26R
112	26.4	5.9000	7.3727	0.5951	-1.4727	-2.28RX

R denotes an observation with a large standardized residual.
 X denotes an observation whose X value gives it large influence.

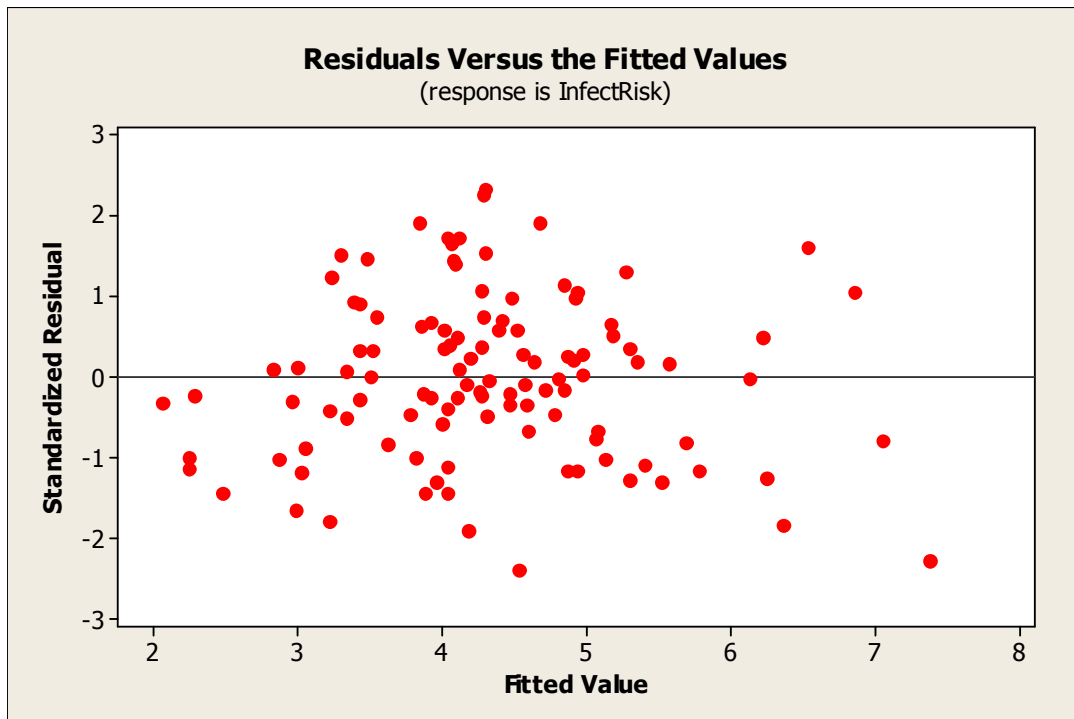
Predicted Values for New Observations

New Obs	Fit	SE Fit	95% CI	95% PI
1	4.5155	0.3943	(3.7333, 5.2978)	(2.6057, 6.4254)

Values of Predictors for New Observations

New Obs	CultRat	XrayRat	NumBeds	MedSch	AvgCens	NumNurses	Available	LoS
1	16.6	97.9	535	0.000000	330	273	51.4	11.4

New Obs	Age	West
1	61.1	0.000000



Standard Normal Distribution

P(Z < z) (z negative)										
Second decimal place in z										
0.09	0.08	0.07	0.06	0.05	0.04	0.03	0.02	0.01	0.00	z
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-3.9
0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	-3.8
0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	-3.7
0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	-3.6
0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	-3.5
0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	-3.4
0.0003	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	-3.3
0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0006	0.0007	0.0007	-3.2
0.0007	0.0007	0.0008	0.0008	0.0008	0.0008	0.0009	0.0009	0.0009	0.0010	-3.1
0.0010	0.0010	0.0011	0.0011	0.0011	0.0012	0.0012	0.0013	0.0013	0.0013	-3.0
0.0014	0.0014	0.0015	0.0015	0.0016	0.0016	0.0017	0.0018	0.0018	0.0019	-2.9
0.0019	0.0020	0.0021	0.0021	0.0022	0.0023	0.0023	0.0024	0.0025	0.0026	-2.8
0.0026	0.0027	0.0028	0.0029	0.0030	0.0031	0.0032	0.0033	0.0034	0.0035	-2.7
0.0036	0.0037	0.0038	0.0039	0.0040	0.0041	0.0043	0.0044	0.0045	0.0047	-2.6
0.0048	0.0049	0.0051	0.0052	0.0054	0.0055	0.0057	0.0059	0.0060	0.0062	-2.5
0.0064	0.0066	0.0068	0.0069	0.0071	0.0073	0.0075	0.0078	0.0080	0.0082	-2.4
0.0084	0.0087	0.0089	0.0091	0.0094	0.0096	0.0099	0.0102	0.0104	0.0107	-2.3
0.0110	0.0113	0.0116	0.0119	0.0122	0.0125	0.0129	0.0132	0.0136	0.0139	-2.2
0.0143	0.0146	0.0150	0.0154	0.0158	0.0162	0.0166	0.0170	0.0174	0.0179	-2.1
0.0183	0.0188	0.0192	0.0197	0.0202	0.0207	0.0212	0.0217	0.0222	0.0228	-2.0
0.0233	0.0239	0.0244	0.0250	0.0256	0.0262	0.0268	0.0274	0.0281	0.0287	-1.9
0.0294	0.0301	0.0307	0.0314	0.0322	0.0329	0.0336	0.0344	0.0351	0.0359	-1.8
0.0367	0.0375	0.0384	0.0392	0.0401	0.0409	0.0418	0.0427	0.0436	0.0446	-1.7
0.0455	0.0465	0.0475	0.0485	0.0495	0.0505	0.0516	0.0526	0.0537	0.0548	-1.6
0.0559	0.0571	0.0582	0.0594	0.0606	0.0618	0.0630	0.0643	0.0655	0.0668	-1.5
0.0681	0.0694	0.0708	0.0721	0.0735	0.0749	0.0764	0.0778	0.0793	0.0808	-1.4
0.0823	0.0838	0.0853	0.0869	0.0885	0.0901	0.0918	0.0934	0.0951	0.0968	-1.3
0.0985	0.1003	0.1020	0.1038	0.1056	0.1075	0.1093	0.1112	0.1131	0.1151	-1.2
0.1170	0.1190	0.1210	0.1230	0.1251	0.1271	0.1292	0.1314	0.1335	0.1357	-1.1
0.1379	0.1401	0.1423	0.1446	0.1469	0.1492	0.1515	0.1539	0.1562	0.1587	-1.0
0.1611	0.1635	0.1660	0.1685	0.1711	0.1736	0.1762	0.1788	0.1814	0.1841	-0.9
0.1867	0.1894	0.1922	0.1949	0.1977	0.2005	0.2033	0.2061	0.2090	0.2119	-0.8
0.2148	0.2177	0.2206	0.2236	0.2266	0.2296	0.2327	0.2358	0.2389	0.2420	-0.7
0.2451	0.2483	0.2514	0.2546	0.2578	0.2611	0.2643	0.2676	0.2709	0.2743	-0.6
0.2776	0.2810	0.2843	0.2877	0.2912	0.2946	0.2981	0.3015	0.3050	0.3085	-0.5
0.3121	0.3156	0.3192	0.3228	0.3264	0.3300	0.3336	0.3372	0.3409	0.3446	-0.4
0.3483	0.3520	0.3557	0.3594	0.3632	0.3669	0.3707	0.3745	0.3783	0.3821	-0.3
0.3859	0.3897	0.3936	0.3974	0.4013	0.4052	0.4090	0.4129	0.4168	0.4207	-0.2
0.4247	0.4286	0.4325	0.4364	0.4404	0.4443	0.4483	0.4522	0.4562	0.4602	-0.1
0.4641	0.4681	0.4721	0.4761	0.4801	0.4840	0.4880	0.4920	0.4960	0.5000	0.0

Standard Normal Distribution

P(Z < z) (z positive)
 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	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.3	0.9995	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9997
3.4	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998
3.5	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998
3.6	0.9998	0.9998	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999
3.7	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999
3.8	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999
3.9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Student's t distribution

Φ	t_{Φ}									
	$\Phi = P(t > t_{\Phi})$									
	0.050	0.025	0.010	0.008	0.005	0.004	0.003	0.002	0.001	0.0004
1	6.31	12.71	31.82	39.78	63.66	79.57	106.10	159.15	318.31	795.77
2	2.92	4.30	6.96	7.81	9.92	11.11	12.85	15.76	22.33	35.33
3	2.35	3.18	4.54	4.93	5.84	6.32	6.99	8.05	10.21	13.94
4	2.13	2.78	3.75	4.01	4.60	4.91	5.32	5.95	7.17	9.13
5	2.02	2.57	3.36	3.57	4.03	4.26	4.57	5.03	5.89	7.21
6	1.94	2.45	3.14	3.32	3.71	3.90	4.15	4.52	5.21	6.22
7	1.89	2.36	3.00	3.16	3.50	3.67	3.89	4.21	4.79	5.62
8	1.86	2.31	2.90	3.04	3.36	3.51	3.70	3.99	4.50	5.22
9	1.83	2.26	2.82	2.96	3.25	3.39	3.57	3.83	4.30	4.94
10	1.81	2.23	2.76	2.89	3.17	3.30	3.47	3.72	4.14	4.73
11	1.80	2.20	2.72	2.84	3.11	3.23	3.39	3.62	4.02	4.57
12	1.78	2.18	2.68	2.80	3.05	3.17	3.33	3.55	3.93	4.44
13	1.77	2.16	2.65	2.77	3.01	3.13	3.28	3.49	3.85	4.34
14	1.76	2.14	2.62	2.74	2.98	3.09	3.23	3.44	3.79	4.26
15	1.75	2.13	2.60	2.71	2.95	3.06	3.20	3.39	3.73	4.18
16	1.75	2.12	2.58	2.69	2.92	3.03	3.17	3.36	3.69	4.12
17	1.74	2.11	2.57	2.67	2.90	3.00	3.14	3.33	3.65	4.07
18	1.73	2.10	2.55	2.66	2.88	2.98	3.11	3.30	3.61	4.02
19	1.73	2.09	2.54	2.64	2.86	2.96	3.09	3.27	3.58	3.98
20	1.72	2.09	2.53	2.63	2.85	2.95	3.07	3.25	3.55	3.95
21	1.72	2.08	2.52	2.62	2.83	2.93	3.06	3.23	3.53	3.91
22	1.72	2.07	2.51	2.61	2.82	2.92	3.04	3.21	3.50	3.88
23	1.71	2.07	2.50	2.60	2.81	2.90	3.03	3.20	3.48	3.86
24	1.71	2.06	2.49	2.59	2.80	2.89	3.01	3.18	3.47	3.83
25	1.71	2.06	2.49	2.58	2.79	2.88	3.00	3.17	3.45	3.81
26	1.71	2.06	2.48	2.58	2.78	2.87	2.99	3.16	3.43	3.79
27	1.70	2.05	2.47	2.57	2.77	2.86	2.98	3.15	3.42	3.78
28	1.70	2.05	2.47	2.56	2.76	2.86	2.97	3.14	3.41	3.76
29	1.70	2.05	2.46	2.56	2.76	2.85	2.96	3.13	3.40	3.74
30	1.70	2.04	2.46	2.55	2.75	2.84	2.96	3.12	3.39	3.73
31	1.70	2.04	2.45	2.55	2.74	2.83	2.95	3.11	3.37	3.72
32	1.69	2.04	2.45	2.54	2.74	2.83	2.94	3.10	3.37	3.70
33	1.69	2.03	2.44	2.54	2.73	2.82	2.94	3.09	3.36	3.69
34	1.69	2.03	2.44	2.54	2.73	2.82	2.93	3.09	3.35	3.68
35	1.69	2.03	2.44	2.53	2.72	2.81	2.93	3.08	3.34	3.67
36	1.69	2.03	2.43	2.53	2.72	2.81	2.92	3.08	3.33	3.66
37	1.69	2.03	2.43	2.52	2.72	2.80	2.92	3.07	3.33	3.65
38	1.69	2.02	2.43	2.52	2.71	2.80	2.91	3.06	3.32	3.64
39	1.68	2.02	2.43	2.52	2.71	2.80	2.91	3.06	3.31	3.64
40	1.68	2.02	2.42	2.52	2.70	2.79	2.90	3.05	3.31	3.63
50	1.68	2.01	2.40	2.49	2.68	2.76	2.87	3.02	3.26	3.57
100	1.66	1.98	2.36	2.45	2.63	2.71	2.81	2.95	3.17	3.46
200	1.65	1.97	2.35	2.43	2.60	2.68	2.78	2.91	3.13	3.40
1000	1.65	1.96	2.33	2.41	2.58	2.66	2.75	2.88	3.10	3.36

Chi-Square Distribution

v	χ^2_{α}									
	$\alpha = P(\chi^2 \geq \chi^2_{\alpha})$									
	0.100	0.050	0.025	0.010	0.005	0.001	0.0001	0.00001	0.000001	0.0000005
1	2.71	3.84	5.02	6.63	7.88	10.83	15.14	19.51	23.93	25.26
2	4.61	5.99	7.38	9.21	10.60	13.82	18.42	23.03	27.63	29.02
3	6.25	7.81	9.35	11.34	12.84	16.27	21.11	25.90	30.66	32.09
4	7.78	9.49	11.14	13.28	14.86	18.47	23.51	28.47	33.38	34.84
5	9.24	11.07	12.83	15.09	16.75	20.52	25.74	30.86	35.89	37.39
6	10.64	12.59	14.45	16.81	18.55	22.46	27.86	33.11	38.26	39.79
7	12.02	14.07	16.01	18.48	20.28	24.32	29.88	35.26	40.52	42.09
8	13.36	15.51	17.53	20.09	21.95	26.12	31.83	37.33	42.70	44.30
9	14.68	16.92	19.02	21.67	23.59	27.88	33.72	39.34	44.81	46.43
10	15.99	18.31	20.48	23.21	25.19	29.59	35.56	41.30	46.86	48.51
11	17.28	19.68	21.92	24.72	26.76	31.26	37.37	43.21	48.87	50.54
12	18.55	21.03	23.34	26.22	28.30	32.91	39.13	45.08	50.83	52.53
13	19.81	22.36	24.74	27.69	29.82	34.53	40.87	46.91	52.75	54.47
14	21.06	23.68	26.12	29.14	31.32	36.12	42.58	48.72	54.64	56.38
15	22.31	25.00	27.49	30.58	32.80	37.70	44.26	50.49	56.49	58.26
16	23.54	26.30	28.85	32.00	34.27	39.25	45.92	52.24	58.32	60.12
17	24.77	27.59	30.19	33.41	35.72	40.79	47.57	53.97	60.13	61.95
18	25.99	28.87	31.53	34.81	37.16	42.31	49.19	55.68	61.91	63.75
19	27.20	30.14	32.85	36.19	38.58	43.82	50.80	57.37	63.68	65.53
20	28.41	31.41	34.17	37.57	40.00	45.31	52.39	59.04	65.42	67.30
21	29.62	32.67	35.48	38.93	41.40	46.80	53.96	60.70	67.15	69.04
22	30.81	33.92	36.78	40.29	42.80	48.27	55.52	62.34	68.86	70.77
23	32.01	35.17	38.08	41.64	44.18	49.73	57.07	63.97	70.55	72.48
24	33.20	36.42	39.36	42.98	45.56	51.18	58.61	65.58	72.23	74.18
25	34.38	37.65	40.65	44.31	46.93	52.62	60.14	67.18	73.89	75.86
26	35.56	38.89	41.92	45.64	48.29	54.05	61.66	68.77	75.55	77.54
27	36.74	40.11	43.19	46.96	49.64	55.48	63.16	70.35	77.19	79.19
28	37.92	41.34	44.46	48.28	50.99	56.89	64.66	71.92	78.82	80.84
29	39.09	42.56	45.72	49.59	52.34	58.30	66.15	73.47	80.44	82.48
30	40.26	43.77	46.98	50.89	53.67	59.70	67.63	75.02	82.04	84.10
35	46.06	49.80	53.20	57.34	60.27	66.62	74.93	82.64	89.95	92.08
40	51.81	55.76	59.34	63.69	66.77	73.40	82.06	90.08	97.65	99.86
50	63.17	67.50	71.42	76.15	79.49	86.66	95.97	104.54	112.61	114.96
100	118.50	124.34	129.56	135.81	140.17	149.45	161.32	172.10	182.13	185.03
150	172.58	179.58	185.80	193.21	198.36	209.26	223.11	235.60	247.15	250.48
200	226.02	233.99	241.06	249.45	255.26	267.54	283.06	297.00	309.84	313.53
224	251.52	259.91	267.35	276.16	282.27	295.14	311.39	325.96	339.36	343.22
250	279.05	287.88	295.69	304.94	311.35	324.83	341.83	357.04	371.02	375.04
500	540.93	553.13	563.85	576.49	585.21	603.45	626.24	646.48	664.96	670.25

Fisher's F distribution

F_{.05}
P(F ≥ F_{.05}) = 0.050
v₁

v₂	1	2	3	4	5	6	7	8	9	10	11	12
1	161.4	199.5	215.7	224.6	230.2	234.0	236.8	238.9	240.5	241.9	243.0	243.9
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38	19.40	19.40	19.41
3	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.76	8.74
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.94	5.91
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.70	4.68
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.03	4.00
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.60	3.57
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.31	3.28
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.10	3.07
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.94	2.91
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85	2.82	2.79
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75	2.72	2.69
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	2.63	2.60
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	2.57	2.53
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.51	2.48
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.31	2.28
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37	2.32	2.28	2.25
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30	2.26	2.23
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32	2.27	2.24	2.20
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.25	2.22	2.18
25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28	2.24	2.20	2.16
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.13	2.09
31	4.16	3.30	2.91	2.68	2.52	2.41	2.32	2.25	2.20	2.15	2.11	2.08
32	4.15	3.29	2.90	2.67	2.51	2.40	2.31	2.24	2.19	2.14	2.10	2.07
33	4.14	3.28	2.89	2.66	2.50	2.39	2.30	2.23	2.18	2.13	2.09	2.06
34	4.13	3.28	2.88	2.65	2.49	2.38	2.29	2.23	2.17	2.12	2.08	2.05
35	4.12	3.27	2.87	2.64	2.49	2.37	2.29	2.22	2.16	2.11	2.07	2.04
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08	2.04	2.00
50	4.03	3.18	2.79	2.56	2.40	2.29	2.20	2.13	2.07	2.03	1.99	1.95
100	3.94	3.09	2.70	2.46	2.31	2.19	2.10	2.03	1.97	1.93	1.89	1.85
200	3.89	3.04	2.65	2.42	2.26	2.14	2.06	1.98	1.93	1.88	1.84	1.80