Grad Stats Final Exam **Fall, 2001**
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There are three major questions on this final. As usual, each sub-question is worth 3 points.

Question A

There is growing concern about the usefulness and appropriateness of using standardized tests such as the SAT for making college admissions decisions. This issue is discussed in an article in this week's *New Yorker* magazine:

> "Drawing on the transcripts of seventy-eight thousand University of California freshmen from 1996 through 1999, the report found that, over all, the most useful statistic in predicting freshman grades was the SAT II [the so-called "achievement" tests], which explained sixteen percent of the "variance" (which is another measure of predictive validity) [in freshmen GPA]. The second most useful was high-school GPA, at 15.4 percent. The SAT [the "aptitude" test] was the least useful, at 13.3 per cent. Combining high-school GPA and the SAT II ["achievement"] explained 22.2 percent of the variance in freshman grades. Adding in SAT scores increased that number by only 0.1 percent. Nor was the SAT better at what one would have thought was its strong suit: identifying high-potential students from bad schools. [12/17/2001, p. 88]

Suppose that we did a similar study at our university and the following variables were available for a number of students:

GPA	freshman GPA (0 to 4 with a mean of 2.85)
SAT	score on the regular or "aptitude" SAT test (40 to 160 with a mean of 110)
ACH	score on the SAT II or "achievement" tests (40 to 160 with a mean of 115)
HSGPA	high-school GPA (0 to 4 with a mean of 3.22)
QUAL	a measure of high-school quality (0 to 10)
SEX	"male" and "female"
ETH	ethnicity with categories "White," "African-American," "Asian-American," and "Hispanic"

Answer the following questions, specifying any new variables you need to create.

1. "The second most useful [predictor of freshman GPA] was high-school GPA, at 15.4 per cent." Specify the MODEL A/C pair we would use to assess whether high-school GPA predicts freshman GPA at our university, ignoring all other variables. [Note: Ignore the

"second most" part of quotation. Also, we are not asking whether GPA explains 15.4 per cent at our university, just whether it is predictive.]

2. If we wanted to have 90 per cent power for detecting an effect of that magnitude (i.e., 15.4 percent), about how many student transcripts would we need to include in our study?

3. "Combining high-school GPA and the SAT II [achievement] explained 22.2 per cent of the variance in freshman grades." Specify the MODEL A/C pair we would use to test whether these two predict in our study.

4. "Adding in SAT [aptitude] scores increased that number by only 0.1 per cent." Specify the MODEL A/C pair we would use to check whether adding SAT [aptitude] contributes in our study. [Note: the 0.1 per cent is not a PRE; extra credit for converting it to a PRE]

5. "Nor was the SAT better at what one would have thought was its strong suit: identifying high-potential students from bad schools." I found this statement to be ambiguous (after all, it is a journalist writing the news summary and not a statistician). One interpretation might be that the statement in (4) above is not improved when asking the question within levels of high-school quality. What MODEL A/C pair would we use to address that question in our data?

6. Another interpretation is that SAT might be differentially useful depending on school quality. That is, SAT might be a very useful predictor of freshman GPA for students coming from poor schools that did not provide the courses necessary for their students to score well on achievement tests but SAT would not be a useful predictor for students coming from high-quality schools. For simplicity, ignore the other variables (ACH and HSGPA) and specify the MODEL A/C pair we would use in this case.

7. We will now go beyond the California study to consider some other questions we might want to answer with our data. The Dean would like to know whether the freshman GPA average of 2.85 is significantly below the typical GPA of 3.02 for graduating students. Assuming that ACH and HSGPA turn out to be useful predictors of freshman GPA as they did in the California study, specify the MODEL A/C comparison for answering the Dean's question in the most powerful way.

8. From now on, use the fewest variables possible to answer the question. One possibility is that the SAT might not be a good predictor of GPA for students with low SAT scores because some (but not all) of those students might still do well by working very hard; and that SAT might become an increasingly good predictor as SAT scores go up. Specify the MODEL A/C pair to address this question. Sketch the graph of MODEL A consistent with the hypothesis and indicate the sign for each regression coefficient in the model.

9. Assuming the above hypothesis were correct, specify a MODEL A/C pair to test whether SAT is a significant predictor of freshman GPA for students with average SAT scores.

10. Ignoring SAT, specify the MODEL A/C pair that would test for any differences in mean freshman GPA by ethnicity. You may want to read the following question before deciding on your codes. Use the same set of codes for both questions.

11. Specify the MODEL A/C pair that tests whether the SAT is more predictive of freshman GPA for whites than for minorities?

12. Assuming that SAT is differentially predictive for whites and minorities, the Civil Rights Commission specifically would like to know whether the SAT is significantly predictive of the freshman GPAs for African-American students. Specify the necessary MODEL A/C pair. This may require codes that are neither orthogonal nor contrasts. And it may be a difficult question so don't get stuck on it.

Question B

A group of researchers wants to test the controversial hypothesis that drinking alcohol interferes with math ability. Specifically, they want to test for a linear relationship between alcohol consumption and performance on a 15-item math test. Participants are randomly assigned to drink one, two or three pints of beer before taking the test. Below are the n's and the mean test scores by condition.

	1 pint	2 pints	3 pints
Mean Math Score	11.5	9.3	6.7
n	8	8	8

1) Come up with the set of codes the researchers should use to test their predictions.

2) Calculate the slope for each of the contrasts you defined above.

3) Calculate the SSRs for each of the contrasts you defined above.

4) The researchers tested for group differences using only an omnibus test. They correctly calculated F*= 2.59, with PA-PC=2 and n-PA=21. What is their conclusion based on this test? Why is this conclusion problematic?

5) Set up the correct model A/ model C comparison to answer the researcher's question about the linear relationship between alcohol consumption and performance. Provide the null hypothesis, PA-PC and n-PA.

6) Using the SSRs you computed in part 3, test the researchers' hypothesis correctly. Provide PRE, F* and a one-sentence conclusion. [Hint: Work backwards from the researchers' omnibus F*.]

Question C

The SAS output on the following pages comes from the automobile fatality dataset. You will recall that in this dataset, the following variables (among others) were measured for each of the 50 states for a given year:

FAT	Automobile fatalities per 100 million vehicle miles
DENS	Population density: number of people per square mile
TEMP	Average minimum January temperature

At the top of the first page of SAS output are univariate statistics on these three variables.

Additionally, the following variables were computed:

DENS2	DENS*DENS
DENSTEMP	DENS*TEMP

Following the univariate statistics are the results from the following PROC REG models:

MODEL FAT=DENS;
MODEL FAT=DENS DENS2;
MODEL FAT=DENS TEMP;
MODEL FAT=DENS TEMP DENSTEMP;
MODEL FAT=DENS TEMP DENS2;

Using this output, answer the following questions:

1. Overall, ignoring TEMP, is there an effect of DENS on FAT? (Provide PRE, F*, PA-PC, N-PA, and a very short substantive conclusion.)

2. Ignoring TEMP, is there any evidence to suggest that DENS is related to FAT in other than a simple linear manner? (Provide PRE, F*, PA-PC, N-PA, and a very short substantive conclusion.)

3. In Model 1, the coefficient for DENS is -.00236. In Model 2, it equals -.00525. Explain why it is more than twice as large (in absolute value) in Model 2 than in Model 1.

4. Allowing for a quadratic relationship between DENS and FAT,

   a) what is the simple slope for DENS at its mean value (again, ignoring TEMP)?

   b) what Models A and C would you compare to test whether this simple slope differs from zero?

5. Models 3, 4, and 5 all include TEMP as one of the predictors. Below are the TEMP slopes, and associated t statistics and p levels, for each of these models:

	B	t	p
Model 3	.01439	1.90	.0639
Model 4	.01834	1.34	.1882
Model 5	.01835	2.51	.0156

Discuss what each of these slopes tells us and why they differ from each other. In light of these slopes, what do you conclude about the effects of January temperature on fatality rates from these models?

6. Is there any evidence to suggest that the effects of TEMP on FAT differ in states that are more versus less densely populated? (Provide PRE, F*, PA-PC, N-PA, and a very short substantive conclusion.)

7. The slope for DENS2 in Model 5 is incredibly small (.00000436), yet it is definitely significant. Explain the meaning of this coefficient. Given the magnitude of this slope, is this a case where we might have too much power and thus be overinterpreting incredibly small effects?

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The MEANS Procedure

Variable      N            Mean         Std Dev         Minimum         Maximum
-------------------------------------------------------------------------------
fat          50       3.5720000       0.8576284       1.7000000       5.8000000
dens         50     144.7200000     219.2521650       1.0000000     953.0000000
temp         50      23.9800000      12.7078475      -3.0000000      65.0000000
-------------------------------------------------------------------------------
```

The REG Procedure
Model: MODEL1
Dependent Variable: fat

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	13.14898	13.14898	27.57	<.0001
Error	48	22.89182	0.47691		
Corrected Total	49	36.04080			

Root MSE	0.69059	R-Square	0.3648
Dependent Mean	3.57200	Adj R-Sq	0.3516
Coeff Var	19.33339		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	3.91393	0.11738	33.34	<.0001
dens	1	-0.00236	0.00044996	-5.25	<.0001

Parameter Estimates

Variable	DF	95% Confidence Limits	
Intercept	1	3.67791	4.14994
dens	1	-0.00327	-0.00146

The REG Procedure
Model: MODEL2
Dependent Variable: fat

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	15.00933	7.50466	16.77	<.0001
Error	47	21.03147	0.44748		
Corrected Total	49	36.04080			

Root MSE	0.66894	R-Square	0.4165
Dependent Mean	3.57200	Adj R-Sq	0.3916
Coeff Var	18.72727		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Type II SS
Intercept	1	4.09433	0.14407	28.42	<.0001	361.39042
dens	1	-0.00525	0.00148	-3.54	0.0009	5.61470
dens2	1	0.00000349	0.00000171	2.04	0.0471	1.86035

Parameter Estimates

Variable	DF	Squared Partial Corr Type II	Tolerance	95% Confidence Limits	
Intercept	1	.	.	3.80450	4.38417
dens	1	0.21071	0.08640	-0.00824	-0.00227
dens2	1	0.08127	0.08640	4.666979E-8	0.00000694

The REG Procedure
Model: MODEL3
Dependent Variable: fat

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	14.77824	7.38912	16.33	<.0001
Error	47	21.26256	0.45239		
Corrected Total	49	36.04080			

Root MSE	0.67260	R-Square	0.4100
Dependent Mean	3.57200	Adj R-Sq	0.3849
Coeff Var	18.82987		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Type II SS
Intercept	1	3.57764	0.21088	16.97	<.0001	130.20730
dens	1	-0.00242	0.00043939	-5.51	<.0001	13.75525
temp	1	0.01439	0.00758	1.90	0.0639	1.62926

Parameter Estimates

Variable	DF	Squared Partial Corr Type II	Tolerance	95% Confidence Limits	
Intercept	1	.	.	3.15340	4.00188
dens	1	0.39281	0.99479	-0.00331	-0.00154
temp	1	0.07117	0.99479	-0.00086422	0.02964

The REG Procedure
Model: MODEL4
Dependent Variable: fat

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	14.83367	4.94456	10.73	<.0001
Error	46	21.20713	0.46102		
Corrected Total	49	36.04080			

Root MSE	0.67899	R-Square	0.4116
Dependent Mean	3.57200	Adj R-Sq	0.3732
Coeff Var	19.00862		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Type II SS
Intercept	1	3.49767	0.31386	11.14	<.0001	57.25311
dens	1	-0.00112	0.00378	-0.30	0.7680	0.04061
temp	1	0.01834	0.01373	1.34	0.1882	0.82272
denstemp	1	-0.00005538	0.00015972	-0.35	0.7304	0.05543

Parameter Estimates

Variable	DF	Squared Partial Corr Type II	Tolerance	95% Confidence Limits	
Intercept	1	.	.	2.86590	4.12945
dens	1	0.00191	0.01371	-0.00873	0.00649
temp	1	0.03735	0.30917	-0.00929	0.04597
denstemp	1	0.00261	0.01298	-0.00037689	0.00026612

The REG Procedure
Model: MODEL5
Dependent Variable: fat

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	17.54623	5.84874	14.55	<.0001
Error	46	18.49457	0.40206		
Corrected Total	49	36.04080			

Root MSE	0.63408	R-Square	0.4868
Dependent Mean	3.57200	Adj R-Sq	0.4534
Coeff Var	17.75137		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Type II SS
Intercept	1	3.70995	0.20510	18.09	<.0001	131.55238
dens	1	-0.00604	0.00144	-4.20	0.0001	7.07595
temp	1	0.01835	0.00730	2.51	0.0156	2.53690
dens2	1	0.00000436	0.00000166	2.62	0.0118	2.76798

Parameter Estimates

Variable	DF	Squared Partial Corr Type II	Tolerance	95% Confidence Limits	
Intercept	1	.	.	3.29711	4.12280
dens	1	0.27672	0.08228	-0.00894	-0.00314
temp	1	0.12062	0.95229	0.00365	0.03305
dens2	1	0.13018	0.08270	0.00000101	0.00000770