Exam 1

Stat 512 SP 2020

Honor Pledge: I have not given, received, or used any unauthorized assistance on this exam.

Signature:_____

Printed Name:_____

Instructions:

- **Open book, open notes, calculator required.**
- **Time limit is 1 hour, 50 minutes - strictly enforced!**
- If an answer is in the computer output, use it; don't calculate it by hand.
- Show your work where appropriate. Put your final answer in the box (if provided).
- Make explanations brief and legible.
- All questions are worth 4 points except where noted. Maximum score is 100.
- Computer input/output is provided at the end of the exam.
- The exam contains a total of 7 pages (including blank page 7).
- There is an additional **9 pages of R output**.

Questions 1 through 5: 2 pts per problem.

For this group of questions, suppose that we have a response variable Y and ten predictor variables (X1 through X10). The investigator is interested in model selection with main effects only (no interaction or polynomial terms). Circle one answer; no need to justify your response.

1. Variables X1 and X3 are highly correlated. This indicates there may be a high value of what? (circle all that apply)

Cook's Distance R^2 VIF

2. The pairwise correlation matrix (from `cor()`) can be used to determine which variable would be added first using forward selection.

TRUE FALSE

3. For this multiple regression, which diagnostic plot is **most useful** for assessing the assumption of equal variance?

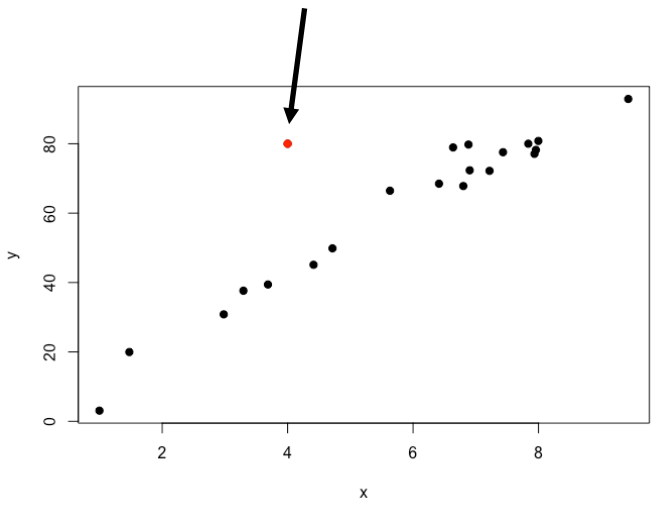
Residuals vs Fitted QQplot of Residuals Histogram of Residuals Std Residuals vs Leverage

4. The presence of correlation among the predictor variables indicates that an interaction should be considered.

TRUE FALSE

5. The point indicated on the below plot has high influence.

TRUE FALSE



Questions 6 through 16: Fitness

Researchers were interested in developing an equation to predict fitness based on the exercise tests rather than on expensive and cumbersome oxygen consumption measurements. The response variable is Oxygen. A total of 6 potential predictor variables are described below. A total of n=31 subjects participated in the study. The analysis is included at the end of the exam as "**Fitness**". Use α=0.05.

Oxygen = Oxygen intake rate (ml per kg body weight per minute)
Age = Age (years)
Weight = Weight (kg)
RestPulse = Heart rate while resting
RunTime = Time to run 1.5 miles (min)
RunPulse = Heart rate while running (same time oxygen rate was measured)
MaxPulse = Maximum heart rate while running

6. Prior to starting model selection, the investigators decided to drop MaxPulse from consideration. Looking at the variable descriptions and the output from `cor()`, discuss why this was a reasonable choice.

• Max pulse & run pulse are highly correlated. (R = 0.93)

-4: low cor w/ response

7. Briefly explain how Model 2 was chosen. Hint: Consider the output for both Models 1 and 2.

Best subsets selection w/ AIC

8. Using Model 2, interpret the partial regression coefficient for Age. Be specific!

A 1 year increase in age is associated with a 0.256 decrease in predicted oxygen with RunTime and RunPulse held constant.

9. Consider Model2. What command would you use to get R to provide the 95% confidence interval for the partial regression coefficient for Age.

emtrends( )
confint( )

-2: emmeans

10. For Model 2, interpret the R^2 value.

81% of variation in Oxygen is explained by the linear regression on Age, RunTime and RunPulse

-2: not specifying about what variation

11. In the `summary()` output for Model2, an F-statistic = 38.64 and p-value < 0.001 are shown. What is being tested here? State the null hypothesis (H_0).

-1 for $\beta_0 = 0$

$H_0: \beta_1 = \beta_2 = \beta_3 = 0$ or all coef's except for β_0 are simultaneously zero.

12. Using Model 2, predict the oxygen for a subject with Age = 45, RunTime = 12 and RunPulse = 160. Give your answer to 1 decimal place.

$\hat{Y} = 111.7181 - 0.2564(45) - 2.8254(12) - 0.1309(160) = 45.33$

45.3

13. Using Model 2, do the regression assumptions appear to be satisfied? Briefly discuss the information in each of these plots. Your discussion should be specific to this analysis!

A. Residuals vs predicted values:

- some evidence of unequal variance
- mega phone

B. QQplot of residuals (Residuals vs Quantiles):

- looks roughly linear - okay

14. Using Model 2, based on the Cook's distance criteria are you concerned that any observations have high influence? Discuss. Note: Use the rule of thumb from class.

Any observations have high influence? Yes (No)

Discuss: all < 1

15. Considering the results for Model 2, a colleague suggests that since the R^2 value would be higher for the full model (all predictors) that the full model will be better for prediction. Do you agree that the full model will be better (than Model 2) for making predictions for new observations? Discuss.

Do you agree? Yes (No)

Discuss:

- full model will always have highest R^2. For prediction should eval w/ cross validation

16. Suppose the investigators had wanted to include sex (M or F) as a predictor in the model. Explain how the design matrix (or `model.matrix`) would have been modified if this variable had been included.

a column for the indicator var for sex would be added

Age	Weight	...	MaxPulse	SexM (for example 0 = F)
44	89.5		182	0
40	75.1		185	0
⋮	⋮		⋮	1
				1

-2: do not describe matrix

lsmeans() is the same as emmeans()

Questions 17 through 26: Average Daily Gain pg 4 R code

An experiment was conducted over a 160 day period to evaluate the effects of a feed additive (TRT) on the growth of cattle. Thirty-two cows (n = 32) were randomly assigned to one of four feed additive treatment levels (TRT = 0, 10, 20 or 30). **NOTE: TRT is a categorical predictor in all models considered here!** The response variable is average daily gain (ADG) over the treatment period. Initial weight (IWT) of each animal was also used as a covariate in some analyses. The analysis is included at the end of the exam as "**Average Daily Gain**". Use α=0.05.

There are 4 models shown in the output:

Model 1A: ANCOVA WITH Interaction
Model 1B: ANCOVA WITH Interaction (alternate parameterization)
Model 2: ANCOVA NO Interaction
Model 3: One-way ANOVA

17. Briefly describe the difference between the ANCOVA models WITH and WITHOUT interaction. Hint: Think in terms of slopes and intercepts.

WITH: allows different slopes for each TRT
WITHOUT: common slope for all TRT

Questions 18 through 21 refer to the ANCOVA WITH Interaction (Models 1A and 1B).

18. Using Model 1A, in the table "Anova Table (Type III tests)" look at the line labeled "IWT" with F=0.0024 and p-value= 0.9617. What is being tested here? State the null hypothesis (H_0) using words. Hint: Think in terms of slopes and intercepts.

H_0: β or slope for reference group, TRT 0, is zero

-3, no mention of reference

19. Test the null hypothesis that the slope for TRT 30 is equal to zero.

. Model 1B coef.

.

Test Statistic: t= 0.686

P-value: 0.499

20. Test for a difference between the slopes for TRT 10 vs TRT 20. Give the test statistic and p-value. Hint: Notice the `lht()` statements used with Model 1B

Model 1B, lht, c2

-2 if test of intercepts

Test Statistic: F= 1.33

P-value: 0.26

21. Calculate the emmean for TRT=30 with IWT=390. In other words, calculate the predicted value. Give your answer to 1 decimal place.

$= 1.096 + 0.00196(390) = 1.8605$

Questions 22 and 23 refer to the ANCOVA NO Interaction (Model 2).

22. Using Model 2, in the table "Anova Table (Type III tests)" look at the line labeled "TRT" with F= 4.04 and p-value= 0.0170. What is being tested here? State the null hypothesis (H_0) using words.
Hint: Think in terms of slopes and intercepts.

H_0: Intercepts for the TRTs are the same.

-2: intercept(s) equals zero.

23. Adjusting for IWT, which TRTS have mean ADG values that are significantly different from each other? Make your conclusions based on Tukey adjusted p-values with α=0.05.

lsmeans contrasts: only TRT0 and TRT30

24. Complete the following table. (**6 pts**) Note that there are n=32 observations from 4 TRTS.

Model	p	SSResid	AIC
1 (ANCOVA w Interaction)	8	2.952	-60.26
2 (ANCOVA NO Interaction)	5	3.424569	-61.51
3 (ANOVA)	4	4.405425	-55.45

$32 \ln\left(\frac{4.405}{32}\right) + 2(4) = -55.45$

25. Using a backward elimination approach, which model would be selected? Circle one answer. (**2 pts**)

Model 1 (Model 2) Model 3

lowest AIC, all terms stat. sig.

26. Considering the table from #24, a colleague says that your AIC selection process is flawed because you did not consider the simple linear regression model (including just IWT). Give the research goals stated in the problem description, does the simple linear regression model need to be considered? Justify your response.

Regression needs to be considered? Yes (No)

Discuss: models w/o TRT will not address research question.