STAT 212-501 (Fall 2022) Name _____
Instructor: Dr. Sharmistha Guha

# Practice Midterm 2

**Instructions** (please read the following carefully before starting the exam):

- **Do not open** the exam unless you are explicitly instructed to do so.
- You may use **one** formula sheet (with writing on front and back), a standard scientific calculator (with **no** internet access), and pencil(s) - all fully functioning (no sharing or borrowing is allowed). **No** cell phones or any other electronic devices are allowed.
- There is **NO partial credit. Only ONE answer is correct** for each of the questions. If you mark two or more options in the Scantron for any question, you will get 0 points for that question *irrespective* of whether one of those marked options is correct or not. **Advice:** Do **not** be hasty! Read **all** options *carefully* before choosing your final answer!
- **Mark your answers clearly** (and fully) with a number 2 pencil on your Scantron.
- **Mark which form** you have, **A or B**, on your Scantron.
- Also, **clearly bubble in the following on your Scantron:** *department* (**STAT**), the *course number* (**212**), the *section number* (**501**), your **name and UIN** on the Scantron.
- You may write on your exam (and use the blank side of each page for scratch work). But none of this work will count. Your score will be based solely on the Scantron.
- No cheating or discussing or helping others in any way will be tolerated. If detected, everyone involved will get a grade of 0 on the exam. You **must** work alone.
- **Turn in both your exam and Scantron** when you are done. Bring your **TAMU ID**.
- Good luck!

**1.** Data for 146 LPGA golfers from the year 2009 were collected. The following variables from this data set were considered for a regression analysis:

$\mathbf{y}$ = scoring average $\quad \mathbf{x_1}$ = average driving distance $\quad \mathbf{x_2}$ = % fairways hit

$\mathbf{x_3}$ = % greens hit $\quad \mathbf{x_4}$ = average putts per round $\quad \mathbf{x_5}$ = % sand saves

$\mathbf{x_6}$ = no. of tournaments $\quad \mathbf{x_7}$ = putts per greens hit $\quad \mathbf{x_8}$ = no. of tournaments completed.

The accompanying output (available at the back of this exam as a 3-page document) shows information and plots obtained from regression models fit to these data in an "R" session.

**Use the information and the attachment above to answer the following 7 questions (i.e. the current one and the next 6 questions).**

The value of $R^2$ for the model containing independent variables $x_3$, $x_4$ and $x_6$ is closest to:

(a) 0.655.

(b) 0.941.

(c) 0.902.

(d) 0.945.

(e) 0.952.

**2.** Considering AIC, BIC, $R^2$ and the principle of parsimony, the best choice of the model is:

(a) Probably the one containing only $x_3$.

(b) Probably the one containing all 8 independent variables.

(c) Probably the one containing $x_1$, $x_3$, $x_4$, $x_5$, $x_6$ and $x_8$.

(d) Any of the models that contain $x_8$.

(e) A secret that Dr. Guha won't reveal.

**3.** A sports reporter decides to use the simple model containing only $x_3$, $x_4$ and $x_8$ to predict next year's scoring average for a promising rookie, Jane Doe. Assume that Jane's percentage of greens hit, average putts per round and number of tournaments completed are 70, 29.5 and 18, respectively. The prediction of her scoring average:

(a) 68.1

(b) 70.1

(c) 71.2

(d) 72.9

(e) 73.5

**4.** It is of interest to test the hypothesis that the variables $x_2$, $x_6$ and $x_7$ are not needed in the same model with the other five independent variables. If we test this null hypothesis using $\alpha = 0.05$, then which of the following is correct?

(a) The $F$-statistic is 4.245 and we would conclude that $x_2$, $x_6$ and $x_7$ are needed in the model if $4.245 > F_{3,137;0.05}$.

(b) The $F$-statistic is 4.245 and we would conclude that $x_2$, $x_6$ and $x_7$ are *not* needed in the model if $4.245 > F_{3,137;0.05}$.

(c) The $F$-statistic is 308.64 and we would conclude that $x_2$, $x_6$ and $x_7$ are needed in the model if $308.64 > F_{3,137;0.05}$.

(d) The $F$-statistic is 308.64 and we would conclude that $x_2$, $x_6$ and $x_7$ are *not* needed in the model if $308.64 > F_{3,137;0.05}$.

(e) The $F$-statistic is 308.64 and we would conclude that $x_2$, $x_6$ and $x_7$ are needed in the model if $308.64 > F_{5,137;0.05}$.

**5.** A plot of the residuals for the full model (i.e., the one containing all 8 independent variables) is provided for you in the last page of the R output attachment. Which of the following is the best conclusion based on this plot?

(a) An assumption of Normally distributed error terms seems reasonable.

(b) There is a clear decrease in the variance of residuals as the predicted value increases.

(c) There appears to be no outliers that have a large influence on the fitted model.

(d) These residuals do not give us any reason to believe that the model assumptions have been violated.

(e) Both options (b) and (c) are true.

**6.** Given that $\sum_{i=1}^{146}(y_i - \bar{y})^2 = 189.4666$, the estimate of the error variance using the full model is:

(a) 189.4666/145.

(b) 189.4666/137.

(c) $189.4666(1 - 0.960028)/137$.

(d) $189.4666(0.960028)/137$.

(e) 0.960028.

**7.** A plot of Cook's D for the full model (i.e., the one containing all 8 independent variables) is provided for you in the last page of the R output attachment. Which of the following is the best conclusion based on this plot?

(a) An assumption of Normally distributed error terms seems reasonable.

(b) There are no extremely large residuals.

(c) There appear to be no outliers that have a large influence on the fitted model.

(d) An assumption of constant variance for the error terms seems reasonable.

(e) Both options (b) and (c) are true.

**8.** A group of entomologists were studying data involving spruce moths. The numbers of moths caught in 60 different traps were recorded. The traps varied according to where they were located on a tree: top, middle, lower or ground. Fifteen traps were used for each location, and an analysis of variance was conducted to determine what effect, if any, the locations had on the number of moths caught. The following partial ANOVA table was determined from the data. (The lower case italicized letters in the table denote entries that are not given to you.)

| Source of variation | Degrees of freedom | Sum of squares | Mean square | $F$ |
|---|---|---|---|---|
| Location | $a$ | $b$ | $c$ | $d$ |
| Error | 56 | 3261.6 | $e$ | |
| Total | $f$ | $g$ | | |

**Use the information and the table above to answer the following 4 questions (i.e. the current one and the next 3 questions).**

The number of moths caught in different traps varies even when all the traps are in the same location. We term this standard deviation $\sigma$. The best estimate of $\sigma$ from the ANOVA table is:

(a) $(g - 3261.6)/56$.

(b) $g/f$.

(c) $\sqrt{g/f}$.

(d) $3261.6/56$.

(e) $\sqrt{3261.6/56}$.

**9.** Let $\mu_t$, $\mu_m$, $\mu_\ell$ and $\mu_g$ denote the average number of moths caught in the top, middle, lower and ground parts of a tree, respectively. The value of the $F$-statistic for testing $H_0 : \mu_t = \mu_m = \mu_\ell = \mu_g$ is:

(a) $(a/b)/58.24$.

(b) $b/3261.6$.

(c) $(b/3)/58.24$.

(d) $(b/a)/3261.6$.

(e) $(a/b)/(g/f)$.

**10.** It turns out that the value of the $F$-statistic is 11.34. If we test the null hypothesis $H_0 : \mu_t = \mu_m = \mu_\ell = \mu_g$ using $\alpha = 0.05$, then which of the following is correct? (Remember, if you can't find a certain degree of freedom on the $F$-table, choose the next <u>smaller</u> one on the table.)

(a) Since $F$ is smaller than the appropriate table value, we cannot reject $H_0$.

(b) Since $F$ is larger than the appropriate table value, we may conclude that $\mu_t \neq \mu_m$, $\mu_m \neq \mu_\ell$ and $\mu_\ell \neq \mu_g$.

(c) We cannot reject equality of the four means since $F > F_{3,50;0.05} = 2.79$.

(d) It is reasonable to conclude that the four means are not all the same since $F > F_{3,50;0.05} = 2.79$.

(e) Since we do not the know the $P$-value it is impossible to draw a conclusion.

**11.** A multiple linear regression model relating $Y$ with $x_1$ and $x_2$ has the form:

$$Y = 10 + x_1 - 3x_2 + 0.9x_1x_2 + \epsilon,$$

where, for every choice of $(x_1, x_2)$, $\epsilon$ has a Normal distribution with mean 0 and standard deviation 1. The expected value of $Y$ when $x_1 = 1$ and $x_2 = 2$ is:

(a) 6.8.

(b) 7.1.

(c) 8.6.

(d) 10.

(e) Cannot be determined from the information given.

**12.** Suppose we want to test 5 null hypotheses: $H_0^{(1)}, \ldots, H_0^{(5)}$, and for simplicity, assume that they are tested using 5 independent datasets. Suppose each hypothesis is now tested using a procedure that controls the respective Type I error rate at a level 0.1. Then, the experimentwise error rate for testing all these hypotheses simultaneously is given by: (**Note:** this question carries **4 points**.)

(a) 0.1.

(b) $(0.1)^5$.

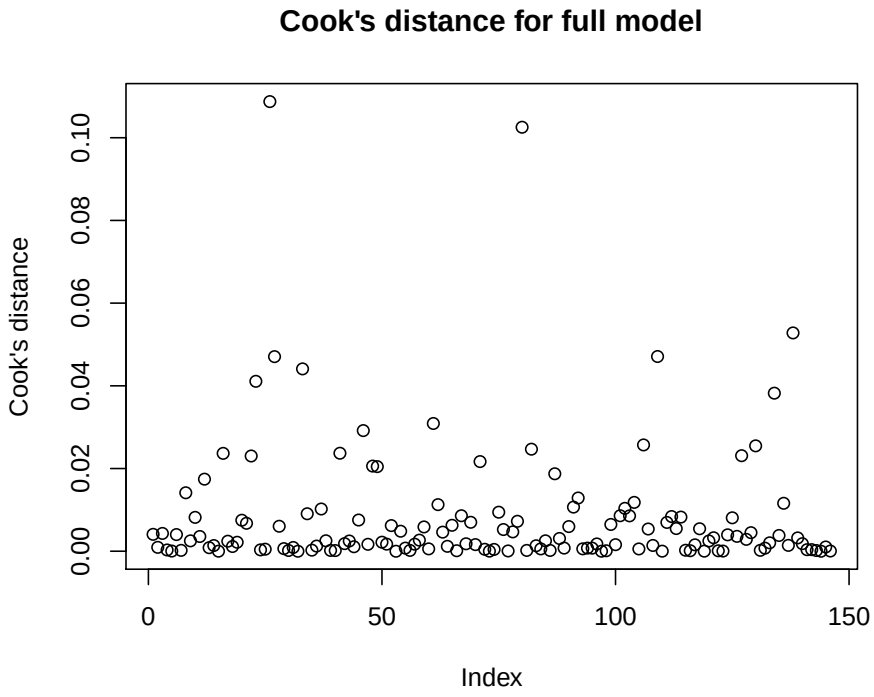
(c) 0.5905.

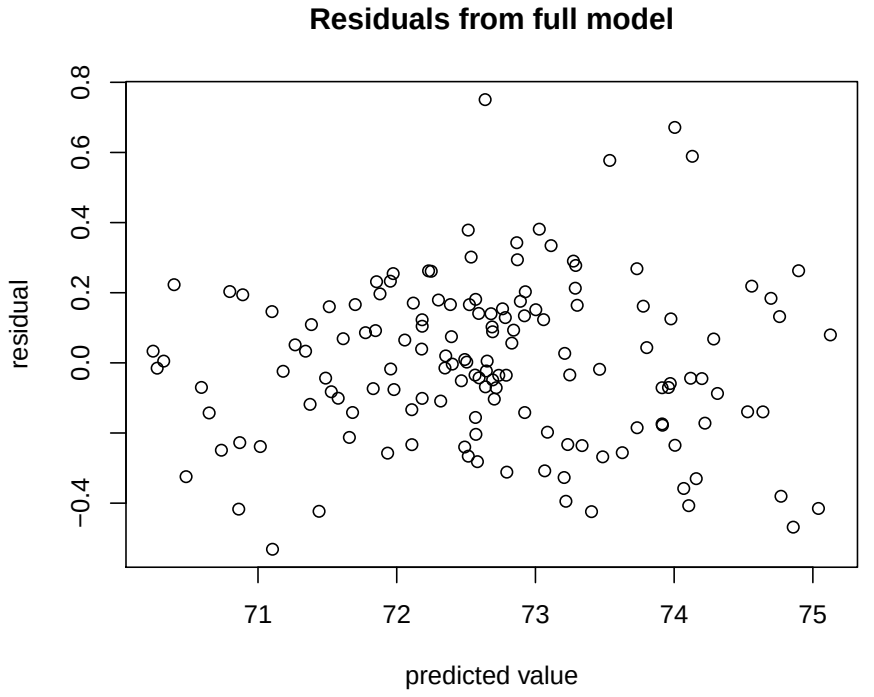
(d) 0.9999.

(e) 0.4095.

```
X=cbind(x1,x2,x3,x4,x5,x6,x7,x8)

leaps(X,y,method='r2',nbest=2)$which

      1     2     3     4     5     6     7     8           AIC     BIC
1 FALSE FALSE FALSE FALSE FALSE FALSE FALSE  TRUE         269.69  278.64
1 FALSE FALSE  TRUE FALSE FALSE FALSE FALSE FALSE         302.86  311.81
2 FALSE FALSE  TRUE  TRUE FALSE FALSE FALSE FALSE          48.05   59.98
2 FALSE FALSE  TRUE FALSE FALSE FALSE  TRUE FALSE         121.99  133.92
3 FALSE FALSE  TRUE  TRUE FALSE FALSE FALSE  TRUE          20.04   34.96
3 FALSE FALSE  TRUE  TRUE FALSE  TRUE FALSE FALSE          39.80   54.72
4 FALSE FALSE  TRUE  TRUE  TRUE FALSE FALSE  TRUE          15.29   33.19
4  TRUE FALSE  TRUE  TRUE FALSE FALSE FALSE  TRUE          16.29   34.19
5  TRUE FALSE  TRUE  TRUE  TRUE FALSE FALSE  TRUE           9.29   30.18
5 FALSE FALSE  TRUE  TRUE  TRUE FALSE  TRUE  TRUE          10.83   31.72
6  TRUE FALSE  TRUE  TRUE  TRUE  TRUE FALSE  TRUE           5.83   29.70
6  TRUE  TRUE  TRUE  TRUE  TRUE FALSE FALSE  TRUE           7.05   30.92
7  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE FALSE  TRUE           4.06   30.91
7  TRUE FALSE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE           5.11   31.98
8  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE           2.32   32.16

$label
[1] "(Intercept)" "1"           "2"           "3"           "4"
[6] "5"           "6"           "7"           "8"

$size
 [1] 2 2 3 3 4 4 5 5 6 6 7 7 8 8 9

$r2
 [1] 0.7253822 0.6553326 0.9406433 0.9015029 0.9516711 0.9446654 0.9538540
 [8] 0.9535363 0.9563137 0.9558510 0.9579181 0.9575638 0.9589913 0.9586936
[15] 0.9600280


> fit=lm(y~x1+x2+x3+x4+x5+x6+x7+x8)
> anova(fit)

Analysis of Variance Table

Response: y
           Df Sum Sq Mean Sq  F value    Pr(>F)
x1          1 41.861  41.861 757.2479 < 2.2e-16 ***
x2          1 37.150  37.150 672.0372 < 2.2e-16 ***
x3          1 46.334  46.334 838.1606 < 2.2e-16 ***
x4          1 53.633  53.633 970.2110 < 2.2e-16 ***
x5          1  0.912   0.912  16.5013 8.144e-05 ***
x6          1  0.444   0.444   8.0349  0.005283 **
x7          1  0.333   0.333   6.0215  0.015387 *
x8          1  1.226   1.226  22.1824 6.008e-06 ***
Residuals 137  7.573   0.055
---



> fit1=lm(y~x2+x6+x7)
> anova(fit1)

Analysis of Variance Table

Response: y
           Df Sum Sq Mean Sq F value    Pr(>F)
x2          1 10.159  10.159  24.553 2.028e-06 ***
x6          1 63.442  63.442 153.329 < 2.2e-16 ***
x7          1 57.110  57.110 138.025 < 2.2e-16 ***
Residuals 142 58.755   0.414
---
```

```
> fit2=lm(y~x1+x3+x4+x5+x8)
> anova(fit2)

Analysis of Variance Table

Response: y
           Df Sum Sq Mean Sq  F value    Pr(>F)
x1          1 41.861  41.861  708.037 < 2.2e-16 ***
x3          1 82.765  82.765 1399.901 < 2.2e-16 ***
x4          1 54.243  54.243  917.479 < 2.2e-16 ***
x5          1  0.830   0.830   14.041 0.0002607 ***
x8          1  1.490   1.490   25.205 1.542e-06 ***
Residuals 140  8.277   0.059
---



> fit3=lm(y~x3+x4+x8)
> summary(fit3)

Call:
lm(formula = y ~ x3 + x4 + x8)

Residuals:
     Min       1Q   Median       3Q      Max
-0.66244 -0.17566  0.02268  0.16736  0.84612

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 61.240140   1.071359  57.161  < 2e-16 ***
x3          -0.195544   0.007981 -24.500  < 2e-16 ***
x4           0.820476   0.041074  19.976  < 2e-16 ***
x8          -0.032671   0.005740  -5.692 6.93e-08 ***
---

Residual standard error: 0.2539 on 142 degrees of freedom
Multiple R-squared:  0.9517,    Adjusted R-squared:  0.9507
F-statistic: 932.1 on 3 and 142 DF,  p-value: < 2.2e-16

> anova(fit3)

Analysis of Variance Table

Response: y
           Df  Sum Sq Mean Sq  F value    Pr(>F)
x3          1 124.164 124.164 1925.500 < 2.2e-16 ***
x4          1  54.057  54.057  838.301 < 2.2e-16 ***
x8          1   2.089   2.089   32.402 6.926e-08 ***
Residuals 142   9.157   0.064
```


Cook's distance for full model
Cook's distance
0.00
0.02
0.04
0.06
0.08
0.10
0
50
100
150
Index


Residuals from full model
residual
−0.4
0.0
0.2
0.4
0.6
0.8
71
72
73
74
75
predicted value