STAT512 – Exam 1
Spring 2018

Mean = 88

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

Signature:____

Printed Name: KEY

Instructions:
- **Open book, open notes, calculator required. No computers or cell phones.**
- **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 13 pages (including computer input/output).
- If you run out of space, you may use the blank area on page 6.

Questions 1 through 5 (Model Selection): Suppose that we have a response variable (Y) and 5 predictor variables (X1 through X5). We are interested in model selection with main effects only (no interactions or polynomial terms). Circle one answer; no need to justify your response. **2 pts** per question.

1. (Multiple) R^2 can be used for model selection.

   TRUE FALSE

2. The model with the lowest AIC will satisfy all model assumptions (equal variance, normality, etc).

   TRUE FALSE

3. The model with the lowest AIC could include predictors that are not statistically significant.

   TRUE FALSE

4. Forward and backwards selection will always arrive at the same model.

   TRUE FALSE

5. Using AIC all subsets selection, suppose the model including X1 and X2 is selected. Using hypothesis testing forward selection, the model including X1 and X2 is also selected. The estimated coefficients for these models will be the same. (betas)

   TRUE FALSE

10

Questions 6 through 17 (MS Activity): In the article "Functional factors that are important correlates to physical activity in people with multiple sclerosis: a pilot study" (Ketelhut et al., 2017), the researchers were interested in identifying variables that are associated with physical activity in people with multiple sclerosis. They considered two response variables (both measures of Activity): MVPA and Total.Activity. Several potential predictor variables were considered:

Walk.Speed: Walking speed (m/sec)
Avg.Peg.Test: Average time to complete peg test. (sec)
Chair.Rise: Time to rise from a seated position. (sec).
TUG.Avg: Timed "up and go" (sec)
LA.TotStr: Strength of the "less affected" leg (N/kg)
MA.TotStr: Strength of the "more affected" leg (N/kg)

Questions 6 through 10 (MS Activity 1): In this group of questions, we use **MVPA** as the response.

6. Which variable would be added first using "traditional" (hypothesis testing) forward selection?

   Variable: LA.TotStr.

   Brief Justification: Strongest correlation

   -2 for lowest pval / highest |t| because only full model is shown.

7. Considering the full model (**MVPAFull**), several of the VIF values are greater than 4 suggesting collinearity. However for the "final" model (**MVPAFinal**) all the VIF values are close to 1 suggesting no problems with collinearity. Explain why the collinearity is greatly reduced for the "final" model. Be specific.

   Full Model: TUG.AVG, Chair.Rise highly correlated ($R=0.91$)
   LA.TotStr, MA.TotStr also highly correlated ($R=0.90$)

   Final Model: By dropping variables we reduce collinearity.

8. Explain how the "final" model (**MVPAFinal**) was selected. Be sure to state both the method and the criteria.

   AICc all subsets selection.

9. Using **MVPAFinal**, predict MVPA for a subject with Avg.Peg.Test = 20 and LA.TotStr = 8. Give your final answer to one decimal place.

   $\hat{Y} = 25.25 - 0.98 \cdot 20 + 3.62 \cdot 8$

   $\boxed{34.4}$

10. In the output for summary() **MVPAFinal**, an F test statistic (F = 6.975, p-value = 0.003) are shown. What is being tested? State the null hypothesis.

    $H_0: \beta_1 = \beta_2 = 0$.

-2 for $\beta_0 = 0$.
-2 for $\beta_1 = \beta_2$

20

Questions 11 through 15 (MS Activity 2): In this group of questions, we use **Total.Activity** as the response.

11. Explain how the "final" model (**TotActFinal**) was selected. Be sure to state both the method and the criteria.

AIC Backwards Elimination

12. Is the assumption of equal variances satisfied? Name the plot you are considering (be specific) and briefly discuss whether the assumption is satisfied.

Plot: Resids vs Fitted

Brief discussion: Shows equal scatter OK

13. Is the assumption of normality satisfied? Name the plot you are considering (be specific) and briefly discuss whether the assumption is satisfied.

Plot: Normal QQplot

Brief discussion: Linear OK.

14. From the results of outlierTest(), we see that obs #29 has the largest magnitude Rstudent residual. Notice the large difference between the unadjusted p-value (p = 0.008) versus the Bonferoni adjusted p-value (p = 0.2809). Which is appropriate here? Briefly justify your response:

Which is appropriate: Unadjusted Bonferonni

Brief Justification: Outlier identified after looking at the data

15. Considering the diagnostic plots, we see that obs #24 appears to be the most influential. Give the approximate Cook's distance for this observation and compare to the rule of thumb from the notes. (**6 pts**)

Approximate Cook's D for Obs #24: ~ 0.5

Compare to rule of thumb: $\not> 1$

High influence: Yes No

22

Questions 16 and 17 (MS Activity): For this question only, we look at both models (**MVPAFinal** and **TotActFinal**).

16. A colleague looks at the AIC values for the two models (**MVPAFinal** AIC = 198.99, **TotActFinal** AIC = 269.19). He concludes that "since the AIC is smaller for MVPAFinal (as compared to TotActFinal) that model fits the data better." Discuss whether it is appropriate to compare AIC values in this way.

Not appropriate to compare AIC since response variables are different.

17. Thinking about the question above, provide an alternative way to compare the "fit" of the two models.

MVPA Final $R^2 = 0.3104$ Adj $R^2 = 0.2659$

Tot Act Final $R^2 =$ ~~[illegible]~~ 0.44 Adj $R^2 = 0.384$

Questions 18 through 26 (Firing Range): A study was done to examine noise exposure at police firing ranges. The primary question was whether the response variable **Noise** (measured in dB) differed based on the shot **Weight** (measured in grams) and **Location** ("Indoor" firing range, "Outdoor" firing range, sound proof "Control" box). Information was recorded for a total of n=36 shots across all 3 Locations. The R input and output are labeled **Firing Range**. Use α=0.05.

18. A colleague looks at the ANOVA table and sees that Location (F = 1.15, p-value = 0.33) is not statistically significant. He concludes that there is "no difference between Locations". Do you agree? Briefly discuss.

No. Since there is a significant interaction we conclude that the effect of location depends on the level of Weight.

19. Again, a colleague looks at the ANOVA table and sees Weight (F = 0.96, p-value =0.33) is not statistically significant. He suggests dropping Weight from the model. Do you agree? Briefly discuss.

No. Principle of Hierarchy.

20. Calculate AIC for the model. Also give the value of p (# parameters).

$$AIC = n \cdot \ln\left(\frac{SSResid}{n}\right) + 2p$$
$$= 36 \cdot \ln\left(\frac{721.7}{36}\right) + 2 \cdot 6$$

AIC: 119.93
p: 6

−1 for wrong p.

20

21. Test the null hypothesis that the intercepts are the same for the three Locations. Give a test statistic and p-value.

ANOVA Table

Test Statistic:	1.15
p-value:	0.33

22. Test the null hypothesis that the slopes are the same for the three Locations. Give a test statistic and p-value.

Test Statistic:	101.68
p-value:	< 0.001

23. Identify the estimated intercept and slope for Indoor Location. **(8 pts)** Give your answers to two decimal places.

4.2553

Intercept: 53.659 − ~~[illegible]~~

Slope: −0.01849 + 0.19156

−2 for −4.26

Intercept:	49.40
Slope:	+0.17

−2 for 0.19

24. One goal of the study is to examine the relationship between Noise and Weight at each Location. Hence the investigators are interested in testing whether the slope at each Location is different from zero. Using the output provided, which Locations have slopes that are significantly different from zero. Hint: Think about confidence intervals.

Which Locations have slopes significantly different from zero? Circle all that apply.

Control   Indoor   Outdoor

Brief justification: CIs do not include zero.

25. Another goal is to compare the slopes for the three Locations. Identify pairs of Locations that have slopes that are significantly different from each other.

Based on emtrends output,

All pairwise comparisons are stat. sig. different

26. Yet another goal is to test for differences between the mean Noise comparing the three Locations (1) at low weight (say 5 grams) and (2) at high weight (say 200 grams). Explain how you would do this. You can either respond in words or provide (brief) R code if that is easier.

Use emmeans to compare Locations at Low, High Weights.

emmeans(FRModel, pairwise ~ Location, at=list(Weight=5))

emmeans(. . . . , at=list(Weight=200))

−4 for emmeans without at option.

28

MS Activity 1 (Questions 6 through 10)

```
library(car)
library(MuMIn)
#Drop Total.Activity since not used in this group of questions
ActivityData <- ActivityData[,-2]
str(ActivityData)
round(cor(ActivityData),2)
#Full Model
MVPAFull <- lm(MVPA ~ Walk.Speed + Avg.Peg.Test + Chair.Rise + TUG.AVG + L
A.TotStr + MA.TotStr, data = ActivityData)
summary(MVPAFull)
vif(MVPAFull)
options(na.action = "na.fail")
MVPAcompare <- dredge(MVPAFull)
head(MVPAcompare)
#Final Model
MVPAFinal <- lm(MVPA ~ Avg.Peg.Test + LA.TotStr, data = ActivityData)
summary(MVPAFinal)
vif(MVPAFinal)
extractAIC(MVPAFinal)
```

```
> library(car)
> library(MuMIn)
> #Drop Total.Activity since not used in this group of questions
> ActivityData <- ActivityData[,-2]
> str(ActivityData)
'data.frame':	34 obs. of  8 variables:
 $ MVPA        : int  13 32 33 18 60 39 16 25 22 21 ...
 $ Walk.Speed  : num  1.28 1.49 1.54 1.46 1.68 2.1 1.63 2.11 1.25 ..
 $ Avg.Peg.Test : num  23.1 17.7 17.9 23.1 18 ...
 $ Chair.Rise  : num  20.75 9.85 11.43 12.22 11.59 ...
 $ TUG.AVG     : num  8.55 6.88 6.5 7.41 7.36 ...
 $ LA.TotStr   : num  4.64 7.25 10.57 8.58 11.14 ...
 $ MA.TotStr   : num  4.62 6.1 9.42 7.76 9.8 ...

> round(cor(ActivityData),2)
              MVPA Walk.Speed Avg.Peg.Test Chair.Rise TUG.AVG LA.TotStr MA.TotStr
MVPA          1.00       0.44        -0.35      -0.47   -0.44      0.49      0.44
Walk.Speed    0.44       1.00        -0.62      -0.80   -0.84      0.50      0.60
Avg.Peg.Test -0.35      -0.62         1.00       0.64    0.72     -0.18     -0.31
Chair.Rise   -0.47      -0.80         0.64       1.00    0.91     -0.50     -0.61
TUG.AVG      -0.44      -0.84         0.72       0.91    1.00     -0.41     -0.55
LA.TotStr     0.49       0.50        -0.18      -0.50   -0.41      1.00      0.90
MA.TotStr     0.44       0.60        -0.31      -0.61   -0.55      0.90      1.00
```

MS Activity 1 continued (Questions 6 through 10)

```
> #Full Model
> MVPAFull <- lm(MVPA ~ Walk.Speed + Avg.Peg.Test + Chair.Rise + TUG.AVG +
LA.TotStr + MA.TotStr, data = ActivityData)

> summary(MVPAFull)

Call:
lm(formula = MVPA ~ Walk.Speed + Avg.Peg.Test + Chair.Rise +
    TUG.AVG + LA.TotStr + MA.TotStr, data = ActivityData)

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)   29.9360    36.5421   0.819   0.4198
Walk.Speed     0.9285    15.6403   0.059   0.9531
Avg.Peg.Test  -0.5942     0.8501  -0.699   0.4905
Chair.Rise    -0.4872     1.3135  -0.371   0.7136
TUG.AVG       -0.4667     2.4549  -0.190   0.8506
LA.TotStr      5.3292     3.0788   1.731   0.0949 .
MA.TotStr     -2.7294     3.1855  -0.857   0.3991
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 18.75 on 27 degrees of freedom
Multiple R-squared:  0.3406,    Adjusted R-squared:  0.1941
F-statistic: 2.324 on 6 and 27 DF,  p-value: 0.06133

> vif(MVPAFull)
  Walk.Speed Avg.Peg.Test   Chair.Rise      TUG.AVG    LA.TotStr    MA.TotStr
    3.874243     2.178964     6.851501     9.123130     5.791174     6.680443

> options(na.action = "na.fail")
> MVPAcompare <- dredge(MVPAFull)
Fixed term is "(Intercept)"
> head(MVPAcompare)
Global model call: lm(formula = MVPA ~ Walk.Speed + Avg.Peg.Test + Chair.R
ise +
    TUG.AVG + LA.TotStr + MA.TotStr, data = ActivityData)
---
Model selection table
     (Int) Avg.Peg.Tst Chr.Ris LA.TtS TUG.AVG Wlk.Spd df   logLik  AICc delta weight
6   25.250     -0.9874          3.616                  4 -144.739 298.9  0.00  0.219
21  18.510                      3.080  -1.471          4 -144.802 299.0  0.13  0.206
7   19.990             -0.9449  2.808                  4 -144.854 299.1  0.23  0.196
5   -1.853                      4.019                  3 -146.369 299.5  0.68  0.156
37 -12.030                      2.976           12.83  4 -145.271 299.9  1.06  0.129
3   48.920             -1.4990                         3 -146.880 300.6  1.70  0.094
Models ranked by AICc(x)
```

MS Activity 1 continued (Questions 6 through 10)

```
> #Final Model
> MVPAFinal <- lm(MVPA ~ Avg.Peg.Test + LA.TotStr, data = ActivityData)
> summary(MVPAFinal)

Call:
lm(formula = MVPA ~ Avg.Peg.Test + LA.TotStr, data = ActivityData)

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)   25.2476    18.2530   1.383  0.17649
Avg.Peg.Test  -0.9874     0.5592  -1.766  0.08728 .
LA.TotStr      3.6158     1.2422   2.911  0.00662 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 17.89 on 31 degrees of freedom
Multiple R-squared:  0.3104,    Adjusted R-squared:  0.2659
F-statistic: 6.975 on 2 and 31 DF,  p-value: 0.003153

> vif(MVPAFinal)
Avg.Peg.Test    LA.TotStr
    1.034945     1.034945
> extractAIC(MVPAFinal)
[1]   3.000 198.991
```

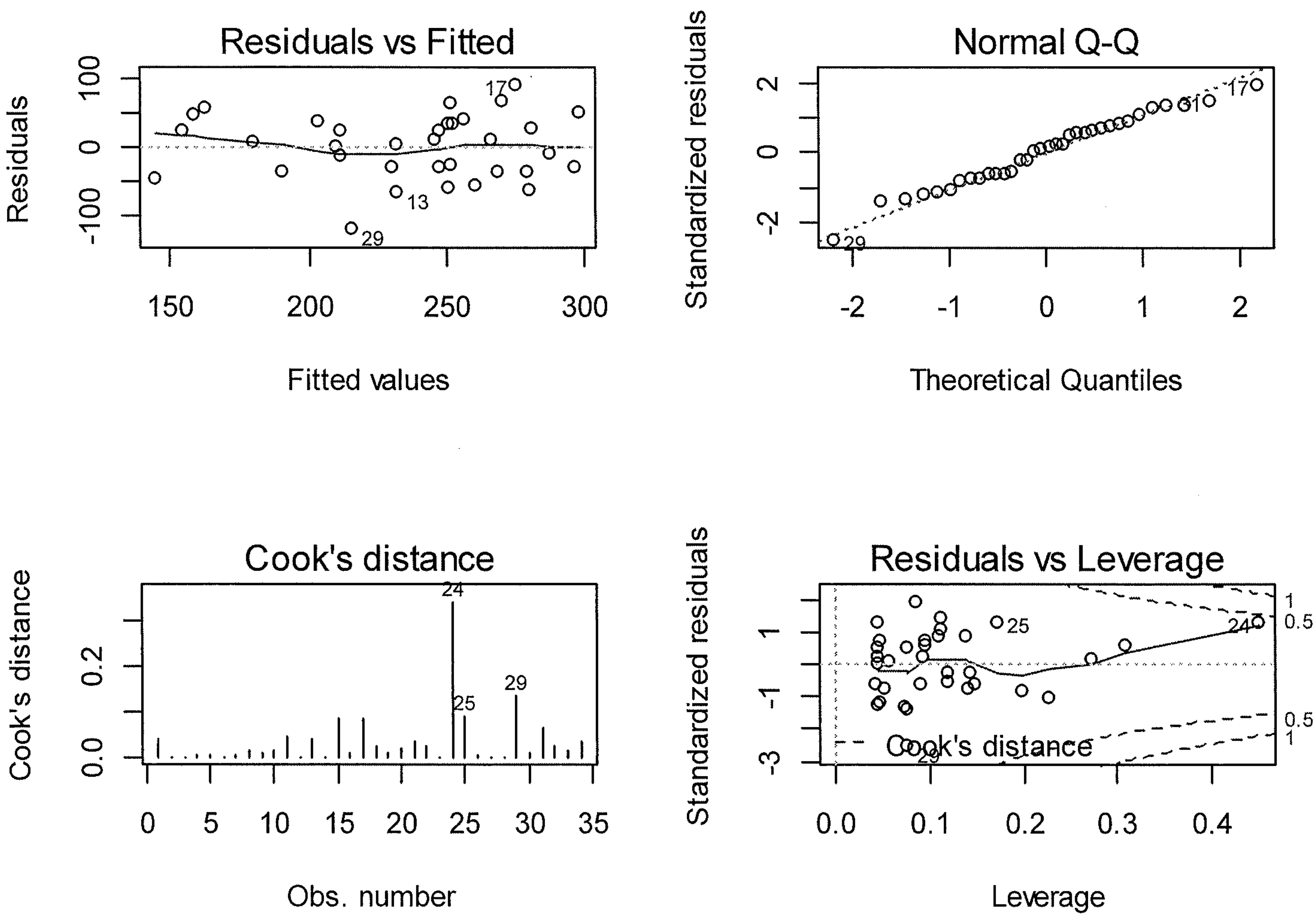
MS Activity 2 (Questions 11 through 15)

```
library(car)
str(ActivityData)
#Full Model
TotActFull <- lm(Total.Activity ~ Walk.Speed + Avg.Peg.Test + Chair.Rise +
TUG.AVG + LA.TotStr + MA.TotStr, data = ActivityData)
#Final Model
TotActFinal <- step(TotActFull, direction = "backward", trace = 0)
summary(TotActFinal)
extractAIC(TotActFinal)
outlierTest(TotActFinal)
par(mfrow=c(2,2))
plot(TotActFinal, which = c(1:2,4:5))
```

```
> library(car)
> str(ActivityData)
'data.frame':      34 obs. of  8 variables:
 $ MVPA          : int  13 32 33 18 60 39 16 25 22 21 ...
 $ Total.Activity: int  179 272 237 201 286 276 232 267 219 204 ...
 $ Walk.Speed    : num  1.28 1.49 1.54 1.46 1.68 2.1 1.63 2.11 1.25 ..
 $ Avg.Peg.Test  : num  23.1 17.7 17.9 23.1 18 ...
 $ Chair.Rise    : num  20.75 9.85 11.43 12.22 11.59 ...
 $ TUG.AVG       : num  8.55 6.88 6.5 7.41 7.36 ...
 $ LA.TotStr     : num  4.64 7.25 10.57 8.58 11.14 ...
 $ MA.TotStr     : num  4.62 6.1 9.42 7.76 9.8 ...
> #Full Model
> TotActFull <- lm(Total.Activity ~ Walk.Speed + Avg.Peg.Test + Chair.Rise
+ TUG.AVG + LA.TotStr + MA.TotStr, data = ActivityData)
> #Final Model
> TotActFinal <- step(TotActFull, direction = "backward", trace = 0)
> summary(TotActFinal)

Call:
lm(formula = Total.Activity ~ Walk.Speed + Chair.Rise + TUG.AVG,
    data = ActivityData)

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  148.171     88.500   1.674  0.10448
Walk.Speed    69.767     39.310   1.775  0.08608 .
Chair.Rise    -9.057      3.283  -2.759  0.00979 **
TUG.AVG       12.287      5.849   2.101  0.04417 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 49.58 on 30 degrees of freedom
Multiple R-squared:   0.44,     Adjusted R-squared:  0.384
F-statistic: 7.858 on 3 and 30 DF,  p-value: 0.0005148
```

MS Activity 2 continued (Questions 11 through 15)

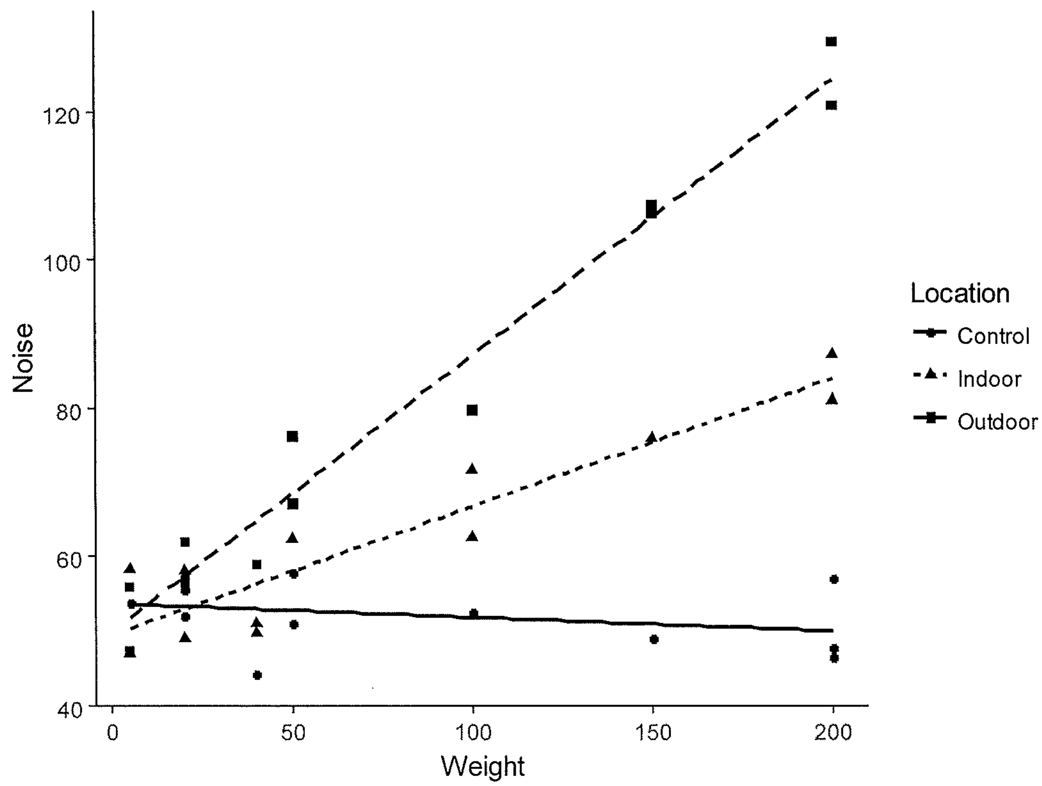
```
> extractAIC(TotActFinal)
[1]   4.0000 269.1942
> outlierTest(TotActFinal)

No Studentized residuals with Bonferonni p < 0.05
Largest |rstudent|:
    rstudent unadjusted p-value Bonferonni p
29 -2.835026           0.008263      0.28094

> par(mfrow=c(2,2))
> plot(TotActFinal, which = c(1:2,4:5))
```



Firing Range (Questions 18 through 26)

```
library(ggplot2)
library(car)
library(emmeans)
str(RangeData)
p <- qplot(Weight, Noise, shape = Location, group = Location, data =
RangeData)
p + geom_smooth(method = "lm", se = FALSE, aes(linetype = Location), color
= "black") + theme_classic()
FRModel <- lm(Noise ~ Location*Weight, data = RangeData)
Anova(FRModel, type = 3)
summary(FRModel)
emtrends(FRModel, pairwise ~ Location,var = "Weight")
```

```
> library(car)
> library(emmeans)
> str(RangeData)
'data.frame':	36 obs. of  3 variables:
 $ Location: Factor w/ 3 levels "Control","Indoor",..: 2 2 2 2 2 2 2...
 $ Weight  : int  5 5 20 20 40 40 50 100 100 150 ...
 $ Noise   : num  58.4 47 48.9 58.1 49.7 51 62.3 71.6 62.5 76 ...
> p <- qplot(Weight, Noise, shape = Location, group = Location, data = Ran
geData)
> p + geom_smooth(method = "lm", se = FALSE, aes(linetype = Location), col
or = "black") + theme_classic()
```




```
> FRModel <- lm(Noise ~ Location*Weight, data = RangeData)
```

Firing Range continued (Questions 18 through 26)

```
> Anova(FRModel, type = 3)
Anova Table (Type III tests)

Response: Noise
                 Sum Sq Df  F value    Pr(>F)
(Intercept)     14562.7  1 605.3154 < 2.2e-16 ***
Location           55.3  2   1.1494    0.3304
Weight             23.1  1   0.9606    0.3349
Location:Weight  4892.8  2 101.6878 4.325e-14 ***
Residuals         721.7 30
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> summary(FRModel)

Call:
lm(formula = Noise ~ Location * Weight, data = RangeData)

Coefficients:
                        Estimate Std. Error t value Pr(>|t|)
(Intercept)             53.65923    2.18099  24.603  < 2e-16 ***
LocationIndoor          -4.25527    3.04922  -1.396    0.173
LocationOutdoor         -3.74754    3.07503  -1.219    0.232
Weight                  -0.01849    0.01887  -0.980    0.335
LocationIndoor:Weight    0.19156    0.02790   6.867 1.27e-07 ***
LocationOutdoor:Weight   0.39098    0.02742  14.259 6.69e-15 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 4.905 on 30 degrees of freedom
Multiple R-squared:  0.9546,    Adjusted R-squared:  0.947
F-statistic: 126.1 on 5 and 30 DF,  p-value: < 2.2e-16

> emtrends(FRModel, pairwise ~ Location,var = "Weight")
$emtrends
 Location Weight.trend         SE df    lower.CL   upper.CL
 Control    -0.0184936 0.01886877 30 -0.05702877 0.02004157
 Indoor      0.1730671 0.02054886 30  0.13110076 0.21503351
 Outdoor     0.3724846 0.01989608 30  0.33185137 0.41311778

Confidence level used: 0.95

$contrasts
 contrast             estimate         SE df t.ratio p.value
 Control - Indoor   -0.1915607 0.02789778 30  -6.867  <.0001
 Control - Outdoor  -0.3909782 0.02742051 30 -14.259  <.0001
 Indoor - Outdoor   -0.1994174 0.02860261 30  -6.972  <.0001

P value adjustment: tukey method for comparing a family of 3 estimates.
```

EXAM#1 Extra Results

Note: This information was NOT provided during the original exam!

MS Activity

#6

```
> MVPANull <- lm(MVPA ~ 1, data = ActivityData)
> add1(MVPANull, scope = MVPAFull, test = "F")
Single term additions
               Df Sum of Sq   RSS    AIC F value    Pr(>F)
<none>                      14388 207.62
Walk.Speed      1    2733.3 11655 202.46  7.5049 0.009975 **
Avg.Peg.Test    1    1753.4 12634 205.21  4.4410 0.043013 *
Chair.Rise      1    3133.8 11254 201.27  8.9106 0.005396 **
TUG.AVG         1    2727.7 11660 202.48  7.4859 0.010060 *
LA.TotStr       1    3467.3 10921 200.25 10.1600 0.003200 **
MA.TotStr       1    2815.2 11573 202.22  7.7844 0.008807 **
```

#9

```
> NewData <- data.frame(Avg.Peg.Test = 20, LA.TotStr = 8)
> predict(MVPAFinal, newdata = NewData)
       1
34.42654
```

#10

```
> anova(MVPANull, MVPAFinal)
Model 1: MVPA ~ 1
Model 2: MVPA ~ Avg.Peg.Test + LA.TotStr
  Res.Df     RSS Df Sum of Sq      F   Pr(>F)
1     33 14387.9
2     31  9922.6  2    4465.3 6.9753 0.003153 **
```

Firing Range

#20

```
> extractAIC(FRModel)
[1]   6.0000 119.9333
```

#23-24

```
> FRAltModel <- lm(Noise ~ Location + Weight:Location -1, data =
RangeData)
> summary(FRAltModel)
Coefficients:
                       Estimate Std. Error t value Pr(>|t|)
LocationControl        53.65923    2.18099  24.603  < 2e-16 ***
LocationIndoor         49.40396    2.13096  23.184  < 2e-16 ***
LocationOutdoor        49.91169    2.16774  23.025  < 2e-16 ***
LocationControl:Weight -0.01849    0.01887  -0.980    0.335
LocationIndoor:Weight   0.17307    0.02055   8.422 2.12e-09 ***
```

```
LocationOutdoor:Weight  0.37248    0.01990  18.722  < 2e-16 ***
```

#26

```
> emmeans(FRModel, pairwise ~ Location, at = list(Weight = 5))
NOTE: Results may be misleading due to involvement in interactio
ns
$emmeans
 Location   emmean       SE df lower.CL upper.CL
 Control  53.56676 2.110120 30 49.25732 57.87620
 Indoor   50.26930 2.055314 30 46.07179 54.46681
 Outdoor  51.77411 2.093426 30 47.49877 56.04946

Confidence level used: 0.95

$contrasts
 contrast          estimate       SE df t.ratio p.value
 Control - Indoor  3.297462 2.945662 30   1.119  0.5098
 Control - Outdoor 1.792649 2.972379 30   0.603  0.8195
 Indoor - Outdoor -1.504813 2.933726 30  -0.513  0.8656

P value adjustment: tukey method for comparing a family of 3 est
imates

> emmeans(FRModel, pairwise ~ Location, at = list(Weight = 200))
NOTE: Results may be misleading due to involvement in interactio
ns
$emmeans
 Location    emmean       SE df  lower.CL  upper.CL
 Control   49.96051 2.545099 30  44.76272  55.15829
 Indoor    84.01739 2.888132 30  78.11904  89.91574
 Outdoor  124.40860 2.733147 30 118.82677 129.99043

Confidence level used: 0.95

$contrasts
 contrast          estimate       SE df t.ratio p.value
 Control - Indoor -34.05688 3.849524 30  -8.847  <.0001
 Control - Outdoor -74.44810 3.734651 30 -19.934  <.0001
 Indoor - Outdoor -40.39121 3.976355 30 -10.158  <.0001

P value adjustment: tukey method for comparing a family of 3 est
imates
```