```
> library(faraway)  #this command brings in a library of regression functions
> library(psych)

Attaching package: ‘psych’

The following object is masked from ‘package:faraway’:

    logit

> library(stats)
> library(olsrr)
Registered S3 methods overwritten by 'car':
  method                           from
  influence.merMod                 lme4
  cooks.distance.influence.merMod lme4
  dfbeta.influence.merMod          lme4
  dfbetas.influence.merMod         lme4

Attaching package: ‘olsrr’

The following object is masked from ‘package:faraway’:

    hsb

The following object is masked from ‘package:datasets’:

    rivers

> library(car)
Loading required package: carData

Attaching package: ‘car’

The following object is masked from ‘package:psych’:

    logit

The following objects are masked from ‘package:faraway’:

    logit, vif

Warning message:
package ‘car’ was built under R version 3.6.3
>
> #Use the QUASARS dataset from the textbook to examine e(i) where
> #e(i) is [Yi - Yhat(i)] where Yhat(i) is Yhat at xi with the ith observation
deleted
>
```

```
> #read in the data which is in a csv file
> quasars <-
read.csv(file="C:/Users/jmard/Desktop/RegressionMethodsSpring2020/Lecture 03
04FEB2020/QUASAR.csv",header = TRUE)
>
> # n=25 observations on 5 independent variables (covariates) and a response
Y=RFEWIDTH
>
> #Peform a multiple regression using the quasar data with only two predictors:
LINEFLUX and AB1450
> LMOD <- lm(RFEWIDTH ~ LINEFLUX + AB1450,data=quasars)
> summary(LMOD)

Call:
lm(formula = RFEWIDTH ~ LINEFLUX + AB1450, data = quasars)

Residuals:
    Min      1Q  Median      3Q     Max
-18.582  -9.881  -1.723   6.753  49.503

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 1232.778    199.096   6.192 3.12e-06 ***
LINEFLUX     205.424     18.819  10.916 2.39e-10 ***
AB1450        85.739      6.547  13.097 7.28e-12 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 16.32 on 22 degrees of freedom
Multiple R-squared:  0.8913,    Adjusted R-squared:  0.8814
F-statistic: 90.18 on 2 and 22 DF,  p-value: 2.508e-11

>
> windows(7,7)
> #save graph in pdf
>
pdf(file="C:/Users/jmard/Desktop/RegressionMethodsSpring2020/Output/ei_QUASAR_R_o
ut.pdf")
>
> #Studentized Residuals vs Leverage Plot
> #Graph for detecting outliers without leverage and outliers with leverage
> ols_plot_resid_lev(LMOD)
>
> ##-----------------------------------------------------------------##
>
> all_obs <-
data.frame(cbind(quasars$LINEFLUX,quasars$AB1450,quasars$RFEWIDTH,LMOD$fitted.val
ues,LMOD$residuals))
>
> names(all_obs) <- c("LINEFLUX","AB1450","RFEWIDTH","Yhat_all","ei_all")
```

```
> head(all_obs,10L)  #note the values for the row corresponding to observation #8
   LINEFLUX AB1450 RFEWIDTH   Yhat_all     ei_all
1    -13.48  19.50      117 135.582396 -18.582396
2    -13.73  19.65       82  97.087342 -15.087342
3    -13.87  18.93       33   6.595665  26.404335
4    -13.27  18.59       92 100.698582  -8.698582
5    -13.56  19.59      114 126.865032 -12.865032
6    -13.95  19.42       50  32.174045  17.825955
7    -13.83  19.18       43  36.247458   6.752542
8    -13.50  20.41      259 209.496738  49.503262
9    -13.66  18.93       58  49.734670   8.265330
10   -13.71  20.00      126 131.204595  -5.204595
> #Now set RFEWIDTH for observation #8 to missing which excludes the observation
from all regression computations.
> all_obs[8,3] <- NA
> head(all_obs,10L)
   LINEFLUX AB1450 RFEWIDTH   Yhat_all     ei_all
1    -13.48  19.50      117 135.582396 -18.582396
2    -13.73  19.65       82  97.087342 -15.087342
3    -13.87  18.93       33   6.595665  26.404335
4    -13.27  18.59       92 100.698582  -8.698582
5    -13.56  19.59      114 126.865032 -12.865032
6    -13.95  19.42       50  32.174045  17.825955
7    -13.83  19.18       43  36.247458   6.752542
8    -13.50  20.41       NA 209.496738  49.503262
9    -13.66  18.93       58  49.734670   8.265330
10   -13.71  20.00      126 131.204595  -5.204595
>
>
> #Fit the regression model with observation #8 missing
> LMODwo8 <- lm(RFEWIDTH ~ LINEFLUX + AB1450,data=all_obs)
> summary(LMODwo8)

Call:
lm(formula = RFEWIDTH ~ LINEFLUX + AB1450, data = all_obs)

Residuals:
    Min      1Q  Median      3Q     Max
-13.093  -6.310  -1.595   5.062  27.745

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  880.501    131.081   6.717 1.20e-06 ***
LINEFLUX     157.423     13.523  11.641 1.27e-10 ***
AB1450        69.848      4.635  15.069 9.85e-13 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 9.747 on 21 degrees of freedom
  (1 observation deleted due to missingness)
```

```
Multiple R-squared:  0.9154,    Adjusted R-squared:  0.9073
F-statistic: 113.6 on 2 and 21 DF,  p-value: 5.489e-12

> LMODwo8$fitted  #note the missing fitted value for observation #8.  We obtain
the fit at observation #8 below.
        1         2         3         4         5         6         7         9
120.47795  91.59945  19.26970  89.97504 114.17045  40.90140  43.02861  52.32848
       10        11        12        13        14        15        16        17
119.19471  43.98908 118.25542 119.14176  76.20112  93.36154  96.43586  64.00419
       18        19        20        21        22        23        24        25
 94.27688 121.75841  78.35733  63.46180  53.96348  66.25572 112.09342  56.49818
>
> x_at_8 <- data.frame(LINEFLUX=-13.5,AB1450=20.41)
>
> fit_at_8_wo8 <- predict(LMODwo8,newdata = x_at_8)
> fit_at_8_wo8
       1
180.8912
>
>  quasars[8, ] #print the 8th row of quasars
  QUASAR REDSHIFT LINEFLUX LUMINOSITY AB1450 ABSMAG RFEWIDTH
8      8     2.81    -13.5      45.27  20.41 -25.36      259
>
> e_at_8_wo8 <- quasars[8,7] - fit_at_8_wo8
> e_at_8_wo8
       1
78.10882
>
> check <- 259 - (880.501 + (157.423*-13.5) + (69.848*20.41))  #RFEWIDTH at obs 8
- Fit at obs 8
> check
[1] 78.11182
>
> LMOD$residuals
          1           2           3           4           5           6
-18.5823958 -15.0873417  26.4043354  -8.6985816 -12.8650317  17.8259548
          7           8           9          10          11          12
  6.7525416  49.5032618   8.2653304  -5.2045950   0.5524107  18.9947144
         13          14          15          16          17          18
 -4.7025411  -1.7234498 -14.9814419   8.4129569  -7.9700885  -4.0123976
         19          20          21          22          23          24
-15.7926644   0.8694368   1.5486756  -0.6238405  -9.8808988 -18.1261402
         25
 -0.8782098
> LMODwo8$residuals
           1           2           3           4           5           6
 -3.47794682  -9.59945329  13.73030133   2.02495669  -0.17044522   9.09859984
           7           9          10          11          12          13
 -0.02861176   5.67151778   6.80528842  -1.98908310  27.74457886   4.85824069
          14          15          16          17          18          19
```

All residuals are shown on the next page.

i	ei	e(8)
1	-18.582	-3.478
2	-15.087	-9.599
3	26.404	13.730
4	-8.699	2.025
5	-12.865	-0.170
6	17.826	9.099
7	6.753	-0.029
8	49.503	78.112
9	8.265	5.672
10	-5.205	6.805
11	0.552	-1.989
12	18.995	27.745
13	-4.703	4.858
14	-1.723	-1.201
15	-14.981	-8.362
16	8.413	12.564
17	-7.970	-9.004
18	-4.012	-3.277
19	-15.793	-5.758
20	0.869	-3.357
21	1.549	-0.462
22	-0.624	-7.963
23	-9.881	-11.256
24	-18.126	-13.093
25	-0.878	-3.498