STAT 430
SAS Examples SAS5
==========
ssh xyz@glue.umd.edu , tap sas913 (old sas82), sas
https://www.statlab.umd.edu/sasdoc/sashtml/onldoc.htm

CH5: CORR & SIMPLE LINEAR REFRESSION
==========

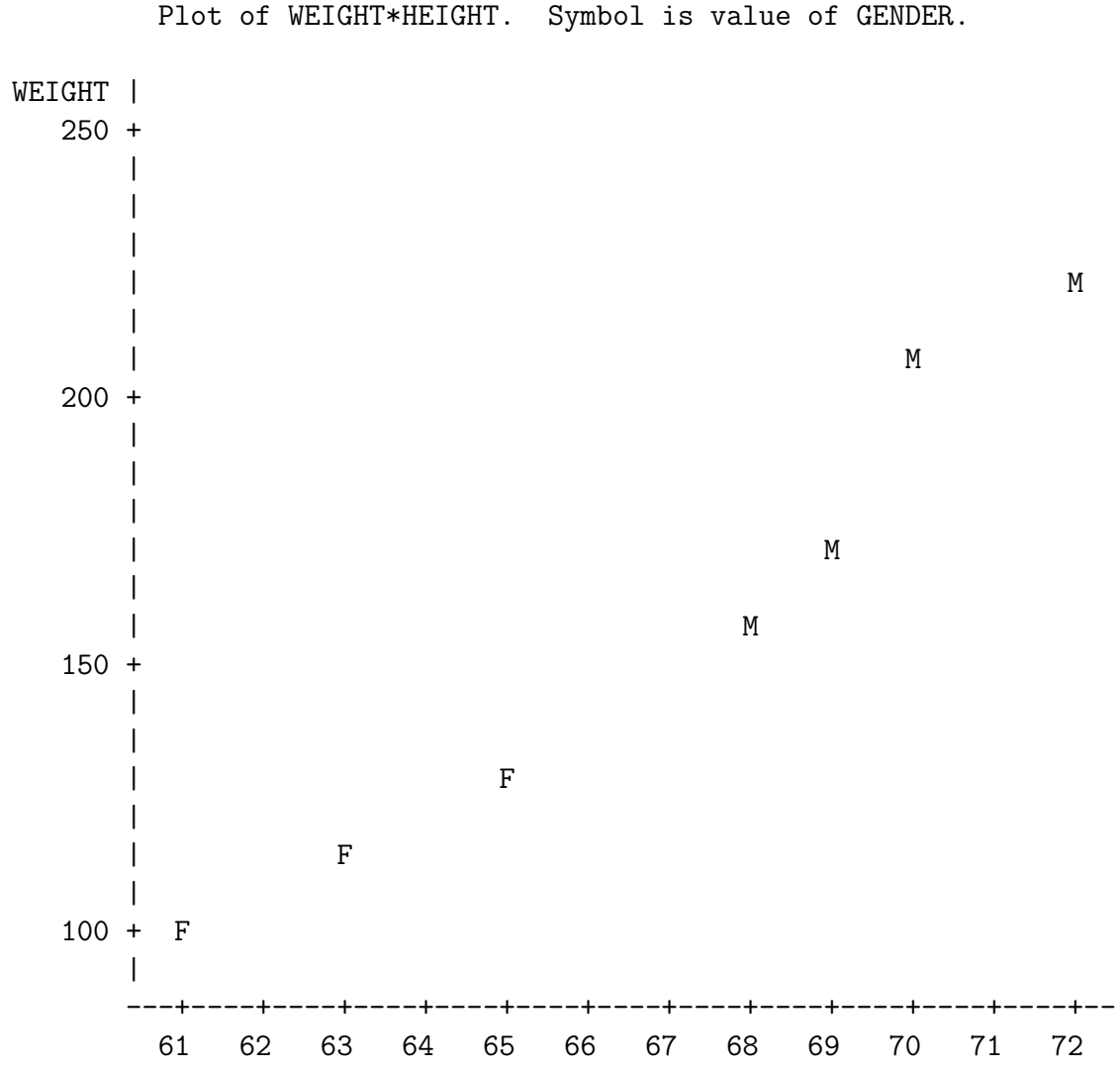
1. Pearson Correlation
2. Spearman Correlation
3. Partial Correlation
4. Simple Linear Regression
5. Adding a Quadratic Term
6. Transforming Data to Get a Better Fit
7. Computing Within-Subject Slopes
8. An Additional Example.

1. Pearson Correlation

```
OPTION PS=35 LS=70;

a. From PROC CORR get also simple statistics.
b. CORR ignores missing data.

DATA SET1;
INPUT GENDER $ HEIGHT WEIGHT AGE;
DATALINES;
M 68 155 23
F 61  99 20
F 63 115 21
M 70 205 45
M 69 170  .
F 65 125 30
M 72 220 48
;
```

Good idea to first plot to get an idea of the relationships!!!

```
PROC PLOT DATA=SET1;
PLOT WEIGHT*HEIGHT=GENDER;
RUN;
```

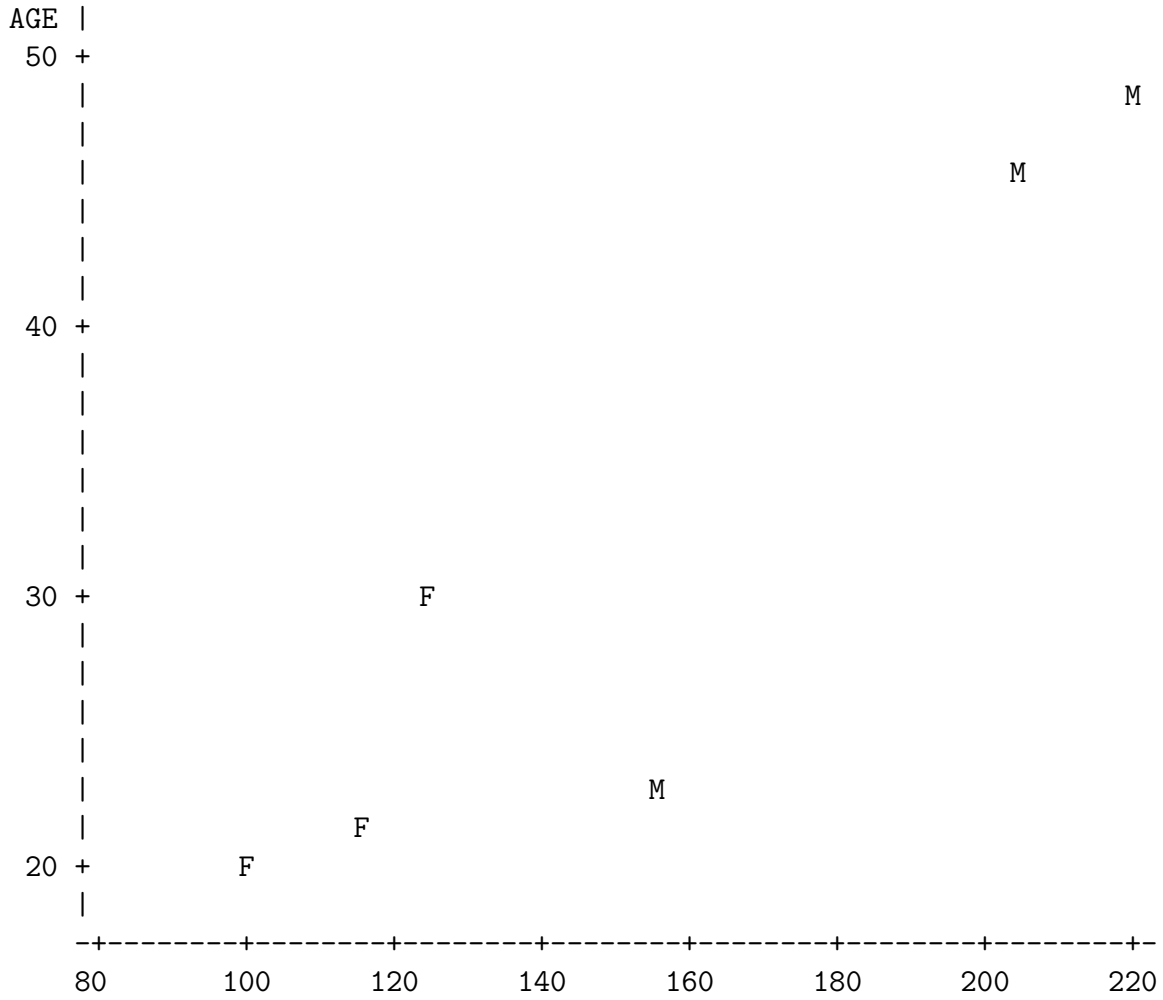


HEIGHT

Expect high corr between HEIGHT and WEIGHT!!!

```
PROC PLOT DATA=SET1;
PLOT AGE*WEIGHT=GENDER;
RUN;
```

Plot of AGE*WEIGHT. Symbol is value of GENDER.



```
NOTE: 1 obs had missing values.

Expect a pretty high corr between WEIGHT and AGE!!!


PROC CORR DATA=SET1;
TITLE 'EXAMPLE OF CORR MATRIX';
VAR HEIGHT WEIGHT AGE;
RUN;
```

3 Variables: HEIGHT WEIGHT AGE

Simple Statistics

Variable	N	Mean	Std Dev	Sum
HEIGHT	7	66.85714	3.97612	468.00000
WEIGHT	7	155.57143	45.79613	1089
AGE	6	31.16667	12.41639	187.00000

Simple Statistics

Variable	Minimum	Maximum
HEIGHT	61.00000	72.00000
WEIGHT	99.00000	220.00000
AGE	20.00000	48.00000

The CORR Procedure

Pearson Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	HEIGHT	WEIGHT	AGE
HEIGHT	1.00000	0.97165	0.86614
		0.0003	0.0257
	7	7	6
WEIGHT	0.97165	1.00000	0.92496
	0.0003		0.0082
	7	7	6
AGE	0.86614	0.92496	1.00000
	0.0257	0.0082	
	6	6	6

NOTE: The corr between HEIGHT, WEIGHT and AGE was obtained from the 6 full pairs excluding the row "M 69 170 ." where AGE is missing.

If only need corr(AGE,HEIGHT) AND corr(AGE,WEIGHT) use WITH!!!

```
PROC CORR DATA=SET1 PEARSON NOSIMPLE;
VAR HEIGHT WEIGHT;
WITH AGE;
RUN;
```

The CORR Procedure

1 With Variables: AGE
2 Variables: HEIGHT WEIGHT

Pearson Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	HEIGHT	WEIGHT
AGE	0.86614	0.92496
	0.0257	0.0082
	6	6

2. Spearman Correlation
---

c. Use the option NOSIMPLE if simple statistics are not needed.
d. To get SPEARMAN corr, we must use the PEARSON option as well.
e. In our exmple we have:

Rank of Height1 is 4, Rank of Height2 is 1, Rank of Height3 is 2 etc.

```
Ranks(Height)= 4 1 2 6 5 3 7
Ranks(Weight)= 4 1 2 6 5 3 7
Ranks(Age)=    3 1 2 5 . 4 6
```

```
              4   1  2   6   5   3   7          4  1  2  6  5  3  7
NOTE: Weight 155 99 115 205 170 125 220  Height 68 61 63 70 69 65 72
```

***SPEARMAN is the correlation of the ranks. Since in this example Weight and Height have the same ranks, SC=1.

```
PROC CORR DATA=SET1 PEARSON SPEARMAN NOSIMPLE;
TITLE 'EXAMPLE OF CORR MATRIX';
VAR HEIGHT WEIGHT AGE;
RUN;
```

The CORR Procedure

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	HEIGHT	WEIGHT	AGE
HEIGHT	1.00000	1.00000	0.94286
		<.0001	0.0048
	7	7	6
WEIGHT	1.00000	1.00000	0.94286
	<.0001		0.0048
	7	7	6
AGE	0.94286	0.94286	1.00000
	0.0048	0.0048	
	6	6	6

3. Partial Correlation

We can remove the effect of AGE using Partial Coor:

```
PROC CORR DATA=SET1 PEARSON NOSIMPLE;
VAR HEIGHT WEIGHT;
PARTIAL AGE;
RUN;
```

The CORR Procedure

```
          1 Partial Variables:    AGE
          2         Variables:    HEIGHT   WEIGHT


      Pearson Partial Correlation Coefficients, N = 6
            Prob > |r| under H0: Partial Rho=0

                              HEIGHT        WEIGHT

          HEIGHT             1.00000       0.91934
                                            0.0272

          WEIGHT             0.91934       1.00000
                              0.0272
```

4. Simple Linear Regression

Use: PROC REG < options > ;

FIT: y=a+bx

General form of PROC REG is:

```
PROC REG DATA=DATASET;
MODEL DEPENDENT VARIABLE(S) = INDEPENDENT VARIABLES / OPTIONS;
RUN;

OPTION PS=35 LS=70;

DATA SET1;
INPUT GENDER $ HEIGHT WEIGHT AGE;
DATALINES;
M 68 155 23
```

```
F 61  99 20
F 63 115 21
M 70 205 45
M 69 170  .
F 65 125 30
M 72 220 48
;

PROC REG DATA=SET1;
MODEL WEIGHT=HEIGHT;  (Weight = a + b*Height + e)
RUN;
```

The REG Procedure
Model: MODEL1
Dependent Variable: WEIGHT

n=7,r=2,q=1,n-r=5,n-1=6,k=1 (one slope b), H_0: b=0

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	q=1	11880	11880	84.45	0.0003
Error	n-r=5	703.38705	140.67741		
Corrected Total	n-1=6	12584			

Root MSE	11.86075	R-Square	0.9441
Dependent Mean	155.57143	Adj R-Sq	0.9329
Coeff Var	7.62399		

Note:
Coeff Var=(Root MSE)/(Dependent Mean)}*100 =
11.86075*100/155.57143=7.62399

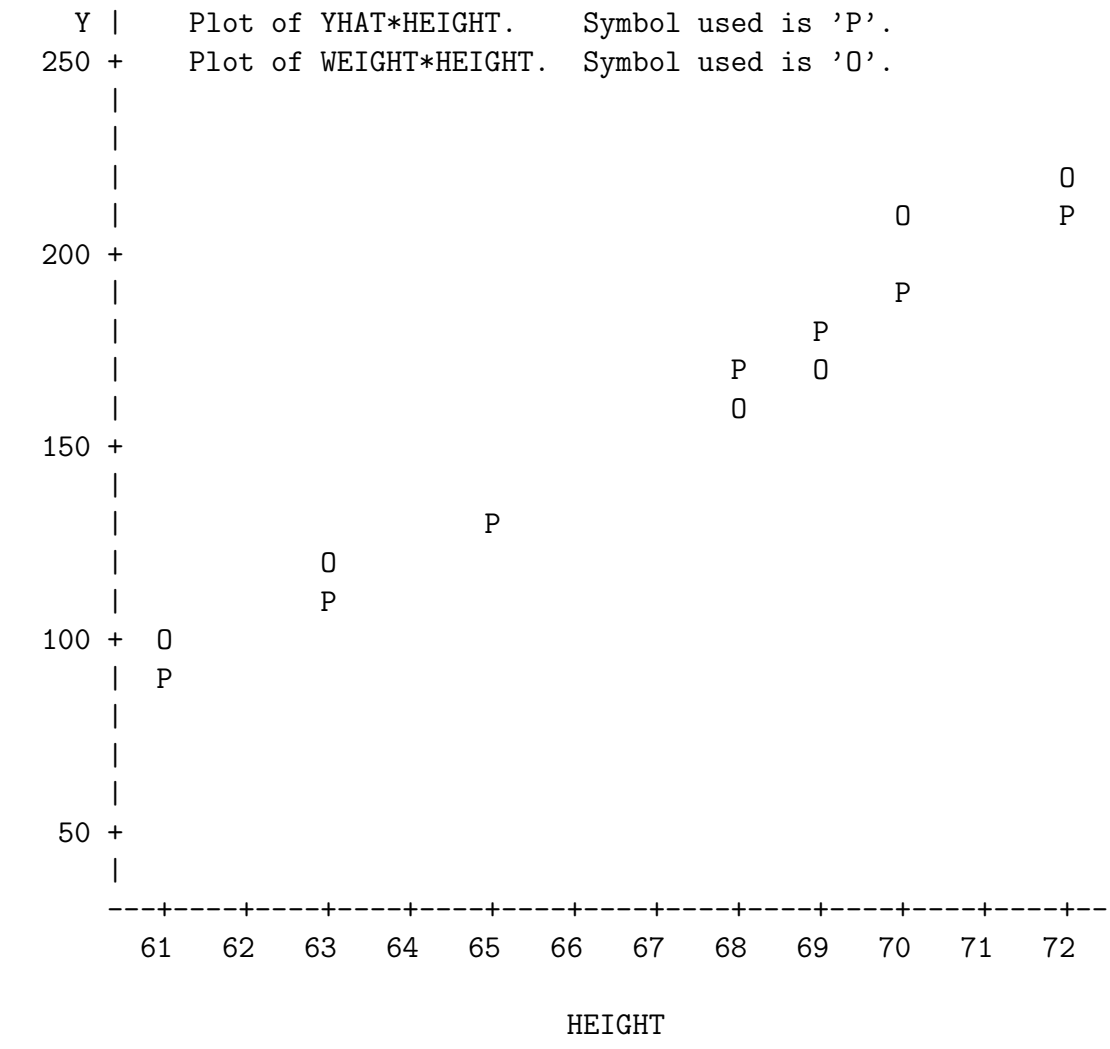
```
Note:  Adj R-Sq = {(n-1)*R^2 - k}/(n-k-1)=(6*0.9441-1)/(7-1-1)=0.93292
```

Parameter Estimates

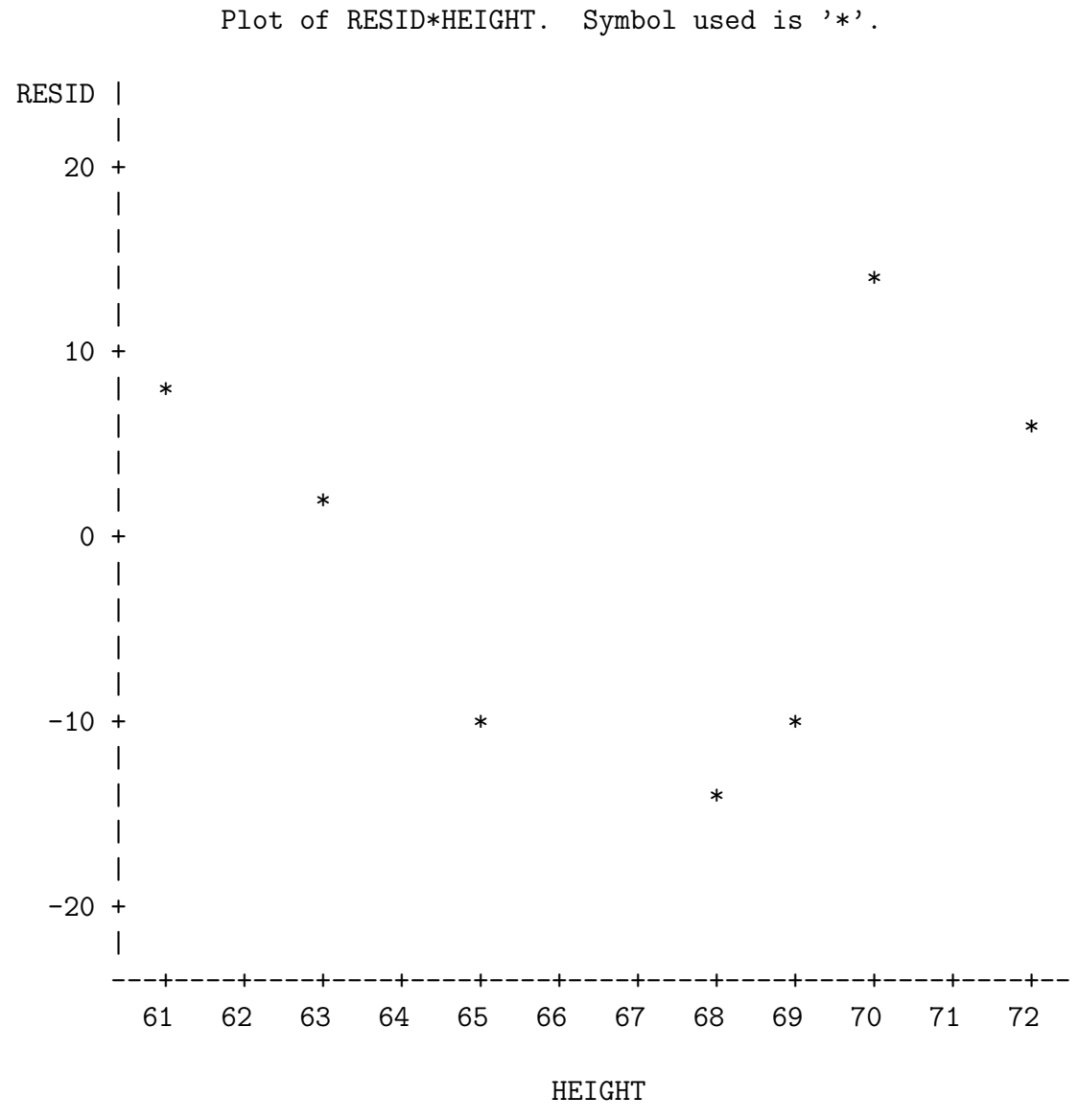
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-592.64458	81.54217	-7.27	0.0008
HEIGHT	1	11.19127	1.21780	9.19	0.0003

```
Note:
P(|T| > |-7.27|)=2*P(T < -7.27) = 0.000769 with df = n-r = 5.
P(|T| > 9.19)   =2*P(T < -9.19) = 0.000256 with df = n-r = 5.


-----------------------------------------------------
Fitted model: WEIGHT =  -592.64458 + 11.19127*HEIGHT
-----------------------------------------------------

Plotting predicted and actual observation on the same plot:
-----------------------------------------------------------

PROC REG DATA=SET1;
MODEL WEIGHT=HEIGHT;
PLOT PREDICTED. *HEIGHT = 'P' WEIGHT*HEIGHT='O' / OVERLAY;
RUN;

The book suggests that but we get a graphical window we cannot select
and paste. So, to get around this problem, define the regression line
in the DATA statement and then plot!

DATA SET1;
INPUT GENDER $ HEIGHT WEIGHT AGE;
YHAT = -592.64458 + 11.19127*HEIGHT; <---Estimated regression line
DATALINES;
M 68 155 23
F 61  99 20
```

```
F 63 115 21
M 70 205 45
M 69 170  .
F 65 125 30
M 72 220 48
;

PROC PLOT DATA=SET1;
PLOT YHAT*HEIGHT='P' WEIGHT*HEIGHT='O'/OVERLAY;
RUN;
```



```
NOTE: 1 obs hidden. <------ Obs too close to Pred


Plot of residuals once using RESIDUAL. and once
using the same trick of defining the residuals
in the DATA statement:

DATA SET1;
INPUT GENDER $ HEIGHT WEIGHT AGE;
/* My definition of YHAT and RESID for resid plot not using RESIDUAL.*/
YHAT = -592.64458 + 11.19127*HEIGHT; <---Estimated regression line
RESID=WEIGHT-YHAT;
DATALINES;
M 68 155 23
F 61  99 20
F 63 115 21
M 70 205 45
M 69 170  .
F 65 125 30
M 72 220 48
;


PROC REG DATA=SET1;           <--- Does regression and gives
MODEL WEIGHT=HEIGHT;               Residual plot using RESIDUAL.
PLOT RESIDUAL. *HEIGHT='O';        But uses GUI of SAS!!!
RUN;

To bypass GUI of SAS, we can declare the new variables
YHAT = -592.64458 + 11.19127*HEIGHT;
RESID=WEIGHT-YHAT;
and then use:

PROC PLOT DATA=SET1;
PLOT RESID*HEIGHT='*';
RUN;
```



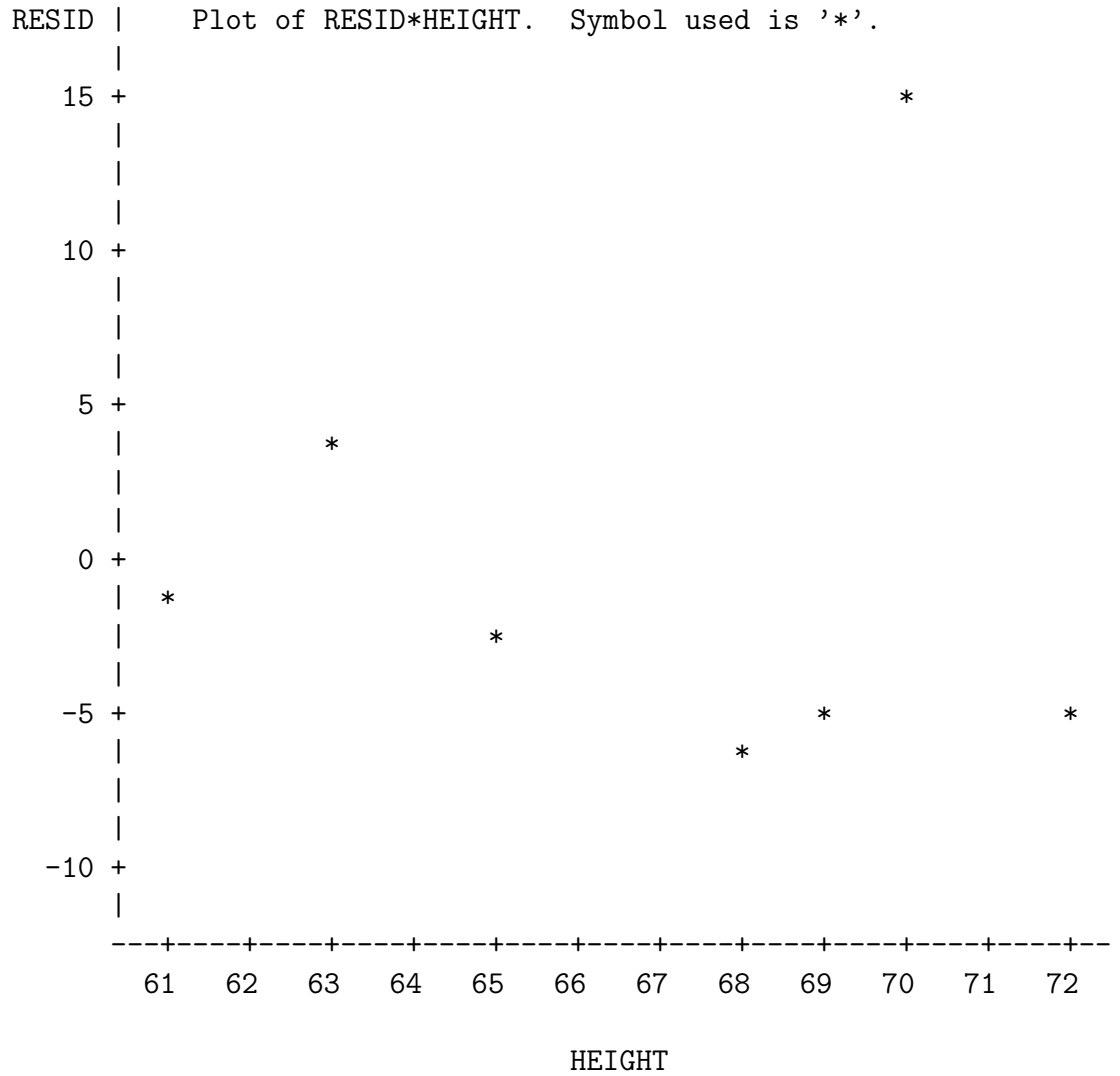
5. Adding a quadratic term: Get higher R^2!!!

```
The residual plot suggests we add a quadratic term in the regresion
eq!!!

DATA SET1;
INPUT GENDER $ HEIGHT WEIGHT AGE;
/* My definition of YHAT and RESID for resid plot not using RESIDUAL.*/
YHAT = 2321.12131 + -76.84468*HEIGHT + 0.66290*HEIGHT**2;
RESID=WEIGHT-YHAT;
HEIGHT2=HEIGHT**2;
DATALINES;
M 68 155 23
F 61  99 20
F 63 115 21
M 70 205 45
M 69 170  .
F 65 125 30
M 72 220 48
;

PROC REG DATA=SET1;                Model: w=a+b_1*H+b_2*H^2+e
MODEL WEIGHT=HEIGHT HEIGHT2;  <--- Does regression and gives
PLOT RESIDUAL. *HEIGHT='O';        Residual plot. But plot is on gui!
RUN;

The REG Procedure, Model: MODEL1, Dependent Variable: WEIGHT
Analysis of Variance: n=7,r=3,q=2,k=2 (b_1,b_2), H_0:b_1=b_2=0

                                Sum of         Mean
 Source                  DF      Squares       Square  F Value  Pr > F

 Model                  q=2        12261   6130.45691    75.97  0.0007
 Error                n-r=4    322.80046     80.70012
 Corrected Total      n-1=6        12584


         Root MSE              8.98332    R-Square     0.9743<--Higher!
         Dependent Mean      155.57143    Adj R-Sq     0.9615
         Coeff Var             5.77440
```

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	2321.12131	1343.15025	1.73	0.1590
HEIGHT	1	-76.84468	40.54924	-1.90	0.1310
HEIGHT2	1	0.66290	0.30525	2.17	0.0956

```
Note: df=4
2*P(T_4 < -1.73)=0.1590, but  2*P(T_1 < -1.73)=0.337
2*P(T_4 < -1.90)=0.1302
2*P(T_4 < -2.17)=0.0958


My trick: To bypass GUI, define YHAT and RESID!!! in DATA statement as above:
YHAT = 2321.12131 + -76.84468*HEIGHT + 0.66290*HEIGHT**2;
RESID=WEIGHT-YHAT;
Then use:


PROC PLOT DATA=SET1;
PLOT RESID*HEIGHT='*';
RUN;
```



6. Transforming Data to get a better fit

```
----------------------------------------
OPTION PS=35 LS=70;

DATA HEART;
INPUT DOSE HR;
DATALINES;
 2 60
```

```
 2 58
 4 63
 4 62
 8 67
 8 65      NOTE: n=10
16 70
16 70
32 74
32 73
;

PROC PLOT DATA=HEART;
PLOT HR*DOSE='o';    <--- HR=a+b*DOSE+e
RUN;
```

```
HR |     Plot of HR*DOSE.  Symbol used is 'o'. Looks like log!!!
   |
74 +                                                              o
73 +                                                              o
72 +
71 +
70 +                               o
69 +
68 +
67 +              o
66 +
65 +              o
64 +
63 +      o
62 +      o
61 +
60 +  o
59 +
58 +  o
   |
   ---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+--
      2   4   6   8  10  12  14  16  18  20  22  24  26  28  30  32
```

DOSE

NOTE: 1 obs hidden. <-- SINCE WE HAVE TWO PAIRS (16,70).

The plot is not exactly linear, but appears on log scale. So
first we run linear simple regression and then we'll use log(DOSE).

```
PROC REG DATA=HEART;
MODEL HR=DOSE;
RUN;
```

The REG Procedure, Model: MODEL1, Dependent Variable: HR
Analysis of Variance

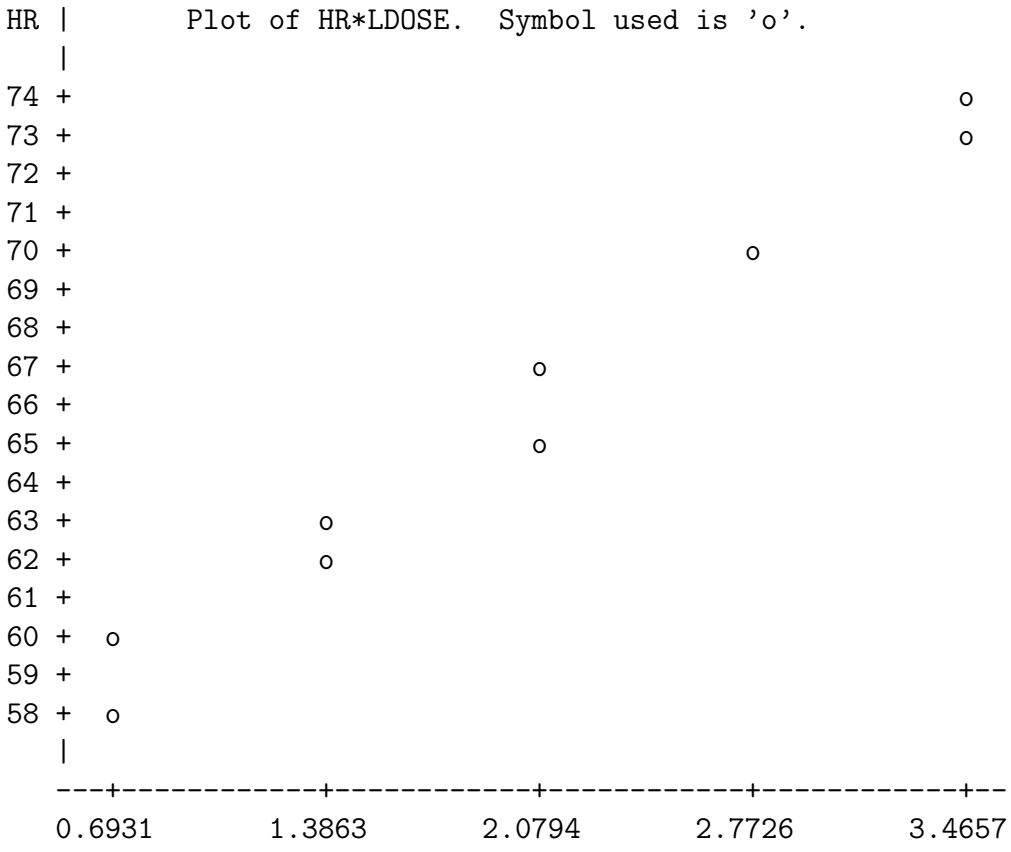
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	233.48441	233.48441	49.01	0.0001
Error	8	38.11559	4.76445		
Corrected Total	9	271.60000			

Root MSE	2.18276	R-Square	0.8597	<--Can be improved.
Dependent Mean	66.20000	Adj R-Sq	0.8421	
Coeff Var	3.29722			

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	60.70833	1.04492	58.10	<.0001
DOSE	1	0.44288	0.06326	7.00	0.0001

```
NOW USE THE LOG TRANSFORMATION!!!


DATA HEART;
INPUT DOSE HR;
LDOSE=LOG(DOSE); <--Dose on log-scale.
DATALINES;
 2 60
 2 58
 4 63
 4 62
 8 67
 8 65
16 70
16 70
32 74
32 73
;

PROC PLOT DATA=HEART;
PLOT HR*LDOSE='o';
RUN;
```



NOTE: 1 obs hidden.

LOOKS LINEAR!!!

```
PROC REG DATA=HEART;
MODEL HR=LDOSE;   <---HR=a+b*log(DOSE)+e
RUN;
```

Get a much larger R^2=0.9810. Before we had R^2=0.8597.

The REG Procedure
Model: MODEL1
Dependent Variable: HR

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	266.45000	266.45000	413.90	<.0001
Error	8	5.15000	0.64375		
Corrected Total	9	271.60000			

Root MSE	0.80234	R-Square	0.9810
Dependent Mean	66.20000	Adj R-Sq	0.9787
Coeff Var	1.21199		

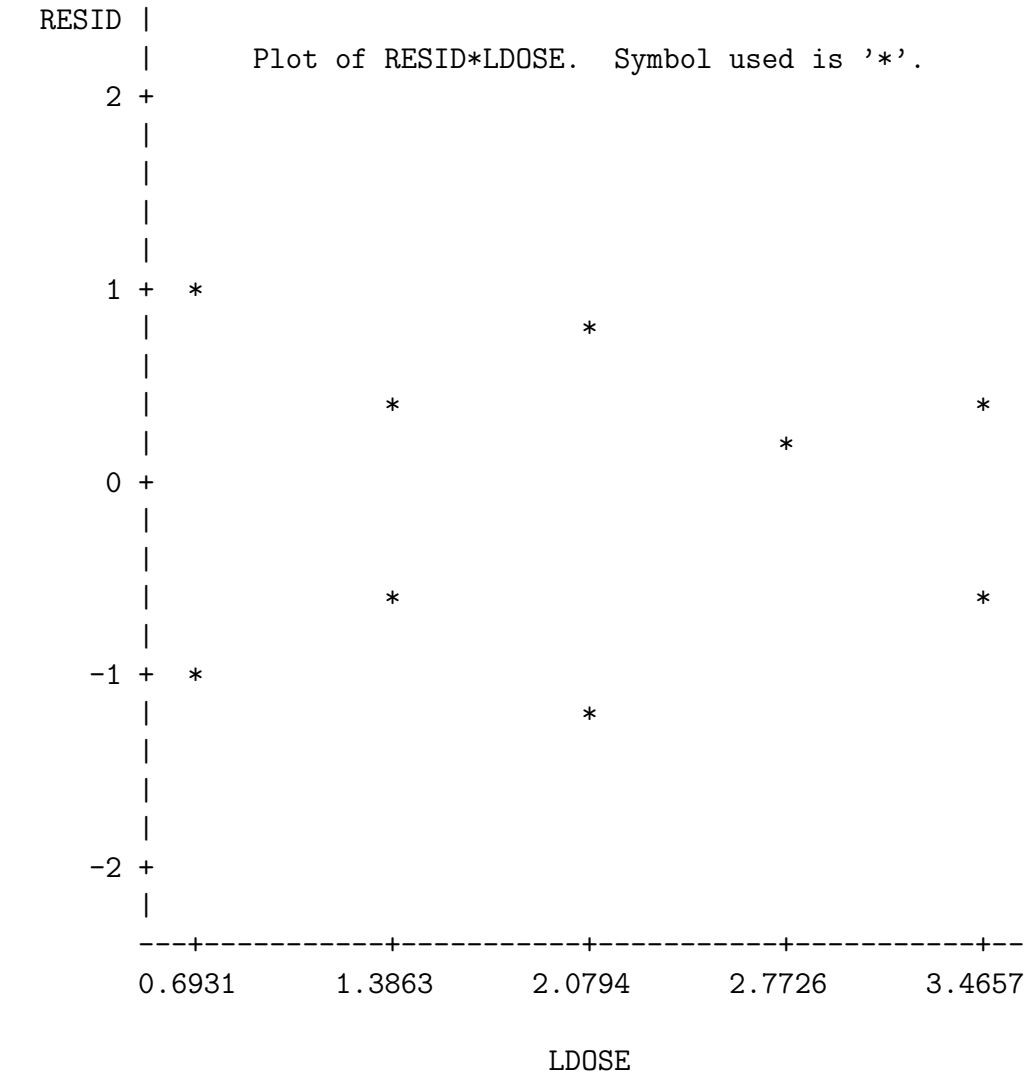
Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	55.25000	0.59503	92.85	<.0001
LDOSE	1	5.26584	0.25883	20.34	<.0001

```
PROC REG DATA=HEART;
MODEL HR=LDOSE;              <--- Does regression and gives
PLOT RESIDUAL. *LDOSE='O';        Residual plot. But plot is on gui!!!
RUN;
```

Simpler: Define the residuals in DATA STATEMENT

```
DATA HEART;
INPUT DOSE HR;
LDOSE=LOG(DOSE);
/* My definition of YHAT and RESID for resid plot not using RESIDUAL.*/
YHAT =55.25000 + 5.26584*LDOSE;
RESID=HR-YHAT;
DATALINES;
 2 60
 2 58
 4 63
 4 62
 8 67
 8 65
16 70
16 70
32 74
32 73
;


PROC PLOT DATA=HEART;
PLOT RESID*LDOSE='*';
RUN;
```



NOTE: 1 obs hidden.

7. Computing Within-Subject Slopes

Get slope from repeated measures for each subject. This is done

with the option OUTSET in REG which creates a new data set listing the slopes and intercepts.

```
OPTION PS=35 LS=70;

DATA TEST;
INPUT ID GROUP $ TIME SCORE;
DATALINES;
1 A 1 2
1 A 2 5
1 A 3 7
2 A 1 4
2 A 2 6
2 A 3 9
3 B 1 8
3 B 2 6
3 B 3 2
4 B 1 8
4 B 2 7
4 B 3 3
;

PROC SORT DATA=TEST;  <--Need this first
BY ID;
RUN;

PROC REG OUTSET=SLOPES DATA=TEST;
BY ID;
ID GROUP;
MODEL SCORE=TIME / NOPRINT;
RUN;



PROC PRINT DATA=SLOPES;
RUN;
```

Obs	ID	_MODEL_	_TYPE_	_DEPVAR_	_RMSE_	Intercept	TIME	SCORE
1	1	MODEL1	PARMS	SCORE	0.40825	-0.3333	2.5	-1
2	2	MODEL1	PARMS	SCORE	0.40825	1.3333	2.5	-1
3	3	MODEL1	PARMS	SCORE	0.81650	11.3333	-3.0	-1
4	4	MODEL1	PARMS	SCORE	1.22474	11.0000	-2.5	-1

We can also compare the slope means between groups by a t-test:

```
PROC TTEST DATA=SLOPES;
CLASS GROUP;
VAR TIME;
RUN;
```

Another Example: Blood Pressure
==========

```
OPTION PS=35 LS=70;

DATA BP;
INPUT SysBP  DiasBP;
DATALINES;
180 110
190 108
178 100
170 100
180 98
168 88
160 80
160 80
172 86
```

```
170 86
140 80
130 72
128 70
;


PROC CORR DATA=BP PEARSON NOSIMPLE;
VAR  SysBP  DiasBP;
RUN;
```

The SAS System

The CORR Procedure

2 Variables: SysBP DiasBP

Pearson Correlation Coefficients, N = 13
Prob > |r| under H0: Rho=0

	SysBP	DiasBP
SysBP	1.00000	0.88221 <.0001
DiasBP	0.88221 <.0001	1.00000

```
PROC REG DATA=BP;
MODEL SysBP=DiasBP;
RUN;
```

The REG Procedure
Model: MODEL1
Dependent Variable: SysBP

Number of Observations Read	13
Number of Observations Used	13

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	3574.85010	3574.85010	38.61	<.0001
Error	11	1018.38066	92.58006		
Corrected Total	12	4593.23077			

Root MSE	9.62185	R-Square	0.7783
Dependent Mean	163.53846	Adj R-Sq	0.7581
Coeff Var	5.88354		

Note: R^2=0.7783^2=0.88221 = Corr(SysBP,DiasBP)= 0.88221

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	45.53172	19.17710	2.37	0.0369
DiasBP	1	1.32477	0.21319	6.21	<.0001