STAT 662 HomeWork 3

45.5/50

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- Question 1
- Question 2
- Question 3
- SAS code & output

Question 1

a) Factor A : Water Amount ✓ $a=2$

Factor B : Autolyse time $b=4$

$N = abn = 2 \times 4 \times 3 = 24$ $n=3$

Factor levels

b) **Provide the specific factor levels, not the number of levels. -0.5**

c) 8 treatment groups = 315 grams & 30 mins, 320 grams & 30 mins

315 grams & 60 mins, 320 grams & 60 mins ✓

315 grams & 90 mins, 320 grams & 90 mins

315 grams & 120 mins, 320 grams & 120 mins

d) **define**

$$y_{ijk} = \mu + \tau_i + \beta_j + (\tau\beta)_{ij} + \epsilon_{ijk}$$

μ: overall population mean of loaf heights **-0.5**

τ_i: effect of ith level of Water Amount $(i=1,2)$

β_j: effect of jth level of Autolyse time $(j=1,2,3,4)$

$(\tau\beta)_{ij}$: the interaction effect of ith level of Water Amount and jth level of Autolyze time, $\left(\begin{array}{l} i=1,2 \\ j=1,2,3,4 \end{array}\right)$

ϵ_{ijk}: random error of kth **dough mix** ~~experiment unit~~ from ith level of Water Amount and jth level of Autolyze time

$(i=1,2;\ j=1,2,3,4;\ k=1,2,3)$

e) Constraints :

$$\sum_{i=1}^{a} \tau_i = 0$$

$$\sum_{j=1}^{b} \beta_j = 0$$ ✓

$$\sum_{i=1}^{a} (\tau\beta)_{ij} = 0, \quad j=1,2,3,4$$

$$\sum_{j=1}^{b} (\tau\beta)_{ij} = 0, \quad i=1,2$$

f) Assumptions : $\epsilon_{ijk} \overset{iid}{\sim} N(0, \sigma^2)$ ✓

Normality

Independent

Constant Variance

g) $\mu = \bar{y}_{...} = 10.60$

$\tau_i = \bar{y}_{i..} - \bar{y}_{...}$

Factor A	$\bar{y}_{i..}$	τ_i
315 grams	10.10	10.10 − 10.60 = −0.5
320 grams	11.10	11.10 − 10.60 = 0.5

$\beta_j = \bar{y}_{.j.} - \bar{y}_{...}$

Factor B	30 min	60 min	90 min	120 min
$\bar{y}_{.j.}$	9.40	10.75	11.10	11.15
β_j	−1.2	0.15	0.5	0.55

$(\tau\beta)_{ij} = \bar{y}_{ij.} - \bar{y}_{i..} - \bar{y}_{.j.} + \bar{y}_{...}$

$(\tau\beta)_{11} = 8.5 - 9.4 - 10.10 + 10.60 = -0.4$

$(\tau\beta)_{12} = 9.4 - 10.75 - 10.10 + 10.60 = -0.85$

$(\tau\beta)_{13} = 10.50 - 11.10 - 10.10 + 10.60 = -0.1$

$(\tau\beta)_{14} = 12.00 - 11.15 - 10.10 + 10.60 = 1.35$

$(\tau\beta)_{21} = 10.30 - 9.4 - 11.10 + 10.60 = 0.4$

$(\tau\beta)_{22} = 12.10 - 10.75 - 11.10 + 10.60 = 0.85$

$(\tau\beta)_{23} = 11.70 - 11.10 - 11.10 + 10.60 = 0.1$

$(\tau\beta)_{24} = 10.30 - 11.15 - 11.10 + 10.60 = -1.35$

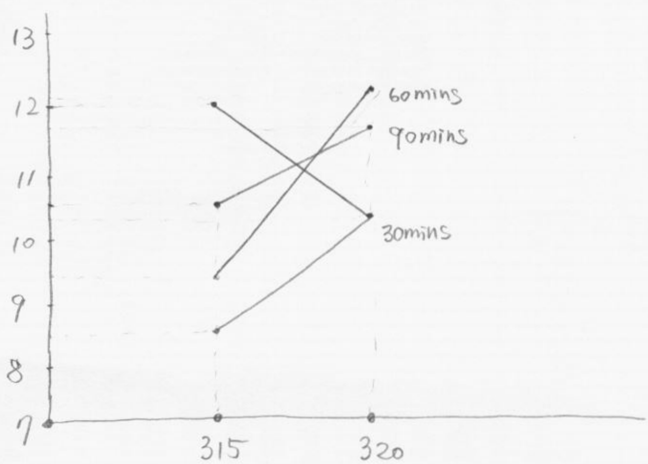
h) $i=1, j=3$

$\bar{y}_{13.} = 10.50$ ← Fitted value

$y_{13.} = 10.1$ ← Actual

$\epsilon_{13.} = y_{13.} - \bar{y}_{13.} = 10.1 - 10.50 = -0.4$

i)



Interaction plot:

The lines are not parallel, which means there's likely an interaction between the two factors.

j.) AVOVA Table

$$SS_A = bn\sum_{i=1}^{a}(\bar{y}_{i..} - \bar{y}_{...})^2$$

$$= 4\times 3\times[(10.10 - 10.60)^2 + (11.10 - 10.60)^2]$$

$$= 6$$

$$SS_B = an\sum_{j=1}^{b}(\bar{y}_{.j.} - \bar{y}_{...})^2$$

$$= 2\times 3\times[(9.40 - 10.60)^2 + (10.75 - 10.60)^2 + (11.10 - 10.60)^2 + (11.15 - 10.60)^2]$$

$$= 12.09$$

$$SS_{AB} = n\sum_{i=1}^{a}\sum_{j=1}^{b}(\bar{y}_{ij.} - \bar{y}_{i..} - \bar{y}_{.j.} + \bar{y}_{...})$$

$$= 3\times[(8.5 - 10.10 - 9.4 + 10.6)^2 + (10.3 - 11.1 - 9.4 + 10.6)^2 +$$
$$(9.4 - 10.10 - 10.75 + 10.6)^2 + (12.10 - 11.1 - 10.75 + 10.6)^2 +$$
$$(10.5 - 10.10 - 11.10 + 10.6)^2 + (11.70 - 11.1 - 11.1 + 10.6)^2 +$$
$$(12.00 - 10.10 - 11.15 + 10.6)^2 + (10.30 - 11.10 - 11.15 + 10.6)^2]$$

$$= 3\times 5.43$$

$$= 16.29$$

	df	SS	MS	F
A	1	6	6	5.581
B	3	12.09	4.03	3.749
AB	3	16.29	5.43	5.098
Error	16	17.2	1.075	
Total	23	51.58		

k.) $\sigma^2 = MSE = 1.075$

1) test for Interaction effects:

$H_0: (\tau\beta)_{ij} = 0 \ \forall (i,j)$

$H_a: (\tau\beta)_{ij} \neq 0$ for at least one (i,j)

$F_{0AB} = 5.098$

Critical value: $F(3, 16, 0.05) = 3.24$ ✓

Reject H_0 if $F_{0AB} \geq$ critical value.

$F_{0AB} = 5.098 > 3.24$,

Thus, Reject H_0.

There's sufficient evidence to conclude that at least one $(\tau\beta)_{ij} \neq 0$, which means there's interaction effects.

test for Water Amount (Main effect)

$H_0: \tau_1 = \tau_2 = 0$ H_a: at least one $\tau_i \neq 0$

$F_{0A} = 5.581$

Critical value: $F(1, 16, 0.05) = 4.49$

Reject H_0 if $F_{0A} \geq$ critical value. ✓

$F_{0A} = 5.581 > 4.49$

Thus, Reject H_0.

There's sufficient evidence to claim H_a: at least one $\tau_i \neq 0$.

test for Autolyse time (main effect)

$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$, H_a: at least one $\beta_j \neq 0$

$F_{0B} = 3.749$

Critical value: $F(3, 16, 0.05) = 3.24$ ✓

Reject H_0 if $F_{0B} \geq$ critical value.

$F_{0B} = 3.749 > 3.24$

Thus, Reject H_0.

There's sufficient evidence to claim H_a: at least one $\beta_j \neq 0$.

m) ANOVA Table $F = 5.581$ for autolyse indicates significant,

-1 then it is ~~appropriate~~ to investigate contrasts of interest or compare the means of the different factor levels.

Tukey's Method (in chapter 3)

$$T\alpha = q_\alpha(a, f) \cdot \sqrt{\frac{MSE}{n}}$$

a: factor level of autolyse time: 4

$$= q_{0.05}\cancel{(4, 20)} \cdot \sqrt{\frac{1.075}{3}}$$

$f = N - a = 24 - 4 = 20$

$$= \cancel{4.24} \times \sqrt{\frac{1.075}{3}}$$

$MSE = 1.075$

$n = 3$

$$= 2.538$$

$H_0: \mu_i = \mu_j \qquad H_a: \mu_i \neq \mu_j$

Reject H_0 if $|\bar{y}_{\cdot i\cdot} - \bar{y}_{\cdot j\cdot}| \geq T\alpha$

Autolyse Time	30min	60min	90min	120min
$\bar{y}_{\cdot j\cdot}$	9.40	10.75	11.10	11.15

$$\left.\begin{aligned}
|\bar{y}_{\cdot1\cdot} - \bar{y}_{\cdot2\cdot}| &= |9.4 - 10.75| = 1.35 < T\alpha \\
|\bar{y}_{\cdot1\cdot} - \bar{y}_{\cdot3\cdot}| &= |9.40 - 11.10| = 1.7 < T\alpha \\
|\bar{y}_{\cdot1\cdot} - \bar{y}_{\cdot4\cdot}| &= |9.40 - 11.15| = 1.75 < T\alpha \\
|\bar{y}_{\cdot2\cdot} - \bar{y}_{\cdot3\cdot}| &= |10.75 - 11.10| = 0.35 < T\alpha \\
|\bar{y}_{\cdot2\cdot} - \bar{y}_{\cdot4\cdot}| &= |10.75 - 11.15| = 0.4 < T\alpha \\
|\bar{y}_{\cdot3\cdot} - \bar{y}_{\cdot4\cdot}| &= |11.10 - 11.15| = 0.05 < T\alpha
\end{aligned}\right\}$$

Fail to Reject H_0.

There's No enough evidence to claim H_a: $\mu_i \neq \mu_j$, which mean that there's different effects of all levels of Autolyze time.

n) By AVOVA Table $F=5.098$ for interaction effects indicates significant.

$$T_\alpha = q_\alpha(ab, ab(n-1)) \cdot \sqrt{\frac{MS_E}{n}}$$

$$= q_{0.05}(8, 16) \cdot \sqrt{\frac{1.075}{3}}$$

$$= 4.90 \times \sqrt{\frac{1.075}{3}}$$

$$= 2.933$$

$n=3$
$a=2$
$b=4$
$ab=8$
$ab(n-1)=16$

$H_0: \mu_{ij} - \mu_{kl} = 0 \qquad H_a: \mu_{ij} - \mu_{kl} \neq 0$

Reject H_0 if $|\bar{y}_{ij.} - \bar{y}_{kl.}| \geq T_\alpha$

$|8.5 - 9.4| = 0.9$

$|8.5 - 10.5| = 2$

$|\bar{y}_{11.} - \bar{y}_{14.}| = |8.5 - 12.0| = 3.5 \quad > T_\alpha$

$|8.5 - 10.30| = 1.8$

$|\bar{y}_{11.} - \bar{y}_{22.}| = |8.5 - 12.10| = 3.6 \quad > T_\alpha$

$|\bar{y}_{11.} - \bar{y}_{23.}| = |8.5 - 11.7| = 3.2 \quad > T_\alpha$

$|8.5 - 10.30| = 1.8$

$|9.4 - 10.50| = 1.1$

$|9.4 - 12.0| = 2.6$

$|9.4 - 10.3| = 0.9$

$|9.4 - 12.1| = 2.7$

$|9.4 - 11.7| = 2.3$

$|9.4 - 10.3| = 0.9$

$|10.5 - 12.0| = 1.5$

$|10.5 - 10.3| = 0.2$

$|10.5 - 12.1| = 1.6$

$|10.5 - 11.7| = 1.2$

$|10.5 - 10.3| = 0.2$

$|12.0 - 10.3| = 1.7$

$|12.0 - 12.1| = 0.1$

$|12.0 - 11.7| = 0.3$

$|12.0 - 10.3| = 1.7$

$|10.3 - 12.1| = 1.8$

$|10.3 - 11.7| = 1.4$

$|10.3 - 10.3| = 0$

$|12.1 - 11.7| = 0.4$

$|12.1 - 10.3| = 1.8$

$|11.7 - 10.3| = 1.4$

For the treatment groups of $|\bar{y}_{11.} - \bar{y}_{14.}|$, $|\bar{y}_{11.} - \bar{y}_{22.}|$, $|\bar{y}_{11.} - \bar{y}_{23.}|$: Reject Ho. There's sufficient evidence to claim that there's different means ~~effects~~ among these treatment groups.

For the other treatment groups ($< T_\alpha$):

Fail to Reject Ho.

There's no sufficient evidence to claim $H_a: \mu_{ij} - \mu_{kl} \neq 0$, which indicates that there's no different effects among these treatment groups.

o).

Treatments: 8 groups total

	1	2	3	4	5	6	7	8
Day1								
Day2		Blocking: df=2						
Day3								
	8.50	9.40	10.5	12.0	10.3	12.1	11.7	10.3

df = 8-1 = 7

total SS = 34.38

SAME as j.)

	df	SS	MS	F
A	1	6	6	6/1.164 = 5.155
B	3	12.09	4.03	4.03/1.164 = 3.462
AB	3	16.29	5.43	5.43/1.164 = 4.665
Block	2	0.91	0.455	0.455/1.164 = 0.391
Error	14	16.29	1.164	
Total	23	51.58		

✓

$(8-1)\times(3-1)=14$
df of Error

Subtraction for SS_E ✓

$= 51.58 - 34.38 - 0.91$

$= 16.29$

Question 2. → Graded on completion except for SAS code/output

a) ANOVA Table checked

b) Model Assumptions:

$\epsilon_{ijk} \overset{iid}{\sim} N(0, \sigma^2)$

normality by Q-Q plot: All data aligned to one straight line, Normality satisfied.

constant variance by plot of residuals vs. fitted values: All data are sparsely & averagely scatterred. Satisfied.

independent error by plot of residuals vs. run order and by residuals vs. fitted values: averagely scatterred. Satisfied.

c) $y = b_0 + b_1 x_1 + b_2 x_2 + b_3 x_2^2 + b_4 x_2^3 + b_5 x_1 x_2 + b_6 x_1 x_2^2 + b_7 x_1 x_2^3 + \epsilon$

i) $y = 11.006 + 1.094 x_1 + 0.481 x_2 - 0.731 x_2^2 + 0.394 x_2^3 - 1.156 x_1 x_2 - 1.069 x_1 x_2^2 + 0.281 x_1 x_2^3$

ii) $x_1 = \frac{317 - 317.5}{2.5} = -0.2$

$x_2 = \frac{100 - 75}{45} = 0.556$

$y = 11.006 + 1.094 \times (-0.2) + 0.481 \times 0.556 - 0.731 \times 0.556^2 + 0.394 \times 0.556^3 - 1.156 \times (-0.2) \times 0.556 - 1.069 \times (-0.2) \times 0.556^2 + 0.281 \times (-0.2) \times 0.556^3$

$= 11.081 \doteq 11.08$

iii) $x_1 = \frac{300 - 317.5}{2.5} = -7$

$x_2 = \frac{80 - 75}{45} = 0.111$

is there any difference between ii) and iii)? But they are asked in different ways

$y = 11.006 + 1.094 \times (-7) + 0.481 \times 0.111 - 0.731 \times 0.111^2 + 0.394 \times 0.111^3 - 1.156 \times (-7) \times 0.111 - 1.069 \times (-7) \times 0.111^2 + 0.281 \times (-7) \times 0.111^3$

$= 4.381$

iv.) $x_1 = \frac{319 - 317.5}{2.5} = 0.6$

$y = 11.006 + 1.094 \times 0.6 + 0.481 x_2 - 0.731 x_2^2 + 0.394 x_2^3 - 1.156 \times 0.6 x_2 - 1.069 \times 0.6 x_2^2 + 0.281 \times 0.6 \times x_2^3$

$= 11.662 + 0.481 x_2 - 0.731 x_2^2 + 0.394 x_2^3 - 0.694 x_2 - 0.641 x_2^2 + 0.169 x_2^3$

$= 11.662 - 0.213 x_2 - 1.372 x_2^2 + 0.563 x_2^3$

Question 3:

a) Plant types as banker: Verbena x hybrida cv. Tapien plant (V.) a=2
(Factor A) Scaevola aemula plant (S.) ✓

Flower with/without: with
(Factor B) without b=2

b) a=2
b=2

	Factor B	
Factor A	with Flower	without Flower
V. plant		
S. plant		

c) V. plant & flower, V. plant & without flower ✓
S. plant & flower, S. plant & without flower

d) N. tenuis adults
*(Not sure whether necessary to specify further for different response variables in e)

e) egg development time
nymphal development time
Female Fecundity
rm (Intrinsic rate of increase)
Sugar of plants

Answers should be specific to two-way ANOVA

f) in Materials and methods section:
for egg development, newly emerged females and males were reared on potted V. plant or S. plant; which are randomly selected (Although Random is not mentioned in paper)
then mature, presumed mated N. tenuis females were collected from the cage and released into another cage to obtain 40 eggs.
By the description for all different response variable measurement, the process is randomized.

-0.5
You can't claim randomization if it is not mentioned in article

g). Yes. there are many N. tenuis female Adults as experiment unit.
per treatment group -0.5
eggs are many for egg development
nymphs are many for nymphal development
N. tenuis female are many for female fecundity
Plant samples are many for sugar analysis.
the experiment has replication.

h) Blocking is not used.

the experimental units are randomly assigned to treatments,

the experiments are not blocking on any other factors.

i) the objective of this study is to study the life history parameters and reproductive potential of a Japanese N. tenuis strain on verbena and scaevola with and without flowers.

y as r_m for reproductive potential / egg development time / Nymphal development time / female fecundity

$y = \mu + \tau_i + \beta_j + (\tau\beta)_{ij} + \epsilon_{ijk}$

μ: overall population mean ~~of y~~ fecundity

τ_i: effect of plant type $i = 1, 2$

$k = ?$

β_j = effect of flower $j = 1, 2$

$(\tau\beta)_{ij}$: interaction effect of ith level of plant types and jth level of flower with/without.

ϵ_{ijk}: random error of the kth ~~experimental unit~~ female N. tenuis

from ith level of plant types and jth level of flower with/without.

* (not sure whether need to specify y for different response variables in e)

Result Section

j) Sample Statistics ✓ | k) test statistic ✓ | l) P-value ✓ | m) conclusion on significance ✓

egg development time

	with F.	without F.
V.	9.4±0.1	–
S.	9.7±0.1	–

Ho: $\mu_{v.} = \mu_{s.}$ Ha: $\mu_{v.} \neq \mu_{s.}$

t = -1.37

df = 82

P-value = 0.173 > 0.05

Do Not Reject Ho.

Not Significant.

Nymphal development time

	with F.	without F.
V.	16.1±0.3	–
S.	16.5±0.3	–

Ho: $\mu_{v.} = \mu_{s.}$ Ha: $\mu_{v.} \neq \mu_{s.}$

t = -0.807

df = 55

P-value = 0.423 > 0.05

Do Not Reject Ho.

not significant.

Female oviposition

Two-Way ANOVA

	with F.	without F.
V.	54.1±7.3	4.4±1.7
S.	50.3±6.8	1.1±0.7

what do these values represent? -0.5

Effect of plants with Flower:

F = 4.38 ✓

P-value = 0.0406 < 0.05

Reject Ho

Significant ✓

Effect of plant without Flower:

F = 235 ✓

P-value < 0.001 < 0.05

Reject Ho.

Significant

provide info for interaction -0.5

Female survival rate

Two-way ANOVA

	with F.	without F.
V.	81.3	6.3
S.	60.0	12.5

effect of flowers:

Z = -4.36

P-Value < 0.001

Reject Ho. Significant.

effect of plant

Z = 0.75

P-Value = 0.450 > 0.05

Not Significant.

Fail to reject Ho.

Ym

	with Flower	without
V.	0.0884±0.00052	–
S.	0.08098±0.00018	–

$\chi^2 = 22.5$

df = 1

P-value < 0.001

Reject Ho.

Significant.

Sugar

		Fructose	glucose
V. plants	1		
	2		
	⋮		

Friedman Test

Ho: $M_1 = M_2$

$\chi^2 = 12.0$

df = 2

P-value = 0.002 < 0.05

Significant

Reject Ho.

	Fructose	glucose	Sucrose
S. plants			

Friedman

Ho: $M_1 = M_2 = M_3$

$\chi^2 = 9.56$

df = 2

P-value = 0.008 < 0.05

Significant

Reject Ho.

Fructose in V. S. Mann Whitney Ho: $M_{v.} = M_{s.}$

U = 54.0

P-value = 0.0004 < 0.05

Significant Reject Ho.

glucose in V. S. Mann Whitney Ho: $M_{v.} = M_{s.}$

U = 53.0

P-value = 0.0008 < 0.05

Significant Reject Ho.

m) the objective of this study was to study the life history parameters and reproductive potential of a Japanese N. tenuis Strain on Verbena and Scaevola with and without flowers and analyzed sugars in the flowers of these two plant species.

* See solutions
-0.5

		Factor B	
		with Flower	without Flower
Factor A	V. plant		
	S. plant		

The intrinsic rate of increase r_m is widely used to evaluate reproductive potential.
r_m values on Verbena and Scaevola with flowers were 0.0884 and 0.08098.
Flowers are essential for the positive effects of these species as banker plants.
* Answer in last page also can specify this question.

```
ods rtf file='hw3_output.rtf' startpage=NO;

data loaf;
infile 'sourdough.csv' firstobs=2 dsd;
input day water autolyse height x1 x2 x22 x23 x1x2 x1x22 x1x23;
run;

proc print data=loaf;
run;

title 'Homework3: Two-Factor Factorial ANOVA';

/*Insert SAS code for Homework 3 here (i.e., before the "ods rtf close;"
command)*/
proc glm data=loaf plots=all;
class water autolyse;
model height= water autolyse water*autolyse;
lsmeans water*autolyse/cl pdiff adjust=tukey;
run;

title 'Homework3: Response Curve Analysis';

proc reg data=loaf;
model height=x1 x2 x22 x23 x1x2 x1x22 x1x23/ss1;
run;

title 'Homework3: Two-Factor Factorial with blocking ANOVA';

proc glm data=loaf plots=all;
class water autolyse day;
model height=day water autolyse water*autolyse;
run;

ods rtf close;
```

The SAS System

Obs	day	water	autolyse	height	x1	x2	x22	x23	x1x2	x1x22	x1x23
1	12	315	30	8.5	-1	-1.00000	1.00000	-1.00000	1.00000	-1.00000	1.00000
2	1	315	30	7.4	-1	-1.00000	1.00000	-1.00000	1.00000	-1.00000	1.00000
3	5	315	30	9.6	-1	-1.00000	1.00000	-1.00000	1.00000	-1.00000	1.00000
4	10	315	60	9.3	-1	-0.33333	0.11111	-0.03704	0.33333	-0.11111	0.03704
5	15	315	60	9.7	-1	-0.33333	0.11111	-0.03704	0.33333	-0.11111	0.03704
6	11	315	60	9.2	-1	-0.33333	0.11111	-0.03704	0.33333	-0.11111	0.03704
7	2	315	90	9.4	-1	0.33333	0.11111	0.03704	-0.33333	-0.11111	-0.03704
8	23	315	90	12.0	-1	0.33333	0.11111	0.03704	-0.33333	-0.11111	-0.03704
9	18	315	90	10.1	-1	0.33333	0.11111	0.03704	-0.33333	-0.11111	-0.03704
10	24	315	120	13.9	-1	1.00000	1.00000	1.00000	-1.00000	-1.00000	-1.00000
11	13	315	120	11.5	-1	1.00000	1.00000	1.00000	-1.00000	-1.00000	-1.00000
12	6	315	120	10.6	-1	1.00000	1.00000	1.00000	-1.00000	-1.00000	-1.00000
13	3	320	30	10.4	1	-1.00000	1.00000	-1.00000	-1.00000	1.00000	-1.00000
14	8	320	30	9.6	1	-1.00000	1.00000	-1.00000	-1.00000	1.00000	-1.00000
15	7	320	30	10.9	1	-1.00000	1.00000	-1.00000	-1.00000	1.00000	-1.00000
16	22	320	60	10.9	1	-0.33333	0.11111	-0.03704	-0.33333	0.11111	-0.03704
17	20	320	60	12.1	1	-0.33333	0.11111	-0.03704	-0.33333	0.11111	-0.03704
18	16	320	60	13.3	1	-0.33333	0.11111	-0.03704	-0.33333	0.11111	-0.03704
19	9	320	90	11.5	1	0.33333	0.11111	0.03704	0.33333	0.11111	0.03704
20	19	320	90	11.1	1	0.33333	0.11111	0.03704	0.33333	0.11111	0.03704
21	21	320	90	12.5	1	0.33333	0.11111	0.03704	0.33333	0.11111	0.03704
22	17	320	120	9.9	1	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
23	4	320	120	10.2	1	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
24	14	320	120	10.8	1	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

The GLM Procedure

Class Level Information		
Class	**Levels**	**Values**
water	2	315 320
autolyse	4	30 60 90 120

Number of Observations Read	24
Number of Observations Used	24

The GLM Procedure

Homework3: Two-Factor Factorial ANOVA

ANOVA
Table

Dependent Variable: height

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	34.38000000	4.91142857	4.57	0.0057
Error	16	17.20000000	1.07500000		
Corrected Total	23	51.58000000			

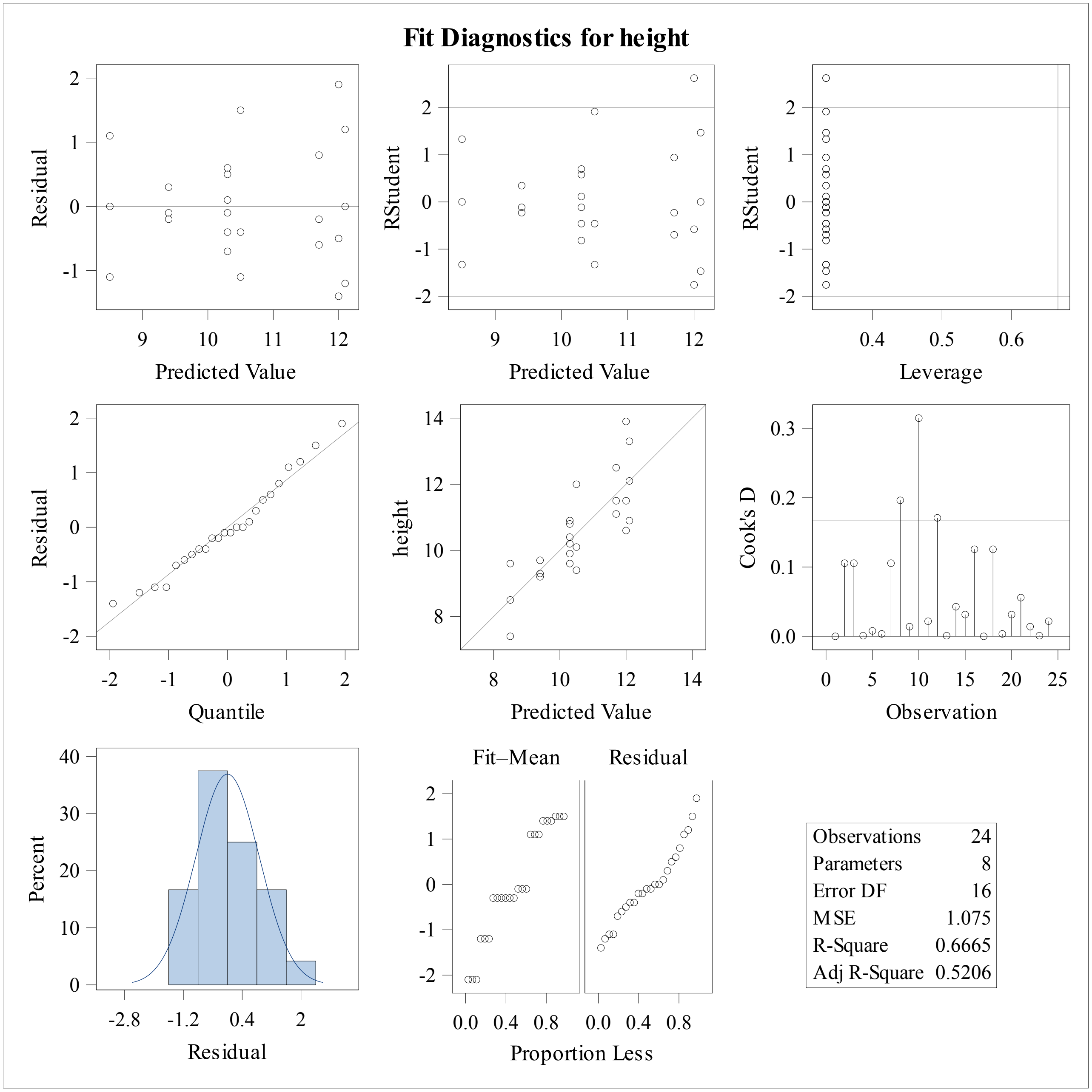
R-Square	Coeff Var	Root MSE	height Mean
0.666537	9.781340	1.036822	10.60000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
water	1	6.00000000	6.00000000	5.58	0.0312
autolyse	3	12.09000000	4.03000000	3.75	0.0326
water*autolyse	3	16.29000000	5.43000000	5.05	0.0119

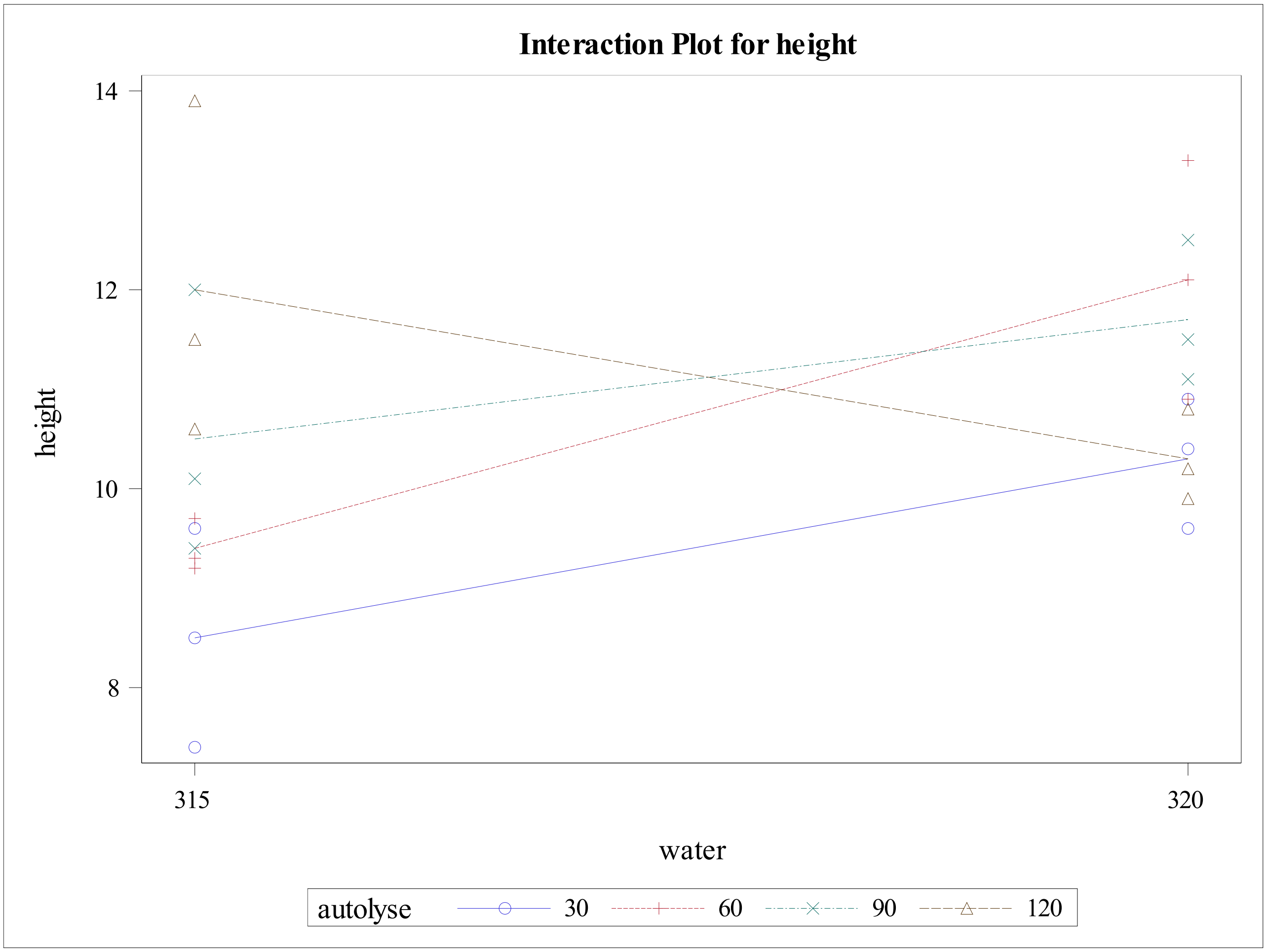
Source	DF	Type III SS	Mean Square	F Value	Pr > F
water	1	6.00000000	6.00000000	5.58	0.0312
autolyse	3	12.09000000	4.03000000	3.75	0.0326
water*autolyse	3	16.29000000	5.43000000	5.05	0.0119

To check whether Assumption satisfied.

Homework3: Two-Factor Factorial ANOVA



Homework3: Two-Factor Factorial ANOVA



The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey

water	autolyse	height LSMEAN	LSMEAN Number
315	**30**	8.5000000	1
315	**60**	9.4000000	2
315	**90**	10.5000000	3
315	**120**	12.0000000	4
320	**30**	10.3000000	5
320	**60**	12.1000000	6
320	**90**	11.7000000	7
320	**120**	10.3000000	8

Homework3: Two-Factor Factorial ANOVA

Least Squares Means for effect water*autolyse Pr > |t| for H0: LSMean(i)=LSMean(j) Dependent Variable: height								
i/j	1	2	3	4	5	6	7	8
1		0.9559	0.3209	0.0138	0.4396	0.0109	0.0273	0.4396
2	0.9559		0.8864	0.1021	0.9559	0.0826	0.1867	0.9559
3	0.3209	0.8864		0.6454	1.0000	0.5753	0.8368	1.0000
4	0.0138	0.1021	0.6454		0.5060	1.0000	0.9999	0.5060
5	0.4396	0.9559	1.0000	0.5060		0.4396	0.7141	1.0000
6	0.0109	0.0826	0.5753	1.0000	0.4396		0.9996	0.4396
7	0.0273	0.1867	0.8368	0.9999	0.7141	0.9996		0.7141
8	0.4396	0.9559	1.0000	0.5060	1.0000	0.4396	0.7141	

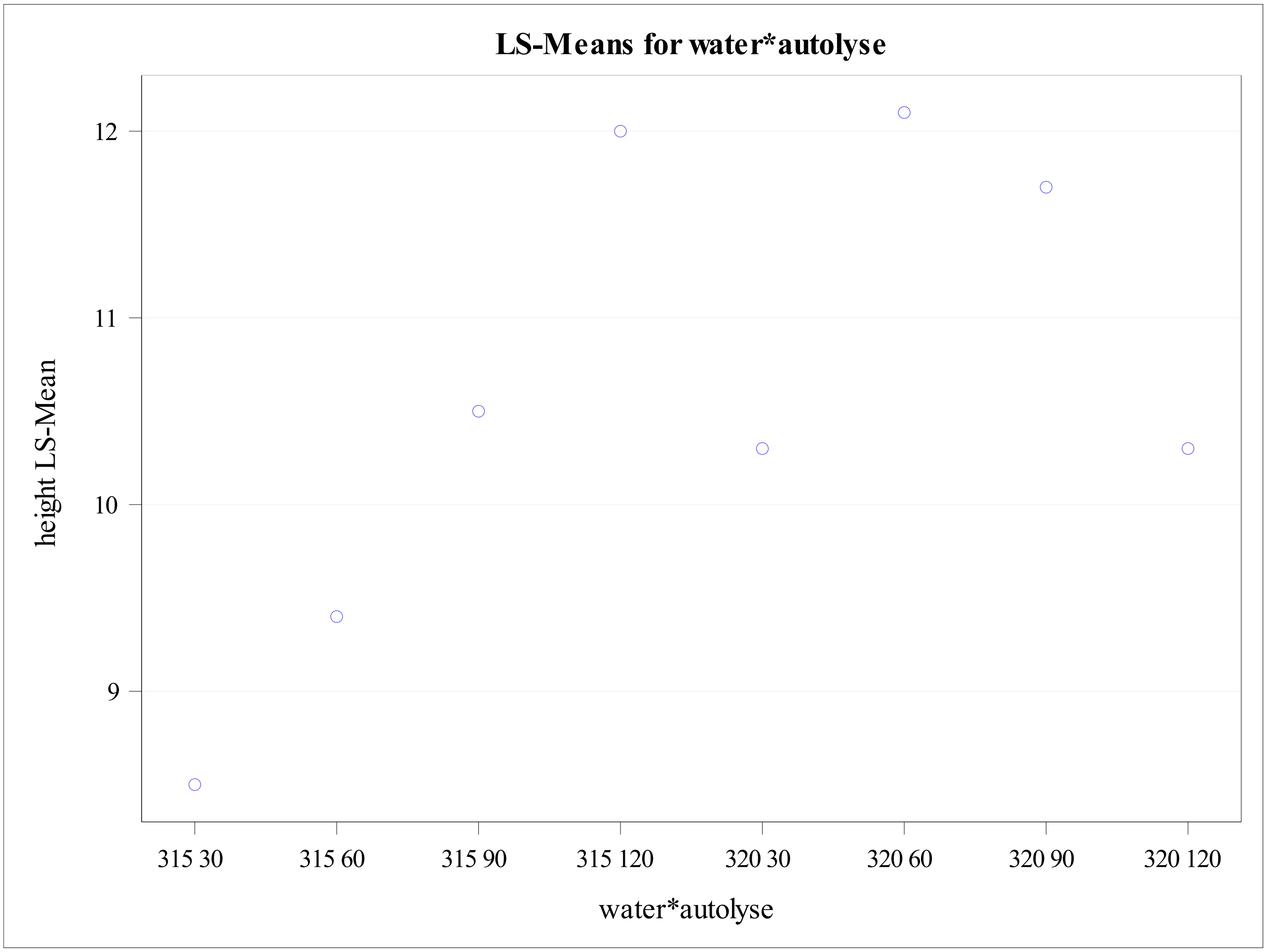
water	autolyse	height LSMEAN	95% Confidence Limits	
315	30	8.500000	7.231005	9.768995
315	60	9.400000	8.131005	10.668995
315	90	10.500000	9.231005	11.768995
315	120	12.000000	10.731005	13.268995
320	30	10.300000	9.031005	11.568995
320	60	12.100000	10.831005	13.368995
320	90	11.700000	10.431005	12.968995
320	120	10.300000	9.031005	11.568995

Least Squares Means for Effect water*autolyse				
i	j	Difference Between Means	Simultaneous 95% Confidence Limits for LSMean(i)-LSMean(j)	
1	2	-0.900000	-3.830924	2.030924
1	3	-2.000000	-4.930924	0.930924
1	4	-3.500000	-6.430924	-0.569076
1	5	-1.800000	-4.730924	1.130924
1	6	-3.600000	-6.530924	-0.669076
1	7	-3.200000	-6.130924	-0.269076
1	8	-1.800000	-4.730924	1.130924
2	3	-1.100000	-4.030924	1.830924

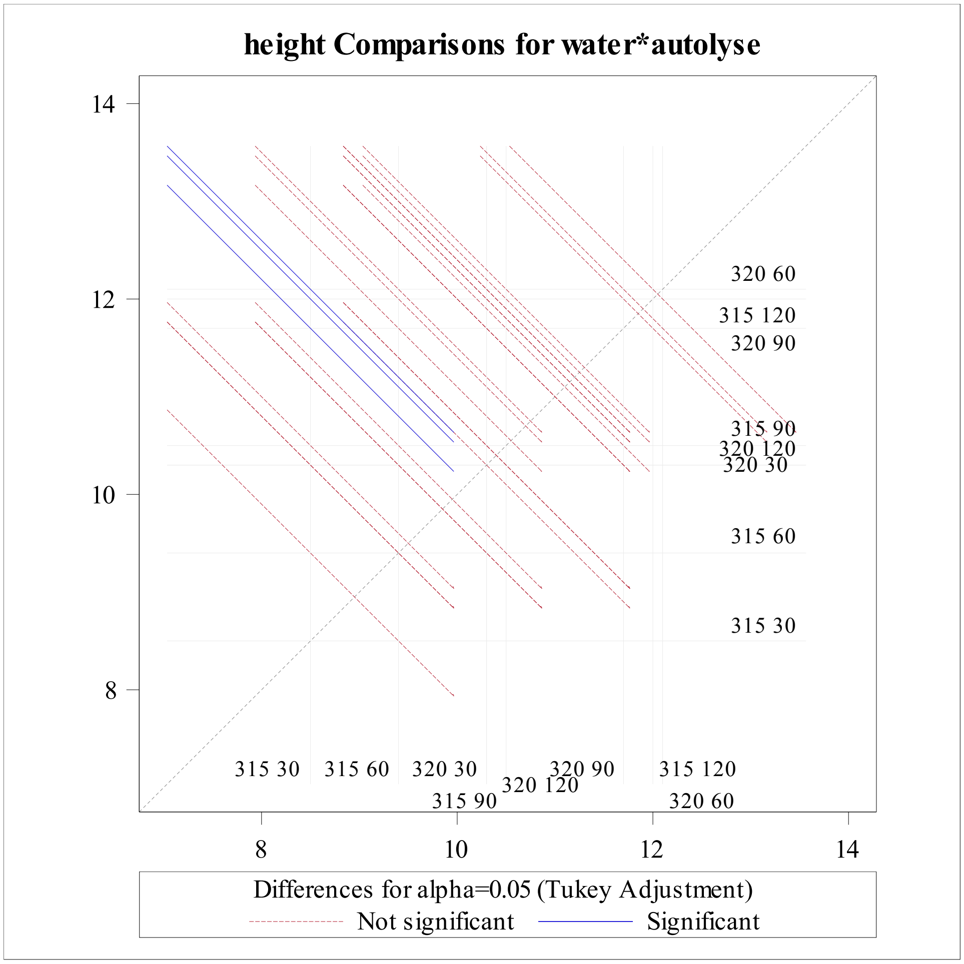
Homework3: Two-Factor Factorial ANOVA

Least Squares Means for Effect water*autolyse				
i	j	Difference Between Means	Simultaneous 95% Confidence Limits for LSMean(i)-LSMean(j)	
2	**4**	-2.600000	-5.530924	0.330924
2	**5**	-0.900000	-3.830924	2.030924
2	**6**	-2.700000	-5.630924	0.230924
2	**7**	-2.300000	-5.230924	0.630924
2	**8**	-0.900000	-3.830924	2.030924
3	**4**	-1.500000	-4.430924	1.430924
3	**5**	0.200000	-2.730924	3.130924
3	**6**	-1.600000	-4.530924	1.330924
3	**7**	-1.200000	-4.130924	1.730924
3	**8**	0.200000	-2.730924	3.130924
4	**5**	1.700000	-1.230924	4.630924
4	**6**	-0.100000	-3.030924	2.830924
4	**7**	0.300000	-2.630924	3.230924
4	**8**	1.700000	-1.230924	4.630924
5	**6**	-1.800000	-4.730924	1.130924
5	**7**	-1.400000	-4.330924	1.530924
5	**8**	0	-2.930924	2.930924
6	**7**	0.400000	-2.530924	3.330924
6	**8**	1.800000	-1.130924	4.730924
7	**8**	1.400000	-1.530924	4.330924

Homework3: Two-Factor Factorial ANOVA



Homework3: Two-Factor Factorial ANOVA



The REG Procedure
Model: MODEL1
Dependent Variable: height

Number of Observations Read	24
Number of Observations Used	24

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	7	34.38000	4.91143	4.57	0.0057
Error	16	17.20000	1.07500		
Corrected Total	23	51.58000			

Homework3: Response Curve Analysis

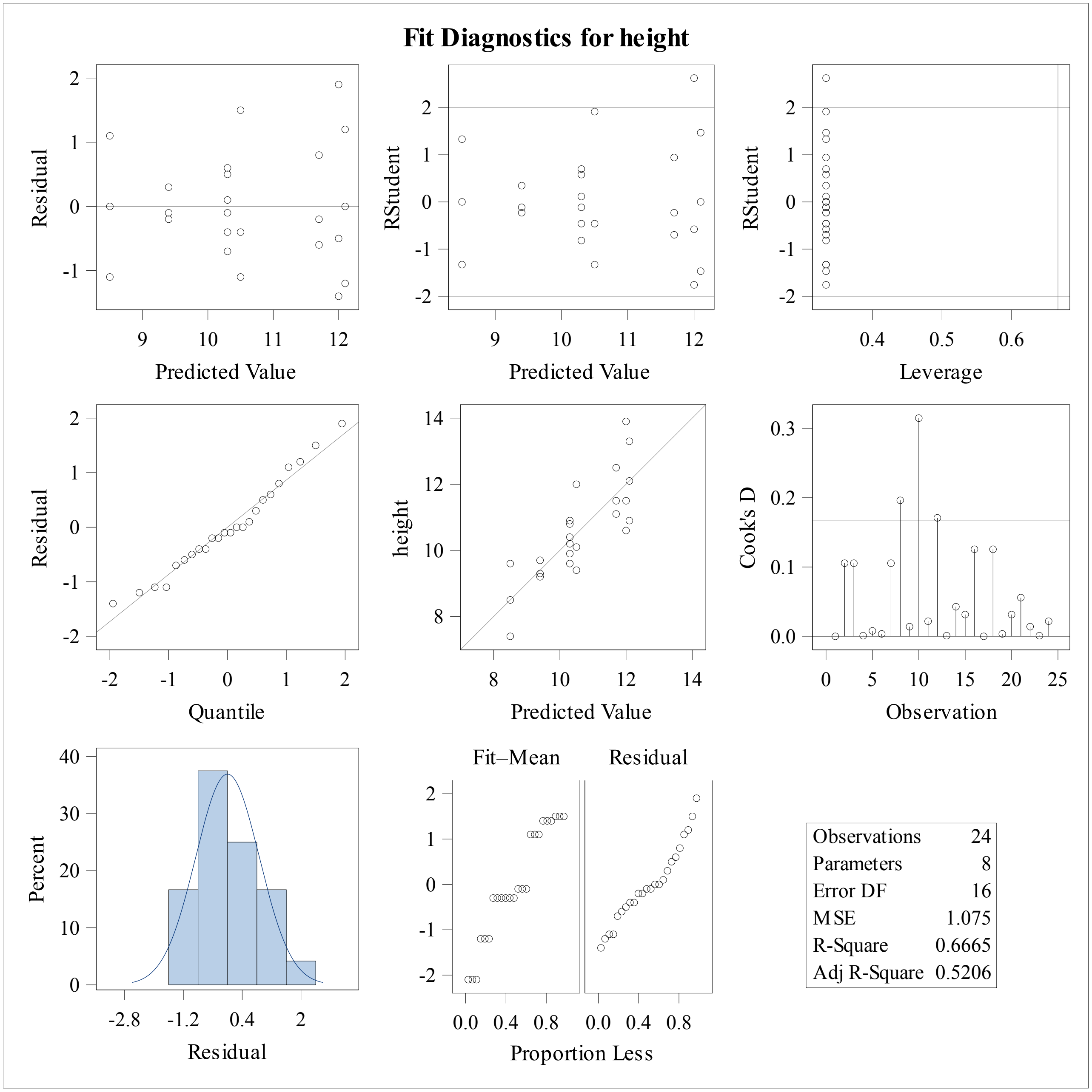
Root MSE	1.03682	**R-Square**	0.6665
Dependent Mean	10.60000	**Adj R-Sq**	0.5206
Coeff Var	9.78134		

Question 2

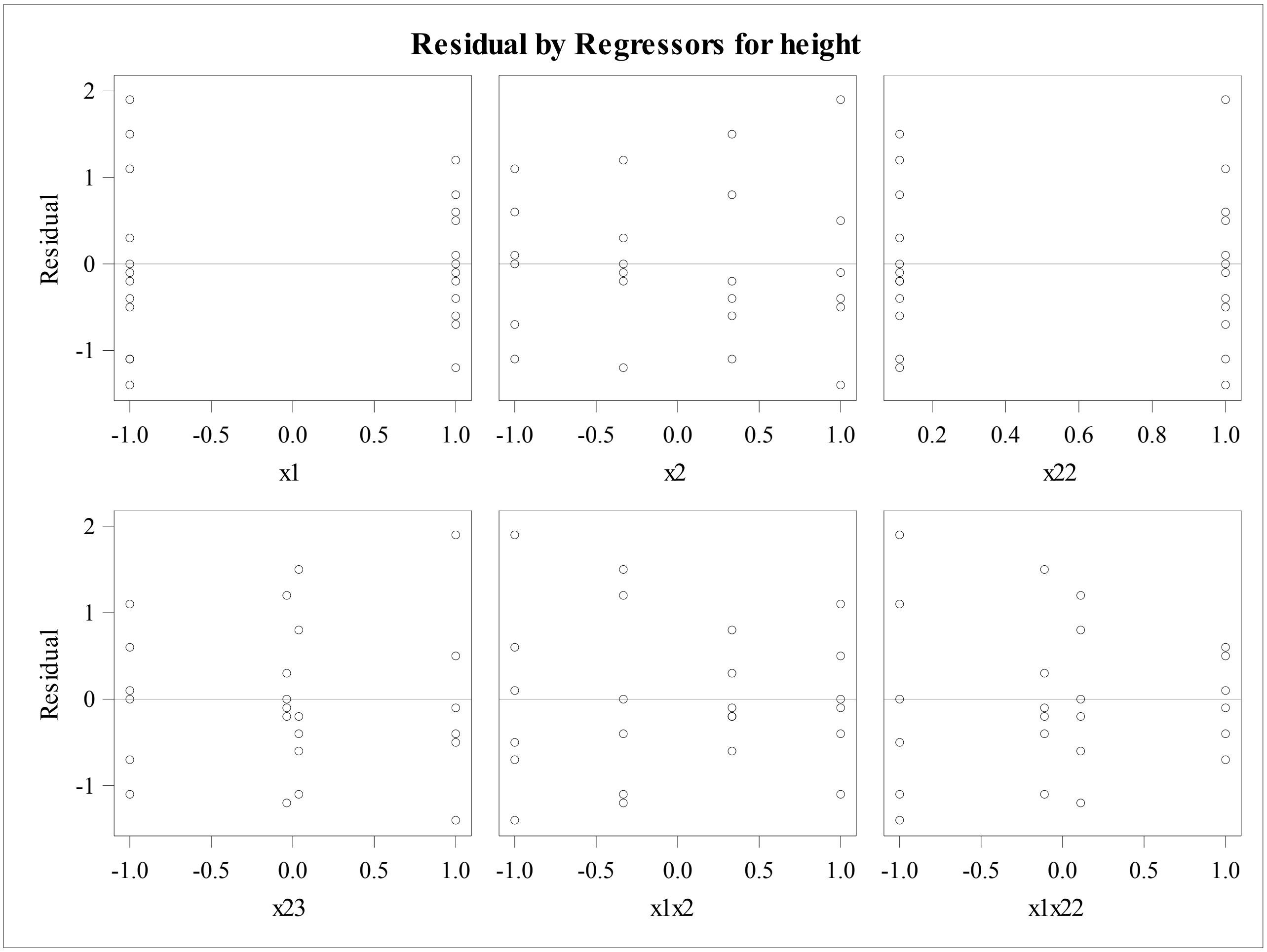
Parameter Estimates						
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**	**Type I SS**
Intercept	1	11.00625	0.33879	32.49	<.0001	2696.64000
x1	1	1.09375	0.33879	3.23	0.0053	6.00000
x2	1	0.48125	1.01085	0.48	0.6404	9.40800
x22	1	-0.73125	0.47619	-1.54	0.1442	2.53500
x23	1	0.39375	1.06480	0.37	0.7164	0.14700
x1x2	1	-1.15625	1.01085	-1.14	0.2695	10.80000
x1x22	1	-1.06875	0.47619	-2.24	0.0393	5.41500
x1x23	1	0.28125	1.06480	0.26	0.7950	0.07500

The REG Procedure
Model: MODEL1
Dependent Variable: height

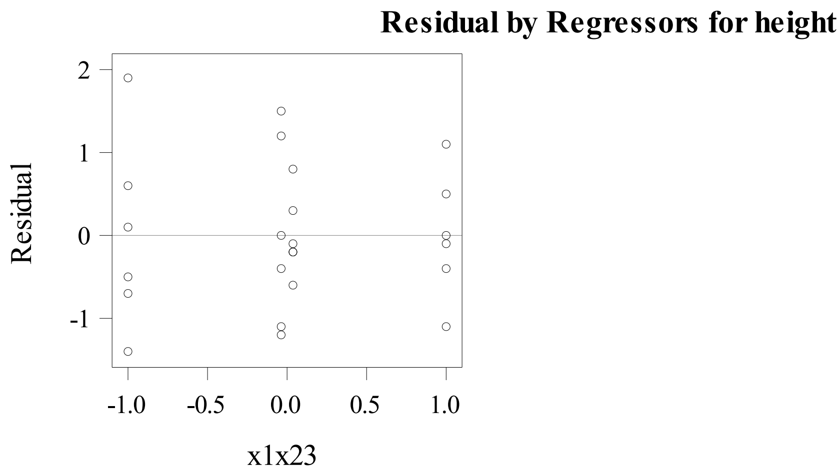
Homework3: Response Curve Analysis



Homework3: Response Curve Analysis



Homework3: Response Curve Analysis



The GLM Procedure

Class Level Information		
Class	**Levels**	**Values**
water	2	315 320
autolyse	4	30 60 90 120
day	24	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Number of Observations Read	24
Number of Observations Used	24

The GLM Procedure

Dependent Variable: height

Homework3: Two-Factor Factorial with blocking ANOVA

Seems like not working please ignore this part.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	23	51.58000000	2.24260870	.	.
Error	0	0.00000000	.		
Corrected Total	23	51.58000000			

R-Square	Coeff Var	Root MSE	height Mean
1.000000	.	.	10.60000

* I didn't give you info on the blocking factor. :)

Source	DF	Type I SS	Mean Square	F Value	Pr > F
day	23	51.58000000	2.24260870	.	.
water	0	0.00000000	.	.	.
autolyse	0	0.00000000	.	.	.
water*autolyse	0	0.00000000	.	.	.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
day	16	17.20000000	1.07500000	.	.
water	0	0.00000000	.	.	.
autolyse	0	0.00000000	.	.	.
water*autolyse	0	0.00000000	.	.	.

Homework3: Two-Factor Factorial with blocking ANOVA