# Section 1

## MANE 6313

## Subsection 1

# Week 10, Module B

# Student Learning Outcome

- Select an appropriate experimental design with one or more factors,
- Select an appropriate model with one or more factors,
- Evaluate statistical analyses of experimental designs,
- Assess the model adequacy of any experimental design, and
- Interpret model results.

# Module Learning Outcome

*Analyze a one-half fraction factorial design using R.*

# Example Problem

**20.17** A $2^{4-1}$ fractional factorial design was conducted on a chemical process by assigning variable 4 to the 123 interaction column.

| *Variable* | *Low Level* | *High Level* |
|---|---|---|
| 1. Feedrate (liters/min) | 5 | 20 |
| 2. Catalyst (%) | A | B |
| 3. Temperature (°C) | 200 | 220 |
| 4. Concentration (%) | 5 | 7 |

The second table summarizes the eight tests that were run, including the levels of each of the four variables and the yield (% reacted) for each test.

| *Test* | *1* | *2* | *3* | *4* | *y (% reacted)* |
|---|---|---|---|---|---|
| 1 | − | − | − | − | 33 |
| 2 | + | − | − | + | 51 |
| 3 | − | + | − | + | 44 |
| 4 | + | + | − | − | 40 |
| 5 | − | − | + | + | 35 |
| 6 | + | − | + | − | 82 |
| 7 | − | + | + | − | 46 |
| 8 | + | + | + | + | 69 |

**(a)** Write down all of the linear combinations of effects that can be estimated from this experiment (assume that third- and higher-order interactions are negligible).
**(b)** Calculate numerical values for the effect estimates and determine which effects are significant using a normal probability plot of the effect estimates.

# Design

```
## Module B
```{r}
# create design
library(FrF2)
p20_17 <- FrF2(8,4,randomize=FALSE)
summary(p20_17)
```
```

R Console

data.frame 2 x 4

data.frame 8 x 4

| | A <fctr> | B <fctr> | C <fctr> | D <fctr> |
|---|---|---|---|---|
| 1 | -1 | -1 | -1 | -1 |
| 2 | 1 | -1 | -1 | 1 |
| 3 | -1 | 1 | -1 | 1 |
| 4 | 1 | 1 | -1 | -1 |
| 5 | -1 | -1 | 1 | 1 |
| 6 | 1 | -1 | 1 | -1 |
| 7 | -1 | 1 | 1 | -1 |
| 8 | 1 | 1 | 1 | 1 |

8 rows

Figure 2: Experimental Design

# Reviewing Design

```
## Module B
```{r}
# create design
library(FrF2)
p20_17 <- FrF2(8,4,randomize=FALSE)
summary(p20_17)
```
```

R Console

data.frame
2 x 4

data.frame
8 x 4

lengths

```
Call:
FrF2(8, 4, randomize = FALSE)

Experimental design of type  FrF2
8  runs

Factor settings (scale ends):

Design generating information:
$legend
[1] A=A B=B C=C D=D

$generators
[1] D=ABC


Alias structure:
$fi2
[1] AB=CD AC=BD AD=BC
```

# Adding Response Variable

```
```{r}
# create and add response
y <- c(33,51,44,40,35,82,46,69)
library(DoE.base)
p20_17 <- add.response(p20_17,y)
print(p20_17)
```
```

data.frame
8 x 5

R Console

| | A | B | C | D | y |
|---|---|---|---|---|---|
| | <fctr> | <fctr> | <fctr> | <fctr> | <dbl> |
| 1 | -1 | -1 | -1 | -1 | 33 |
| 2 | 1 | -1 | -1 | 1 | 51 |
| 3 | -1 | 1 | -1 | 1 | 44 |
| 4 | 1 | 1 | -1 | -1 | 40 |
| 5 | -1 | -1 | 1 | 1 | 35 |
| 6 | 1 | -1 | 1 | -1 | 82 |
| 7 | -1 | 1 | 1 | -1 | 46 |
| 8 | 1 | 1 | 1 | 1 | 69 |

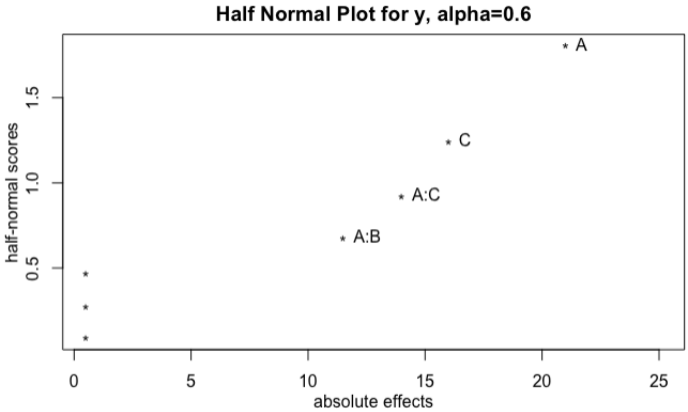
8 rows

Figure 4: Adding Response Variable

# Half-Normal Plot

```
```{r}
# Daniel Plot
DanielPlot(p20_17,half=TRUE,response='y',alpha=0.6)
```
```

R Console



# Model

```
```{r}
p20_17.model1=aov(y~A+B+C+A:B+A:C,data=p20_17)
summary(p20_17.model1)
```
```

```
            Df Sum Sq Mean Sq F value   Pr(>F)    
A            1  882.0   882.0    1764 0.000566 ***
B            1    0.5     0.5       1 0.422650    
C            1  512.0   512.0    1024 0.000975 ***
A:B          1  264.5   264.5     529 0.001885 ** 
A:C          1  392.0   392.0     784 0.001273 ** 
Residuals    2    1.0     0.5                     
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Figure 6: Model Fitting

# Interaction Plot

```{r}
# Interaction plot
IAPlot(p20_17,show.alias=TRUE)
```

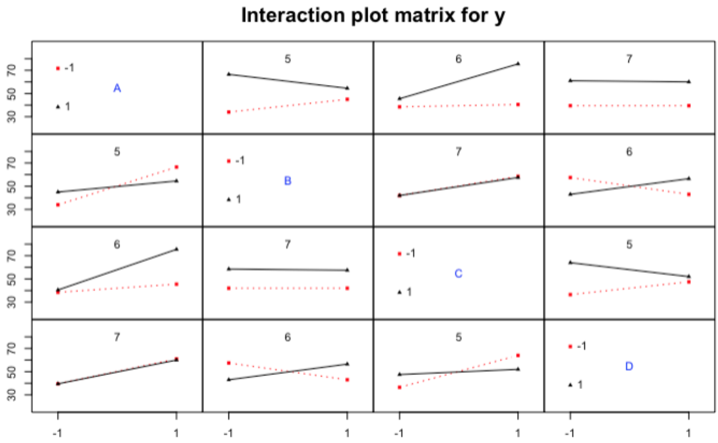



Figure 7: Interaction Plot

# R Demonstration