For each example: define the following:

• The correct design

• Factors

• Levels of a factor

• Treatments

• Blocking (if any)

• Experimental Unit

• Response Variable

• Interaction (if any)

• A partial ANOVA table with Factors and degrees of freedom for each factor

• All of the null and alternative hypotheses

• Statistical model notation

A pharmacist would like to test to see if a certain pain reliever has a significant impact on the number of days per week that that patients with chronic severe headaches experience headaches. The patients will be randomly assigned one of three treatments. Full dose, half dose, or control, each group will contain 50 patients. The patients will take the drug daily for 12 weeks and will report then number of days that they experienced severe headaches.  
(BF1)

• Factors – Level of Dose

• Levels of a factor – Full Dose, half dose, Control

• Treatments - Full Dose, half dose Control

• Blocking (if any) - none

• Experimental Unit - Patient

• Response Variable - # of days they experience a headache

• Interaction (if any) - none

• A partial ANOVA table with Factors and degrees of freedom for each factor

Source df

Grand Mean 1

Drug 2

Residuals 147

Total 150

• All of the null and alternative hypotheses

Ho: αF= αH = αC =0

Ha: at least one of the α’s is not equal to zero

• Statistical model notation



A wheat farmer wants to maximize his profits. The value of wheat can be determined by its wheat content. The main factors that influence the protein content of wheat are the amount of water the plant receives, ~~and the type of fertilizer the plant was given~~. The farmer generally purchases two types of wheat. The farmer randomly assigns ten different fields to be planted with one of the two types of wheat. The farmer then divides each of the plots by four and randomly assigns within each plot to receive either 3 acre/feet of water, 5 acre/feet of water, 7 acre/feet of water, or 9 acre/feet of water. At the end of the season the wheat is harvested and the protein content is measured.  
(SP/RM)

• Factors – Wheat and Water

• Levels of a factor – Wheat (Type 1, Type 2) Water (3, 5, 7, 9);

• Treatments: 1) Wheat1Water3, 2) Wheat 1Water5, 3) Wheat1Water7, 4) W1Water9 5) Wheat2Water3 6) Wheat2Water5, 7) Wheat2Water7,8) Wheat2Water9

• Blocking (if any) Plots of the field for Water

• Experimental Unit – Plot for Wheat SubPlot for Water

• Response Variable – Protein Content within wheat

• Interaction (if any) – Water\*Wheat

• A partial ANOVA table with Factors and degrees of freedom for each factor

Source df

Grand Mean 1

Wheat 1

Plot (Block) 8

Water 3

Interaction (Wheat\*Water) 3

Residuals 24

Total 40

• All of the null and alternative hypotheses

Ho: α1= α2 =0 (Type of Wheat)

Ha: at least one of the α’s is not equal to zero

Ho: β3= β5 = β7 = β9=0 (Water Amount)

Ha: at least one of the β’s is not equal to zero

H0: No interaction between Wheat and Water

Ha: interaction between Wheat and Water

• Statistical model notation



A pharmacist would like to test to see if a certain pain reliever and the age of the patient has a significant impact on the number of days per week that that patients with chronic severe headaches experience headaches. The patients are randomly assigned one of three treatments. Full dose, half dose, or control. The age of the patient is also recorded (Young adult, middle aged, elderly). The patients will take the drug daily for 12 weeks and will report then number of days that they experienced severe headaches. From the thirty patients in each age category, 10 will receive a certain dosage.  
(BF2)

• Factors – Dose of pain reliever and age

• Levels of a factor – Dose (Full, half, and control) and Age (Young adult, middle aged, elderly)

• Treatments – 1) Full/Young Adult, 2) Full/Middle aged, 3) Full/Elderly, 4) Half/Young Adult, 5) Half/Middle aged, 6) Half/Elderly, 7) Control/Young Adult, 8) Control /Middle aged, 9) Control /Elderly,

• Blocking (if any) - none

• Experimental Unit - Patient

• Response Variable - number of days that they experienced severe headaches

• Interaction (if any) – Age and Dosage

• A partial ANOVA table with Factors and degrees of freedom for each factor

Source df

Grand Mean 1

Drug 2

Age 2

Interaction (Age\*Drug) 4

Residuals 81

Total 90

• All of the null and alternative hypotheses

Ho: αF= αH = αC =0

Ha: at least one of the α’s is not equal to zero (Drug)

Ho: βYA= βMA = βE=0 (Water Amount)

Ha: at least one of the β’s is not equal to zero

H0: No interaction between Drug and Age

Ha: interaction between Drug and Age

• Statistical model notation



A college basketball team wants to improve their free-throw shooting. A recent study showed that following through with your hand after a shot improves the number of free throws you make. The coach has developed a week-long training camp to help develop the practice in his players. The coach will develop three different style of follow through. Partial follow though, medium follow through, and full follow through. Given that the coach believes height is a nuisance variable, 12 Players will be divided into groups by height equally (Less than 5’10”, 5’10” to 6’2’’, 6’2’’ to 6’6’’, and taller than 6’6’’) and randomly assigned to a follow through style. After a week of training, each player will take 50 free throws and the number of baskets made will be recorded.   
 (CB)

• The correct design

• Factors – Style of Follow Through

• Levels of a factor – Partial medium , Full

• Treatments Partial medium , Full

• Blocking (if any) - Height

• Experimental Unit - Players

• Response Variable - # of baskets made

• Interaction (if any) - None

• A partial ANOVA table with Factors and degrees of freedom for each factor

Source df

Grand Mean 1

Height (Block) 3

FollowThrough 2

Residuals 6

Total 12

• All of the null and alternative hypotheses

Ho: α1= α2 = α3 = α4 =0 (follow through)

Ha: at least one of the α’s is not equal to zero (follow through)

• Statistical model notation

A women’s pro bowling coach is interested in improving his team's overall performance. The coach is interested in determining if players tend to play better on a full stomach as well as how well they throw different bowling ball weights. For the next team practice she randomly assigns half of the team to eat 30 minutes before playing. The other half of the team must not eat for 12 hours before practice. There are 12 players on the team. Each player plays four games and is randomly assigned an order to throw four ball weights, one ball weight for the game.   
(SP/RM)

A factory owner is required by government regulation to control the amount of lead that is released into a local river to operate. The EPA requirements for lead content in safe water is less 50 parts per billion. The factory utilizes physical filters and chemical treatment to limit river contamination. The factory is testing two types of filters and three chemical treatments to see what is most effective at limiting river pollution. In a controlled environment both filters are set up three times. Each chemical treatment is randomly assigned to one of the controlled environment, and the treatment is applied in the morning. During the work day, pollution levels are collected every 15 minutes, and are collected over the course of two days.   
(BF2)

An experiment was designed to test the effect of a growth hormone extracted from the pituitary gland of cows. Normally, rats stop active growth when they get about 150 days old. Twenty female rats who had stopped growing had their initial weight measured, due to initial weight being a possible nuisance factor. They then were injected with the hormone each day for three weeks. Half the rats got daily doses of 0.25 ml, the other half got doses of 0.10 ml. After the three weeks the final weight in grams is recorded.   
(ANCOVA)

A factory owner recently read a psychological study which showed that productivity among blue collar workers can be strongly improved by giving them more frequent breaks from work. Currently all employees are given two 15-minute breaks in addition to their lunch break. The owner randomly assigns employees to either stay at two 15-minute breaks, have three 10-minute breaks, or five 5-minute breaks. Each group has 10 employees. Productivity ratings were recorded for each employee.   
(BF1)

A professor of an experimental design class wants to help his students improve their test scores. He wants to see what method (either read select sections of the textbook to prepare, or participate in a study session with the TA) best helps students prepare for and perform well on the test. The professor believes that college class is a possible nuisance factor. The students are divided by class (freshman, sophomore…), in the experimental design class there are 2 freshman, 2 sophomores, 2 juniors, and 2 seniors. Within each class a randomly selected student will be randomly assigned to either read select sections of the textbook to prepare, or participate in a study session with the TA. The remaining student in the age class is assigned to the other method. After the test test scores for each student are recorded.   
(CB)

Suppose you want to study to see whether watching Sesame Street for a year will increase four-year old girls’ understanding of number concepts. 30 girls will be given a pre-test before the study begins, given understanding levels is a nuisance variable. Unfortunately, it is not reasonable to force children into the “treatment” or “control” group, so the study will be strictly observational. Conveniently 15 girls choose to watch and 15 choose not to. After a year a post test will be administered, and the scores will be recorded.   
(ANCOVA)

An experiment was designed to compare four doses of insulin A,B,C,D and their effect on blood sugar levels in rabbits. Four rabbits were selected and over the course of four weeks the rabbits were randomly assigned each of the dosages (one per week). Blood sugar levels were recorded at the end of each week.   
(LS)

Wireworms have been a long-term problem on your land for several years now. You have learned that soil fumigation can significantly improve the quality of your soil. There are five type of soil fumigation that you know of. Your land is divided into 25 even plots. The northern part of the land has higher elevation and gradually declines toward the southern part of the land. The east part of the land is most rocky and gradually becomes less rocky toward the western part of the land. A year after the fumigation the number of wireworms is counted in each plot   
(LS)