

# ESMA 6787: Homework 1

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## Problem 1: Syllabus Acknowledgment

I have read the syllabus, understand its contents, and have no questions.

## Problem 2: Definitions in Your Own Words

- **Experiment:** Method to answer a research question, where the researcher controls an environment and only changes one or many treatment holding all other things constant
- **Experimental unit:** unit that will receive the treatment
- **Observational unit:** it is the person, thing or event where are studying.
- **Background variable:** Are all the factor that can affect the study but are not controlled for
- **Independent (predictor) variable:** It is what is applied as treatment
- **Dependent (response) variable:** It is the outcome or what we observe after we apply the treatment
- **Confounded factors:** Are un observe factors that affect both the treatment and the observed factor
- **Experimental error:** It is how far our experiment is from the reality.
- **Randomization:** Treatments are applied randomly
- **Replicate:** recreation of the experiments with the same settings and specification but with different data

## Problem 3: Lady Tasting Tea

- (a) Units in this experiment:
- (b) Treatments in this experiment:
- (c) Randomization method using physical devices:
- (d) Adjustments if cups differ in material (porcelain vs china):

## Problem 4: Paper Airplane Experiment

- (a) Experimental treatments:
- (b) Experimental units and homogeneity:
- (c) Randomization process:
- (d) Procedure for applying treatment to unit:
- (e) Measurement process:

## Problem 5: Gasoline Mileage Study

- (a) Comparison of strengths and weaknesses:
- (b) Identification of true experiment(s) and justification:

## Problem 6: Baseball League as Experiment

- Treatments and units:
- Application of treatment to unit:
- Randomization and replication:
- Possibility and use of blocking:

## Problem 7: Tomato Fertilizer and Variety

- Experimental setup:
- Use of replication and randomization:
- Additional design principles in second season:

## Problem 8: Hand Washing Experiment

- (a) Experimental unit:
- (b) Factors:
- (c) Response:

## Problem 9: Real-life Application

## Problem 10: Variance as Quadratic Form

## Problem 11: Cell Means Model with Unequal Group Sizes

- (a) Proposed cell means model:
- (b) Design matrix  $X$  and its rank:
- (c) Computation of  $X'X$ :
- (d) OLS estimates as a function of  $y$ :
- (e) Analysis of Table 1 dataset:
  - i. OLS estimates:
  - ii. Projection matrix  $P_X$ :
  - iii. Compute  $y'(I - P_X)y$ :
  - iv. Compute  $\bar{y}_{..}$  and  $\bar{y}_{i.}$  for all  $i$ :
  - v. Estimability of  $\mu_1$ :
  - vi. Estimability of  $\mu_2 - \mu_3$ :
  - vii. Estimability of  $\mu_1 - \frac{\mu_2 + \mu_3}{2}$ :

## Problem 12: Fixed-Effect Model with Unequal Group Sizes

- (a) Proposed fixed-effect model:
- (b) Design matrix  $X$  and its rank:
- (c) Computation of  $X'X$ :
- (d) OLS estimates as a function of  $y$ :
- (e) Using Table 1 dataset:
  - i. OLS estimates:
  - ii. Projection matrix  $P_X$ :
  - iii. Compute  $y'(I - P_X)y$ :
  - iv. Compute  $\bar{y}_{..}$  and  $\bar{y}_i$  for all  $i$ :
  - v. Estimability of  $\alpha_1$ :
  - vi. Estimability of  $\alpha_2 - \alpha_3$ :
  - vii. Estimability of  $\alpha_1 - \frac{\alpha_3 + \alpha_4}{2}$ :