Question 12.1

Describe a situation or problem from your job, everyday life, current events, etc., for which a design of experiments approach would be appropriate.

Answer 12.1

At a manufacturing company, we often implement design of experiment to analyze the root cause of a product failure. The purpose of the design of experiment is to identify the highest possible single material that led to the failure, and swap it with the same type of material with different brands, production dates, etc. and observe to see if the failure rate drops. The ultimate goal is to find out the right combination of materials to maintain the manufacturing process.

Question 12.2

To determine the value of 10 different yes/no features to the market value of a house (large yard, solar roof, etc.), a real estate agent plans to survey 50 potential buyers, showing a fictitious house with different combinations of features. To reduce the survey size, the agent wants to show just 16 fictitious houses. Use R's `FrF2` function (in the `FrF2` package) to find a fractional factorial design for this experiment: what set of features should each of the 16 fictitious houses have?

Answer 12.2

```
# Clear global environment, load relevant package. Fractional factorial design is implemented using FrF2 function with 16 different houses and 10 combination of features.
> rm(list=ls())
> library(FrF2)
> df1 <- FrF2(nruns = 16,nfactors = 10)
> df1
    A  B  C  D  E  F  G  H  J  K
1  -1  1  1  1 -1 -1  1 -1  1 -1
2  -1  1 -1  1 -1  1 -1 -1 -1  1
3  -1  1 -1 -1 -1  1 -1  1  1 -1
4  -1 -1 -1  1  1  1  1 -1  1 -1
5   1  1 -1 -1  1 -1 -1 -1  1  1
6   1  1  1  1  1  1  1  1  1  1
7   1 -1 -1 -1 -1 -1  1 -1 -1 -1
8  -1 -1  1 -1  1 -1 -1  1  1 -1
9   1  1  1 -1  1  1  1 -1 -1 -1
10 -1 -1 -1 -1  1  1  1  1 -1  1
11 -1  1  1 -1 -1 -1  1  1 -1  1
12  1 -1  1  1 -1  1 -1  1 -1 -1
13  1 -1 -1  1 -1 -1  1  1  1  1
14  1  1 -1  1  1 -1 -1  1 -1 -1
15  1 -1  1 -1 -1  1 -1 -1  1  1
16 -1 -1  1  1  1 -1 -1 -1 -1  1
class=design, type= FrF2
```

Question 13.1

For each of the following distributions, give an example of data that you would expect to follow this distribution (besides the examples already discussed in class).

a. Binomial
b. Geometric c. Poisson
d. Exponential e. Weibull

Answer 13.1

a. Binomial: Observations of student taking multiple tests with expected test result to be either pass or fail.
b. Geometric: Assume students can pass the test with a score of C or higher. Observations of passing the exam by random selection with replacement are recorded. The probability of passing the test with at least ten observations would follow geometric distribution.
c. Poisson: An assembly machine produces components continuously. 10 samples selected randomly each day for inspection, and the quality inspector will stop production if failure rate reach a threshold of 4% or higher. The probability that one day the production would be stopped would follow Poisson distribution.
d. Exponential: The amount of time it takes for a machine working nonstop to produce a defect product.
e. Weibull: The amount of time for a machine to break down can follow Weibull distribution with α = 1,000 hours and β = .6.

Question 13.2

In this problem you, can simulate a simplified airport security system at a busy airport. Passengers arrive according to a Poisson distribution with $\lambda_1 = 5$ per minute (i.e., mean interarrival rate $\mu_1 = 0.2$ minutes) to the ID/boarding-pass check queue, where there are several servers who each have exponential service time with mean rate $\mu_2 = 0.75$ minutes. [Hint: model them as one block that has more than one resource.] After that, the passengers are assigned to the shortest of the several personal-check queues, where they go through the personal scanner (time is uniformly distributed between 0.5 minutes and 1 minute).

Answer 13.2

Airport security system was simulated using Python with SimPy package. The number of security personnel and personal scanner is predefined with 10 and 20 accordingly, with arrival rate being 5 per minute, check rate being .75 minutes, runtime being 360 minutes, and replications being 100 to set up the system. The result suggests that the combination of 10 security personnel and 30 personal scanners yield a wait time for 100 people to approximately 16 minutes.