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.

The design of experiments approach would be appropriate to analyze the rice-cooking process in my daily life.

I. **The output response is measured by the taste, and it will be rated on a scale of 1(worst) to 10(best).**
II. **There are three factors in the analysis, each factor with two choices: The price of rice brand (cheap/ costly); Water to rice ratio(2:1/1:1); Steaming time(Long(50mins)/ short(30 mins))**

III. **Then we will have 2^3=8 combinations, for each combination, we run a test and then use linear regression to analyze the relationship between factors and response and within factors.**

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? Note: the output of `FrF2` is "1" (include) or "-1" (don't include) for each feature.

From above, we could tell in order to solve the problem, we need build a model with 16 runs which represent each house and each run (house) will have 10 different attributes.

```
> library(FrF2)
> FrF2(nruns= 16, nfactors = 10)
   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
```

Above matrix shows the 16 combinations of 10 attributes(From A to K). Each row represents one house type while each column accounts for one house merit ("1" (include) or "-1" (don't include) for each feature).

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

Binomial Distribution:

Count how many three 3 pointers could be made out of 150 shots by NBA star player, Stephen Curry, given the fact that in 2018-2019 NBA season, his 3 pointers shooting percentage is 47.66% (61/128 shooting attempts)

Geometric Distribution:

For a job candidate, geometric distribution can be used to analyze the number of interviews taken before successful landing a new job.

Poisson Distribution:

The number of pop up commercials when browsing the Instagram per hour.

Exponential Distribution:

The amount of time(Minutes)between two commercials pop up when we are browsing the Instagram.

Weibull Distribution:

When K >1:
i.e. modelling the amount of time (wear out life) it takes a brand new vehicle to do a service maintenance to avoid the break down.

When K <1:
Modelling the amount of time(early life) it takes a 20-year old car to change parts.

When K=1: equivalent to Exponential Distribution: example given above.

Question 13.2

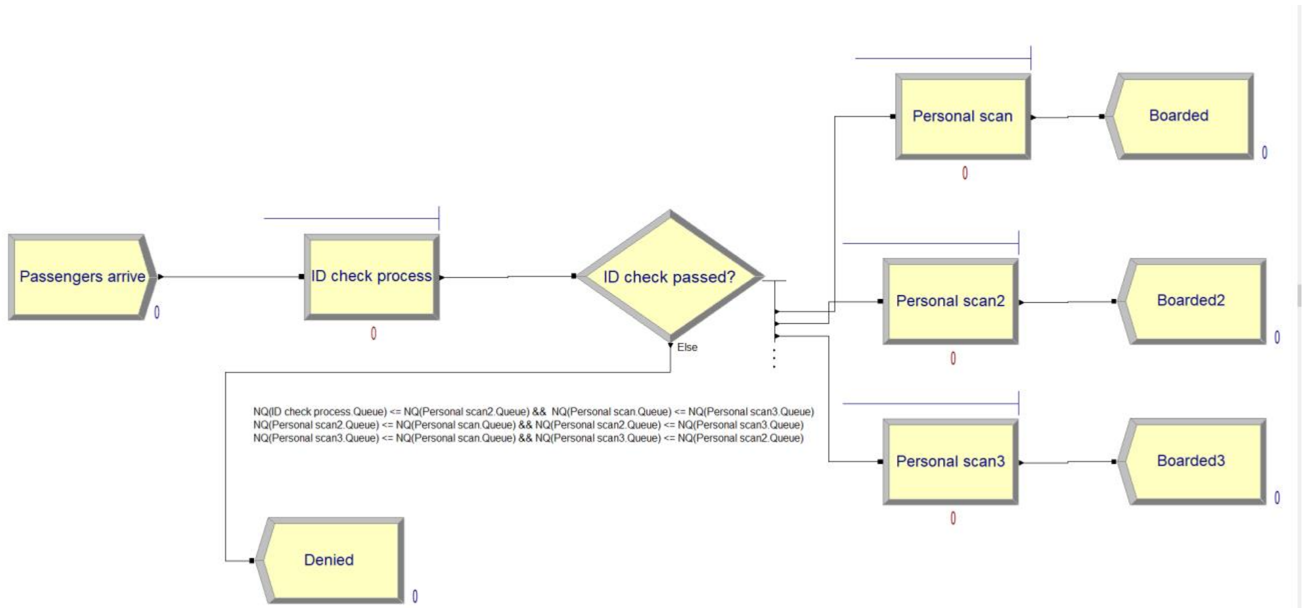
In this problem you, can simulate a simplified airport security system at a busy airport. Passengers arrive according to a Poisson distribution with $\lambda_1 = 5$ per minute (i.e., mean interarrival rate $\mu_1 = 0.2$ minutes) to the ID/boarding-pass check queue, where there are several servers who 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).

Use the Arena software (PC users) or Python with SimPy (PC or Mac users) to build a simulation of the system, and then vary the number of ID/boarding-pass checkers and personal-check queues to determine how many are needed to keep average wait times below 15 minutes. [If you're using SimPy, or if you have access to a non-student version of Arena, you can use $\lambda_1 = 50$ to simulate a busier airport.]

For this question, I chose to use Arena to dig in deeper.

The conclusion: 4 ID/boarding-pass checkers and 3 personal-check queues seem to be the optimal choice to keep average wait times below 15 minutes.

<u>Step1: Create flowchart and set parameters based on the assumptions given above.</u>



1. Since Arena works better with continuous data, we need to convert $\lambda_1 = 5$ per minute to mean interarrival rate $\mu_1 = 0.2$ minutes and then put into the "Passenger arrive" module.
2. Build the ID check process while setting it as exponential distribution time with mean rate $\mu_2 = 0.75$ minutes, Resource set to be 4.
3. Create a decision block to assign passengers to the shortest personal scanning queue.

4. N-way with Expression conditions as below: Make sure passengers being assigned to right queue.

NQ(ID check process.Queue) <= NQ(Personal scan2.Queue) && NQ(Personal scan.Queue) <= NQ(Personal scan3.Queue)
NQ(Personal scan2.Queue) <= NQ(Personal scan.Queue) && NQ(Personal scan2.Queue) <= NQ(Personal scan3.Queue)
NQ(Personal scan3.Queue) <= NQ(Personal scan.Queue) && NQ(Personal scan3.Queue) <= NQ(Personal scan2.Queue)

5. Each personal scan block follows uniform distribution. 3 blocks in this case.
6. Finally, direct passengers to the ending point. Mission Completed.

Step2: Run this workflow and generate a report.

6:05:20PM **Category Overview** October 21, 2020

Unnamed Project

Replications: 1 Time Units: Minutes

Key Performance Indicators

System	Average
Number Out	2,402

Total Number of Passengers in the simulation: 2402

6:05:20PM **Category Overview** October 21, 2020

Unnamed Project

Replications: 1 Time Units: Minutes

Entity

Time

VA Time	Average	Half Width	Minimum Value	Maximum Value
Entity 1	1.2233	0.050726424	0.00136493	5.6543

NVA Time	Average	Half Width	Minimum Value	Maximum Value
Entity 1	0.00	0.000000000	0.00	0.00

Wait Time	Average	Half Width	Minimum Value	Maximum Value
Entity 1	3.6366	(Correlated)	0.00	10.5083

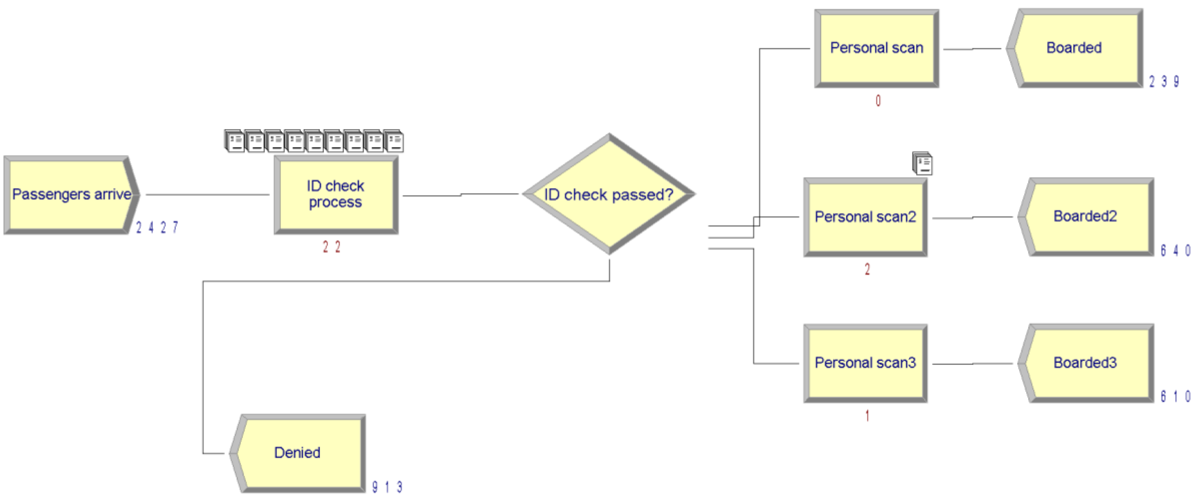
Transfer Time	Average	Half Width	Minimum Value	Maximum Value
Entity 1	0.00	0.000000000	0.00	0.00

Other Time	Average	Half Width	Minimum Value	Maximum Value
Entity 1	0.00	0.000000000	0.00	0.00

Total Time	Average	Half Width	Minimum Value	Maximum Value
Entity 1	4.8599	(Correlated)	0.4582	14.6844

Average wait time: 3.6366 minutes, Max wait time per entity:10.5083 minutes

The wait time here is below the threshold 15 minutes, as requested in the questions.



6:09:37PM **Category Overview** October 21, 2020

Unnamed Project

Replications: 1 Time Units: Minutes

Queue

Time

Waiting Time	Average	Half Width	Minimum Value	Maximum Value
ID check process.Queue	2.7784	(Correlated)	0.00	9.7517
Personal scan.Queue	2.4106	(Insufficient)	0.00	8.9495
Personal scan2.Queue	1.2396	(Correlated)	0.00	9.7467
Personal scan3.Queue	1.1441	(Correlated)	0.00	9.3611

Other

Number Waiting	Average	Half Width	Minimum Value	Maximum Value
ID check process.Queue	14.0049	(Correlated)	0.00	55.0000
Personal scan.Queue	1.2003	(Correlated)	0.00	13.0000
Personal scan2.Queue	1.6568	(Correlated)	0.00	13.0000
Personal scan3.Queue	1.4563	(Correlated)	0.00	12.0000

Step3: Tweaking the parameters (the number of ID/boarding-pass checkers and personal-check queues) to find other viable options:

Since I'm currently using the student version of Arena software with limited access. (Max Entity below 150), there is error message popping up when I set **the number of ID/boarding-pass checkers to 1,2,3,5,6,7 and more) which infers that the number of passengers in ID/boarding-pass check exceeds 150 at a time in our simulation. Comparing with our current solution, they are obviously not the optimal option.**