Homework 4

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```
library(png)
library(tidyverse)
library(reticulate)
library(ggplot2)

use_python("/home/d/anaconda3/bin/python3.6")
use_condaenv("ci", required = TRUE)
```

1. Necessity and Sufficiency

1.1. Probability of Neccessity and Sufficiency

1.1.1

```
X = c(1,0, 1, 0, 1, 0, 1, 0)
Q = c(0, 0, 1, 1, 0, 0, 1, 1)
X_and_Q = as.integer(X&Q)
ny = c(0, 0, 0, 0, 1, 1, 1, 1)
Y = as.integer(X_and_Q|ny)
print(data.frame(X,Q, ny, Y))
```

```
##   X Q ny Y
## 1 1 0  0 0
## 2 0 0  0 0
## 3 1 1  0 1
## 4 0 1  0 0
## 5 1 0  1 1
## 6 0 0  1 1
## 7 1 1  1 1
## 8 0 1  1 1
```

```
print("After Intervention do(X=0) we have:")
```

```
## [1] "After Intervention do(X=0) we have:"
```

```
X_new = c(0,0,0,0,0,0,0,0)
Y_new = as.integer((X_new&Q)|ny)
print(data.frame(X_new, X, Q, ny, Y, Y_new))
```

```
##   X_new X Q ny Y Y_new
## 1     0 1 0  0 0     0
## 2     0 0 0  0 0     0
## 3     0 1 1  0 1     0
## 4     0 0 1  0 0     0
## 5     0 1 0  1 1     1
## 6     0 0 0  1 1     1
## 7     0 1 1  1 1     1
## 8     0 0 1  1 1     1
```

From the above table when $X = 1$ and $Y = 1$, we get the following values
$n_y = (0, 1, 1), n_x = 1, n_q = (1, 0, 0)$

After intervention on X $do(X = 0)$, $Y = 0|do(X = 0), X = 1, Y = 1)$ is satisfied by the following exogenous variables:
$n_y = 0$, and $n_q = 1$

$P(Y_0 = 0|X = 1, Y = 1) = 0.8 * 0.9 = 0.72$

1.1.2

```
print("After Intervention do(X=1) we have:")
```

```
## [1] "After Intervention do(X=1) we have:"
```

```
X_new = c(1,1,1,1,1,1,1,1)
Y_new = as.integer((X_new&Q)|ny)
print(data.frame(X_new, X, Q, ny, Y, Y_new))
```

```
##   X_new X Q ny Y Y_new
## 1     1 1 0  0 0     0
## 2     1 0 0  0 0     0
## 3     1 1 1  0 1     1
## 4     1 0 1  0 0     1
## 5     1 1 0  1 1     1
## 6     1 0 0  1 1     1
## 7     1 1 1  1 1     1
## 8     1 0 1  1 1     1
```

$n_y = (0, 0), n_x = 0, n_q = (0, 1)$
After intervention on X, $do(X = 1)$, and from the table we get $n_y = 0$, and $n_q = 1$
$P(Y_1 = 1|X = 0, Y = 0) = 0.8 * 0.9 = 0.72$

1.2 Probability of Neccessity and Sufficiency, and Identifiability

1.2.1

$$PNS = P(y|x) - P(y|x')$$
$$0.9198813 - 0.19920710.7206742$$

1.2.2

$$PN = \frac{PNS}{P(y|x)}$$
$$= 0.7834426$$

$$PS = \frac{PNS}{P(y'|x')}$$
$$= 0.899941$$

2. Mediation

3. Effect of the treatment on the treated