Homework 6

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Vacuum pumps are being audited to determine if the process is in control and also capable of meeting the customer specifications. Samples of size n=5 are taken each hour of the day and tested with the data on vacuum recorded. The results of 10 consecutive hours of testing are provided.

```
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.1 --

## v ggplot2 3.3.5     v purrr   0.3.4
## v tibble  3.1.6     v dplyr   1.0.8
## v tidyr   1.2.0     v stringr 1.4.0
## v readr   2.1.2     v forcats 0.5.1

## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
library(data.table)
```

```
##
## Attaching package: 'data.table'

## The following objects are masked from 'package:dplyr':
##
##     between, first, last

## The following object is masked from 'package:purrr':
##
##     transpose
```

```
dt <- fread("Homework 6.csv")
dt
```

```
##     Sample One Two Three Four Five
##  1:      1  15  17    16   17   14
##  2:      2  16  16     9   14   15
##  3:      3  17  17    15   15   14
##  4:      4  18  15    16   16   16
##  5:      5  13  15    17   16   19
##  6:      6  10  15    11   17   18
##  7:      7  15  15    14   14   16
##  8:      8  14  13    12   15   14
##  9:      9  15  18    18   12   10
## 10:     10  12  12    15   15   16
```

```
valueTable <- data.table("SampleSize" = 2:7,
                         "A2" = c(1.88, 1.02, .73, .58, .48, .42),
                         "D3" = c(rep(0, 5), .08),
                         "D4" = c(3.27, 2.57, 2.28, 2.11, 2.00, 1.92),
                         "d2" = c(1.13, 1.69, 2.06, 2.33, 2.53, 2.70))

valueTable <- valueTable[ncol(dt) - 2]
```

A.

Find the x and R of each sample and record above.

```
dt[, c("xBar", "R") := .(rowMeans(dt[,2:ncol(dt)]),
                         do.call(pmax, dt[,2:ncol(dt)]) -
                          do.call(pmin, dt[,2:ncol(dt)]))]
dt
```

```
##     Sample One Two Three Four Five xBar R
##  1:      1  15  17    16   17   14 15.8 3
##  2:      2  16  16     9   14   15 14.0 7
##  3:      3  17  17    15   15   14 15.6 3
##  4:      4  18  15    16   16   16 16.2 3
##  5:      5  13  15    17   16   19 16.0 6
##  6:      6  10  15    11   17   18 14.2 8
##  7:      7  15  15    14   14   16 14.8 2
##  8:      8  14  13    12   15   14 13.6 3
##  9:      9  15  18    18   12   10 14.6 8
## 10:     10  12  12    15   15   16 14.0 4
```

B

Find and record the grand mean $\bar{\bar{x}}$ and $\bar{R}$ in the appropriate boxes.

```
writeLines(paste("The grand mean is:", xBar <- mean(dt$xBar)))
```

```
## The grand mean is: 14.88
```

```
writeLines(paste("The R is:", R <- mean(dt$R)))
```

```
## The R is: 4.7
```

C

Find the UCL and LCL for the $\bar{x}$ chart.

```
writeLines(paste("The UCL for the x chart is:", xBarUCL <- xBar + (valueTable$A2 * R)))
```

```
## The UCL for the x chart is: 17.606
```

```
writeLines(paste("The LCL for the x chart is:", xBarLCL <- xBar - (valueTable$A2 * R)))
```

```
## The LCL for the x chart is: 12.154
```

D

Find the UCL and LCL for the R chart.

```
writeLines(paste("The UCL for the R chart is:", RUCL <- valueTable$D4 * R))
```

```
## The UCL for the R chart is: 9.917
```

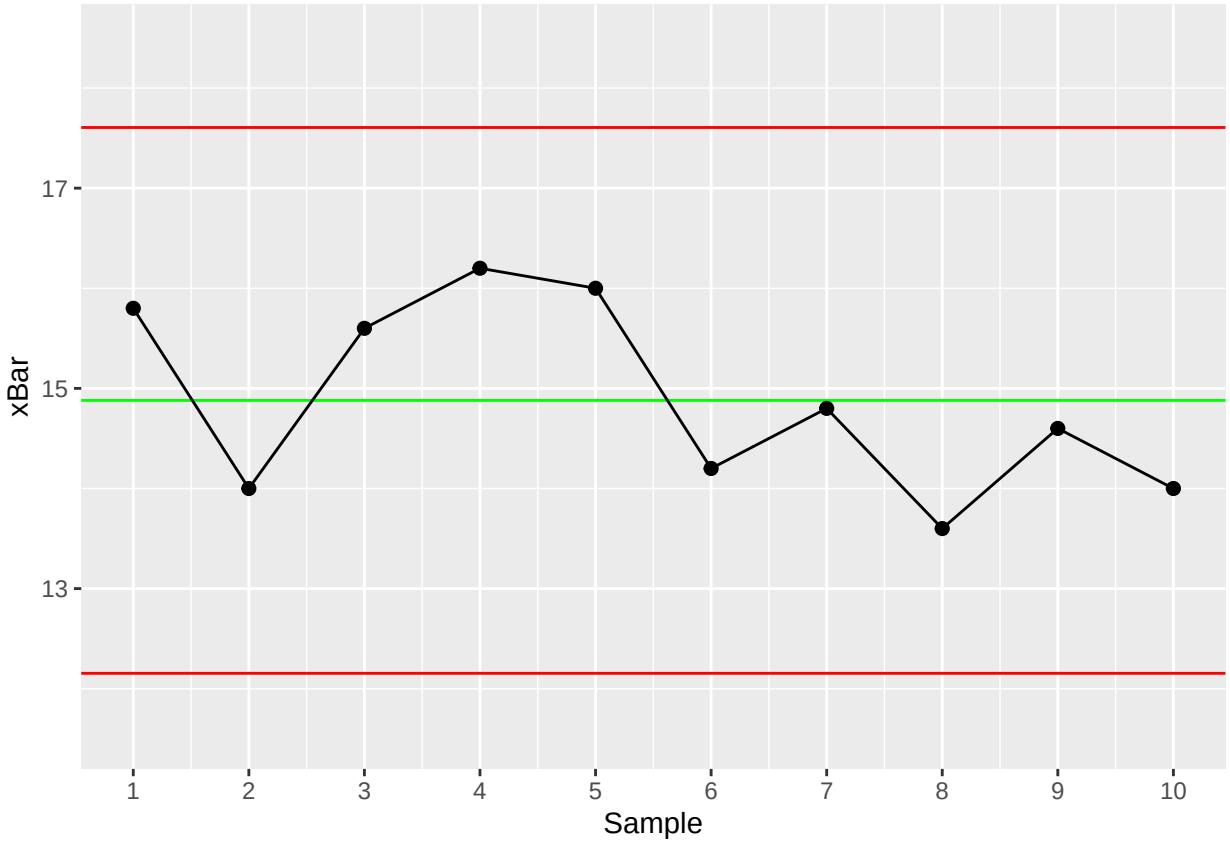
```
writeLines(paste("The LCL for the R chart is:", RLCL <- valueTable$D3 * R))
```

```
## The LCL for the R chart is: 0
```

E

Sketch out a control chart for the x-bar chart. Is the process in control in terms of the "average" vacuum pressure? _____ Yes or No

```
dt %>%
  ggplot() +
  geom_hline(yintercept = xBarLCL, color = "red") +
  geom_hline(yintercept = xBar, color = "green") +
  geom_hline(yintercept = xBarUCL, color = "red") +
  geom_line(aes(x = Sample, y = xBar)) +
  geom_point(aes(x = Sample, y = xBar), size = 2) +
  scale_x_continuous("Sample", 1:nrow(dt)) +
  ylim(c(xBarLCL - (xBarLCL * .05), xBarUCL * 1.05))
```



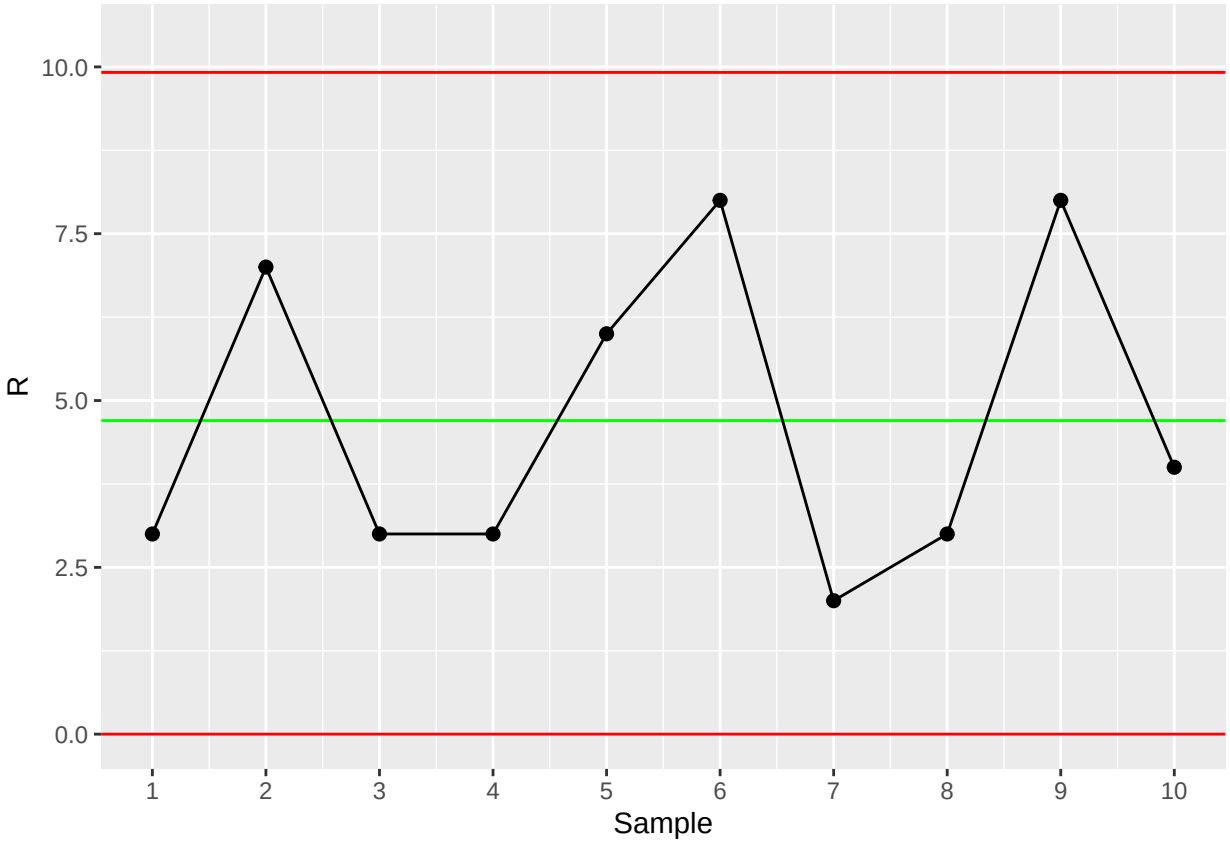

```
if(min(dt$xBar) > xBarLCL & max(dt$xBar) < xBarUCL) {
  writeLines("The process is in control in terms of the average.")
} else {
  writeLines("The process is not in control in terms of the average.")
}
```

```
## The process is in control in terms of the average.
```

F

Sketch out a control chart for the R chart. Is the process in control in terms of the "variation" in the process? _____ Yes or No

```
dt %>%
  ggplot() +
  geom_hline(yintercept = R, color = "green") +
  geom_hline(yintercept = RLCL, color = "red") +
  geom_hline(yintercept = RUCL, color = "red") +
  geom_line(aes(x = Sample, y = R)) +
  geom_point(aes(x = Sample, y = R), size = 2) +
  scale_x_continuous("Sample", 1:nrow(dt)) +
  ylim(c(RLCL - (RLCL * .05), RUCL * 1.05))
```




```
if(min(dt$R) > RLCL & max(dt$R) < RUCL) {
  writeLines("The process is in control in terms of the variation")
} else {
  writeLines("The process is not in control in terms of the variation")
}
```

```
## The process is in control in terms of the variation
```

The process is in control in terms of the average.

G

Find the process standard deviation (σ)

```
writeLines(paste("The standard deviation is:", sigma <- (R / valueTable$d2)))
```

```
## The standard deviation is: 2.01716738197425
```

H

Find the appropriate process capability index for the process if the lower and upper specification limits are 8 to 20.

```
LSL <- 8
USL <- 20
if((LSL + USL) / 2 == xBar) {
  writeLines("The process is centered")
  C <- (USL - LSL) / (6 * sigma)
} else {
  writeLines("The process is not centered")
  C <- min((USL - xBar) / (3 * sigma),
           (xBar - LSL) / (3 * sigma))
}
```

```
## The process is not centered
```

```
writeLines(paste("C is:", C))
```

```
## C is: 0.846070921985816
```

I

What is your interpretation of the capability index?

```
if(C < 1) {
  writeLines("Because C is less than one, the process is not capable and process improvement should beg
} else {
  writeLines("Because C is greater than one, the process is capabale.")
  if(C < 1.33) {
    writeLines("However, because C is still under 1.33, we should probably improve the process a bit mo
  }
}
```

```
## Because C is less than one, the process is not capable and process improvement should begin immediat
```