

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 —
```

```
## ✓ ggplot2 3.3.5      ✓ purrr 0.3.4
## ✓ tibble 3.1.6       ✓ dplyr 1.0.8
## ✓ tidyr 1.2.0        ✓ stringr 1.4.0
## ✓ readr 2.1.2        ✓ 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 <int>	One <int>	Two <int>	Three <int>	Four <int>	Five <int>
1	15	17	16	17	14
2	16	16	9	14	15
3	17	17	15	15	14
4	18	15	16	16	16
5	13	15	17	16	19
6	10	15	11	17	18
7	15	15	14	14	16
8	14	13	12	15	14
9	15	18	18	12	10
10	12	12	15	15	16

1-10 of 10 rows

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

1-10 of 10 rows

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
```

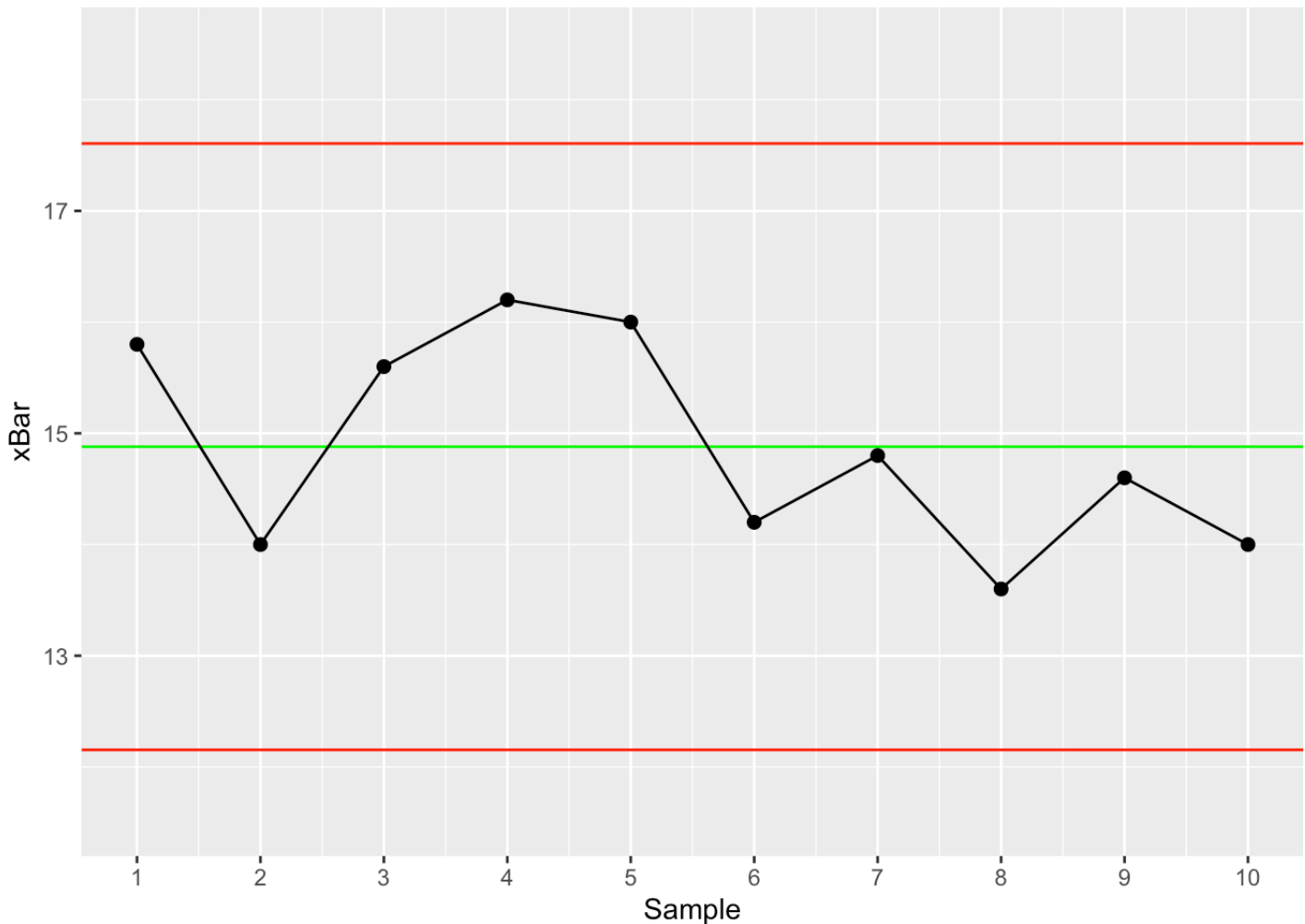
```
writeLines(paste("The LCL for the R chart is:", RLCL <- valueTable$D3 * R))
```

```
## 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))
```



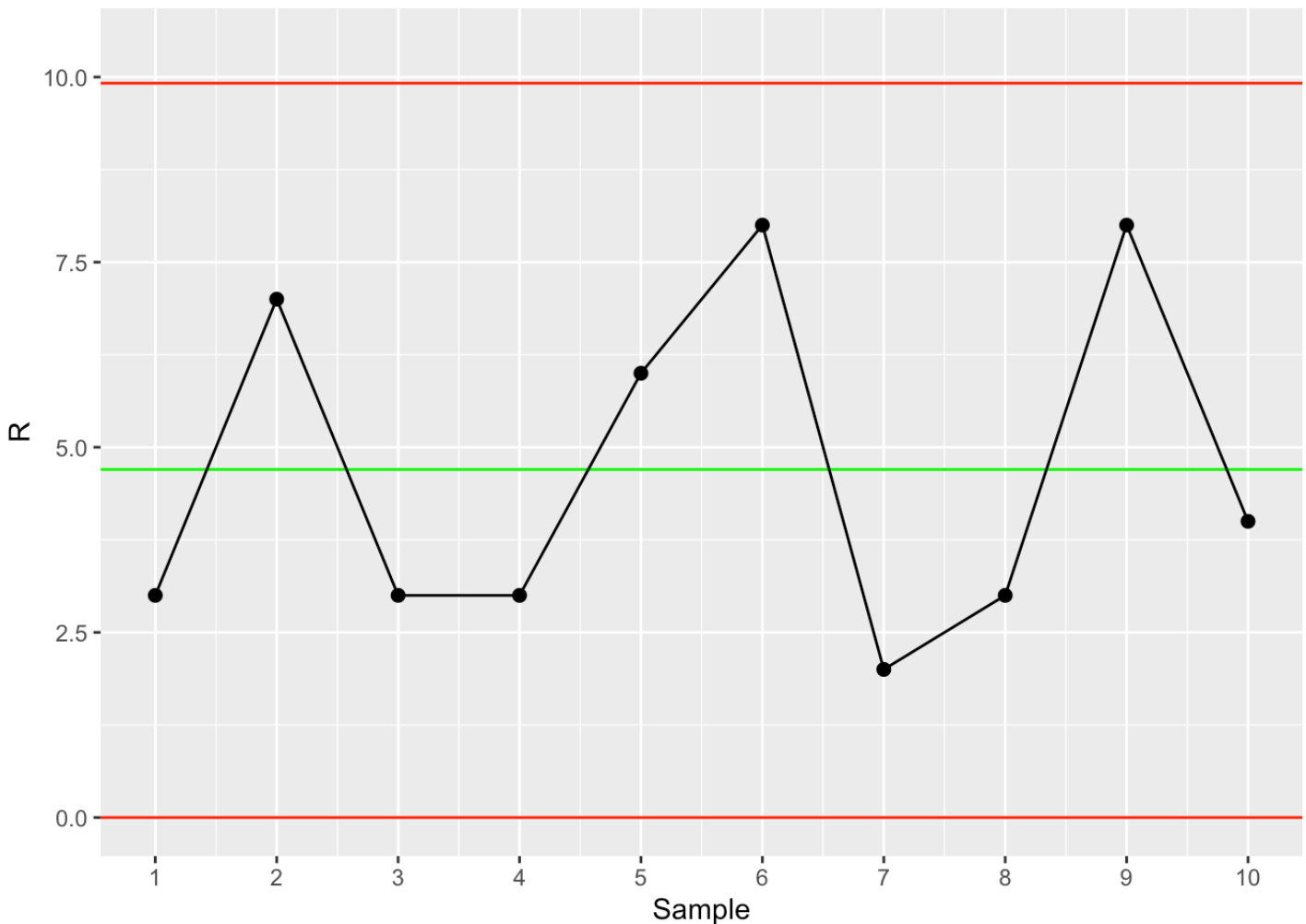
```
if(min(dt$xBar) > xBarLCL & max(dt$xBar) < xBarUCL) {
  writeLines("The process is in control in terms of the average.")
} else {
  writeLines("The process is not in control in terms of the average.")
}
```

```
## 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
```

|

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 impr  
ovement should begin immediately.")  
} else {  
  writeLines("Because C is greater than one, the process is capable.")  
  if(C < 1.33) {  
    writeLines("However, because C is still under 1.33, we should probably improve th  
e process a bit more.")  
  }  
}
```

```
## Because C is less than one, the process is not capable and process improvement sho  
uld begin immediately.
```