Homework 1

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2025/06/26

1. The Iowa data set `iowa.csv` is a toy example that summarises the yield of wheat (bushels per acre) for the state of Iowa between 1930-1962. In addition to yield, year, rainfall and temperature were recorded as the main predictors of yield.
    a. First, we need to load the data set into R using the command `read.csv()`. Use the help function to learn what arguments this function takes. Once you have the necessary input, load the data set into R and make it a data frame called `iowa.df`.

    ```
    ?read.csv
    iowa.df<-read.csv("data/iowa.csv", sep = ';', header=T)
    ```

    b. How many rows and columns does `iowa.df` have?

    ```
    dim(iowa.df)
    ```

    ```
    ## [1] 33 10
    ```

    ```
    # or
    nrow(iowa.df)
    ```

    ```
    ## [1] 33
    ```

    ```
    ncol(iowa.df)
    ```

    ```
    ## [1] 10
    ```

    c. What are the names of the columns of `iowa.df`?

    ```
    colnames(iowa.df)
    ```

    ```
    ##  [1] "Year"  "Rain0" "Temp1" "Rain1" "Temp2" "Rain2" "Temp3" "Rain3" "Temp4"
    ## [10] "Yield"
    ```

    d. What is the value of row 5, column 7 of `iowa.df`?

    ```
    iowa.df[5, 7]
    ```

    ```
    ## [1] 79.7
    ```

    e. Display the second row of `iowa.df` in its entirety.

    ```
    iowa.df[2, ]
    ```

    ```
    ##   Year Rain0 Temp1 Rain1 Temp2 Rain2 Temp3 Rain3 Temp4 Yield
    ## 2 1931 14.76  57.5  3.83    75  2.72  77.2   3.3  72.6  32.9
    ```

2. Syntax and class-typing.
    a. For each of the following commands, either explain why they should be errors, or explain the non-erroneous result.

```
vector1 <- c("5", "12", "7", "32")
max(vector1)
sort(vector1)
sum(vector1)
```

- `max(vector1)`:
    - Result: "7"
    - Explanation: While the elements appear numeric, they're stored as character strings. R performs

lexicographical comparison: Compares first characters: '7' > '5' > '3' > '1'. Thus "7" is considered the "maximum" string

- `sort(vector1)`:
  - Result: `"12" "32" "5"  "7"`
  - Explanation: Character strings are sorted alphabetically by Unicode values: '1' (ASCII 49) < '3' (51) < '5' (53) < '7' (55) Note this differs from numerical sorting (which would be 5,7,12,32)
- `sum(vector1)`:
  - Error in sum(vector1) : invalid 'type' (character) of argument
  - Explanation: The sum() function requires numeric input. No implicit type conversion occurs, unlike some other languages.

b. For the next series of commands, either explain their results, or why they should produce errors.

```
vector2 <- c("5",7,12)
vector2[2] + vector2[3]

dataframe3 <- data.frame(z1="5",z2=7,z3=12)
dataframe3[1,2] + dataframe3[1,3]

list4 <- list(z1="6", z2=42, z3="49", z4=126)
list4[[2]]+list4[[4]]
list4[2]+list4[4]
```

- `vector2[2] + vector2[3]`:
  - Result: Error in vector2[2] + vector2[3] : non-numeric argument to binary operator
  - Explanation: We created a character vector through coercion (all elements become strings) so the actual stored values: c("5", "7", "12"). We're trying to add two character strings "7" + "12"
- `dataframe3[1,2] + dataframe3[1,3]`:
  - Result: `19`
  - Works because: Data frames maintain column types z2 and z3 remain numeric despite z1 being character. We're extracting values, not columns
- `list4[[2]]+list4[[4]]`:
  - Result: `168`
  - Works because: [[ ]] extracts actual numeric values (42 + 126). List elements maintain their original types
- `list4[2]+list4[4]`:
  - Result: Error in list4[2] + list4[4] : non-numeric argument to binary operator
  - Error because: [ ] returns sublists (not the actual values). We're trying to add list(42) + list(126)

3. Working with functions and operators.
   a. The colon operator will create a sequence of integers in order. It is a special case of the function `seq()` which you saw earlier in this assignment. Using the help command `?seq` to learn about the function, design an expression that will give you the sequence of numbers from 1 to 10000 in increments of 372. Design another that will give you a sequence between 1 and 10000 that is exactly 50 numbers in length.

```r
?seq
seq(from = 1, to = 10000, by = 372)
```

```
##  [1]    1  373  745 1117 1489 1861 2233 2605 2977 3349 3721 4093 4465 4837 5209
## [16] 5581 5953 6325 6697 7069 7441 7813 8185 8557 8929 9301 9673
```

```r
seq(from = 1, to = 10000, length.out = 50)
```

```
##  [1]     1.0000   205.0612   409.1224   613.1837   817.2449  1021.3061
##  [7]  1225.3673  1429.4286  1633.4898  1837.5510  2041.6122  2245.6735
## [13]  2449.7347  2653.7959  2857.8571  3061.9184  3265.9796  3470.0408
## [19]  3674.1020  3878.1633  4082.2245  4286.2857  4490.3469  4694.4082
```

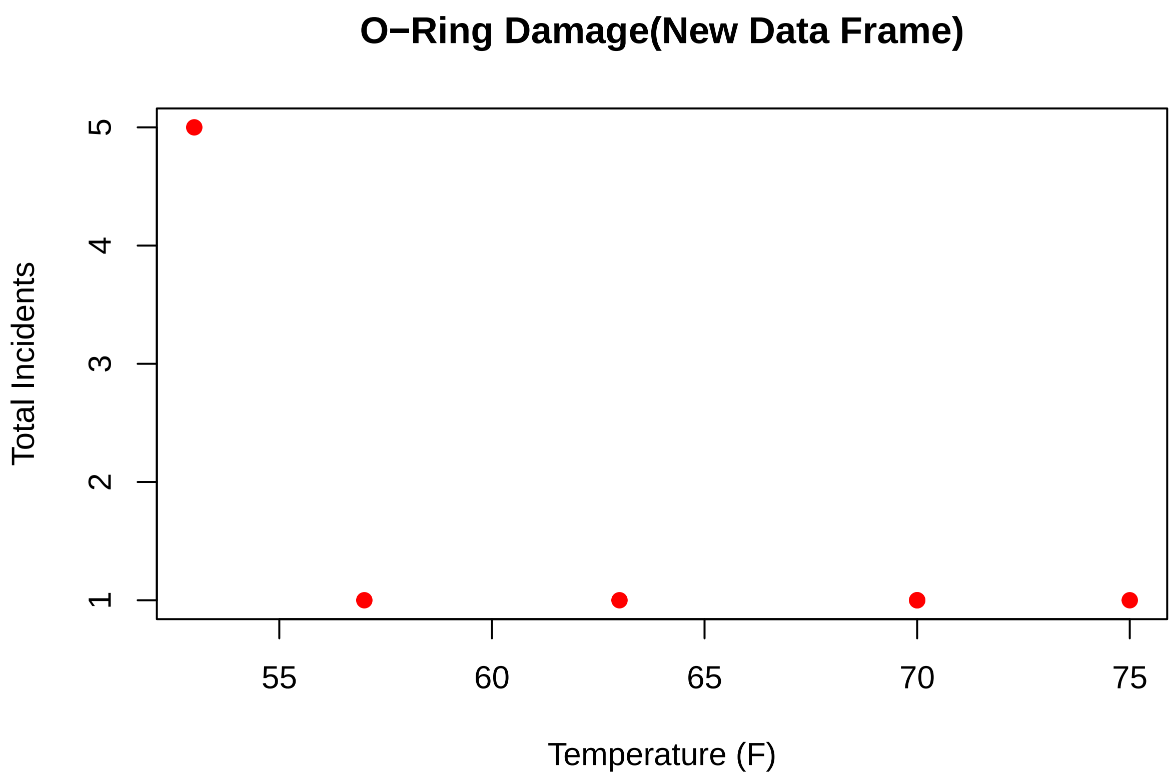
```
## [25]  4898.4694  5102.5306  5306.5918  5510.6531  5714.7143  5918.7755
## [31]  6122.8367  6326.8980  6530.9592  6735.0204  6939.0816  7143.1429
## [37]  7347.2041  7551.2653  7755.3265  7959.3878  8163.4490  8367.5102
## [43]  8571.5714  8775.6327  8979.6939  9183.7551  9387.8163  9591.8776
## [49]  9795.9388 10000.0000
```

b. The function `rep()` repeats a vector some number of times. Explain the difference between `rep(1:3, times=3)` and `rep(1:3, each=3)`.
   - `rep(1:3, times=3)`:
     - Repeats the **entire vector** `1:3` three times.
     - Output: 1 2 3 1 2 3 1 2 3
     - The sequence `1, 2, 3` is repeated back-to-back three times.
   - `rep(1:3, each=3)`:
     - Repeats **each element** of the vector three times before moving to the next element.
     - Output: 1 1 1 2 2 2 3 3 3
     - Each number (`1`, then `2`, then `3`) is repeated three times consecutively.
   - **Summary:**
     - `times` repeats the whole vector.
     - `each` repeats each element individually before moving to the next.

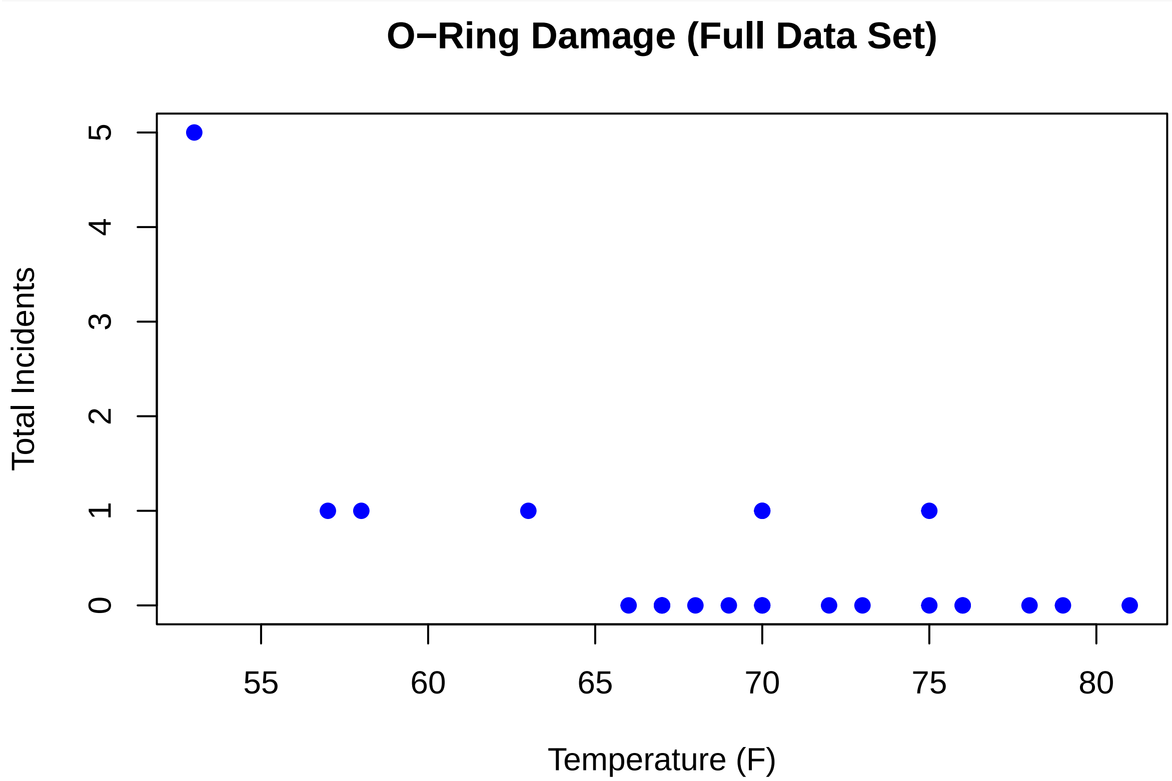
MB.Ch1.2. The `orings` data frame gives data on the damage that had occurred in US space shuttle launches prior to the disastrous Challenger launch of 28 January 1986. The observations in rows 1, 2, 4, 11, 13, and 18 were included in the pre-launch charts used in deciding whether to proceed with the launch, while remaining rows were omitted.

Create a new data frame by extracting these rows from `orings`, and plot total incidents against temperature for this new data frame. Obtain a similar plot for the full data set.

```r
# Create a new data frame by extracting these rows from orings
library(DAAG)
selected_rows <- c(1, 2, 4, 11, 13, 18)
orings_subset <- orings[selected_rows, ]

# Plot total incidents against temperature for this new data frame
plot(orings_subset$Temperature, orings_subset$Total,
     xlab = "Temperature (F)", ylab = "Total Incidents",
     main = "O-Ring Damage(New Data Frame)",
     pch = 19, col = "red")
```




```r
# Obtain a similar plot for the full data set
plot(orings$Temperature, orings$Total,
     xlab = "Temperature (F)", ylab = "Total Incidents",
     main = "O-Ring Damage (Full Data Set)",
     pch = 19, col = "blue")
```



MB.Ch1.4. For the data frame `ais` (DAAG package)

a. Use the function `str()` to get information on each of the columns. Determine whether any of the columns hold missing values.

```r
# Load the DAAG package
library(DAAG)

# Load the ais dataset
data(ais)

# Get the structure of the ais data frame
str(ais)
```

```
## 'data.frame':    202 obs. of  13 variables:
##  $ rcc   : num  3.96 4.41 4.14 4.11 4.45 4.1 4.31 4.42 4.3 4.51 ...
##  $ wcc   : num  7.5 8.3 5 5.3 6.8 4.4 5.3 5.7 8.9 4.4 ...
##  $ hc    : num  37.5 38.2 36.4 37.3 41.5 37.4 39.6 39.9 41.1 41.6 ...
##  $ hg    : num  12.3 12.7 11.6 12.6 14 12.5 12.8 13.2 13.5 12.7 ...
##  $ ferr  : num  60 68 21 69 29 42 73 44 41 44 ...
##  $ bmi   : num  20.6 20.7 21.9 21.9 19 ...
##  $ ssf   : num  109.1 102.8 104.6 126.4 80.3 ...
##  $ pcBfat: num  19.8 21.3 19.9 23.7 17.6 ...
##  $ lbm   : num  63.3 58.5 55.4 57.2 53.2 ...
##  $ ht    : num  196 190 178 185 185 ...
##  $ wt    : num  78.9 74.4 69.1 74.9 64.6 63.7 75.2 62.3 66.5 62.9 ...
##  $ sex   : Factor w/ 2 levels "f","m": 1 1 1 1 1 1 1 1 1 1 ...
##  $ sport : Factor w/ 10 levels "B_Ball","Field",..: 1 1 1 1 1 1 1 1 1 1 ...
```

```r
# Check for missing values in each column
colSums(is.na(ais))
```

```
##    rcc    wcc     hc     hg   ferr    bmi    ssf pcBfat    lbm     ht     wt
##      0      0      0      0      0      0      0      0      0      0      0
##    sex  sport
##      0      0
```

b. Make a table that shows the numbers of males and females for each different sport. In which sports is there a large imbalance (e.g., by a factor of more than 2:1) in the numbers of the two sexes?

```r
# Load the data
library(DAAG)
data(ais)

# Create the table of counts
sex_by_sport <- table(ais$sport, ais$sex)
print(sex_by_sport)
```

```
##
##            f  m
##   B_Ball  13 12
##   Field    7 12
##   Gym      4  0
##   Netball 23  0
##   Row     22 15
##   Swim     9 13
##   T_400m  11 18
##   T_Sprnt  4 11
```

```
##    Tennis   7  4
##    W_Polo   0 17
```

```r
# Find sports with >2:1 gender imbalance
imbalance <- sex_by_sport[, "f"] / sex_by_sport[, "m"]  # female:male ratio

# Sports where females outnumber males by >2:1
female_dominant <- names(which(imbalance > 2))

# Sports where males outnumber females by >2:1
male_dominant <- names(which(imbalance < 0.5))

cat("\nSports with female > 2 male:", female_dominant)
```

```
##
## Sports with female > 2 male: Gym Netball
```

```r
cat("\nSports with male > 2 female:", male_dominant)
```

```
##
## Sports with male > 2 female: T_Sprnt W_Polo
```

MB.Ch1.6.Create a data frame called `Manitoba.lakes` that contains the lake's `elevation` (in meters above sea level) and `area` (in square kilometers) as listed below. Assign the names of the lakes using the `row.names()` function.

	elevation	area
Winnipeg	217	24387
Winnipegosis	254	5374
Manitoba	248	4624
SouthernIndian	254	2247
Cedar	253	1353
Island	227	1223
Gods	178	1151
Cross	207	755
Playgreen	217	657

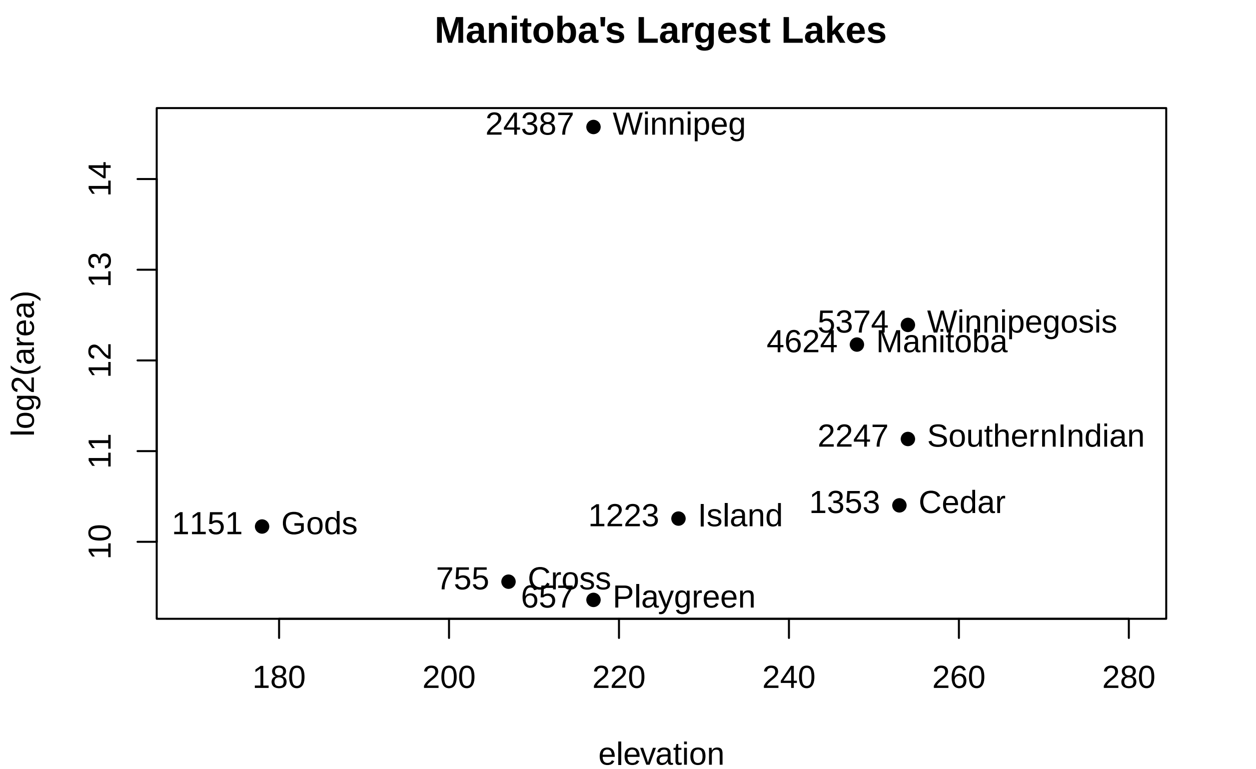
```r
# Create the data frame
Manitoba.lakes <- data.frame(
  elevation = c(217, 254, 248, 254, 253, 227, 178, 207, 217),
  area = c(24387, 5374, 4624, 2247, 1353, 1223, 1151, 755, 657)
)

# Set row names (lake names)
row.names(Manitoba.lakes) <- c("Winnipeg", "Winnipegosis", "Manitoba",
                              "SouthernIndian", "Cedar", "Island",
                              "Gods", "Cross", "Playgreen")

# Display the result
Manitoba.lakes
```

```
##                  elevation  area
## Winnipeg               217 24387
## Winnipegosis           254  5374
## Manitoba               248  4624
## SouthernIndian         254  2247
## Cedar                  253  1353
```

```
## Island                    227   1223
## Gods                      178   1151
## Cross                     207    755
## Playgreen                 217    657
```

(a) Use the following code to plot `log2(area)` versus `elevation`, adding labeling information (there is an extreme value of area that makes a logarithmic scale pretty much essential):

```r
attach(Manitoba.lakes)
plot(log2(area) ~ elevation, pch=16, xlim=c(170,280))
# NB: Doubling the area increases log2(area) by 1.0
text(log2(area) ~ elevation, labels=row.names(Manitoba.lakes), pos=4)
text(log2(area) ~ elevation, labels=area, pos=2)
title("Manitoba's Largest Lakes")
```

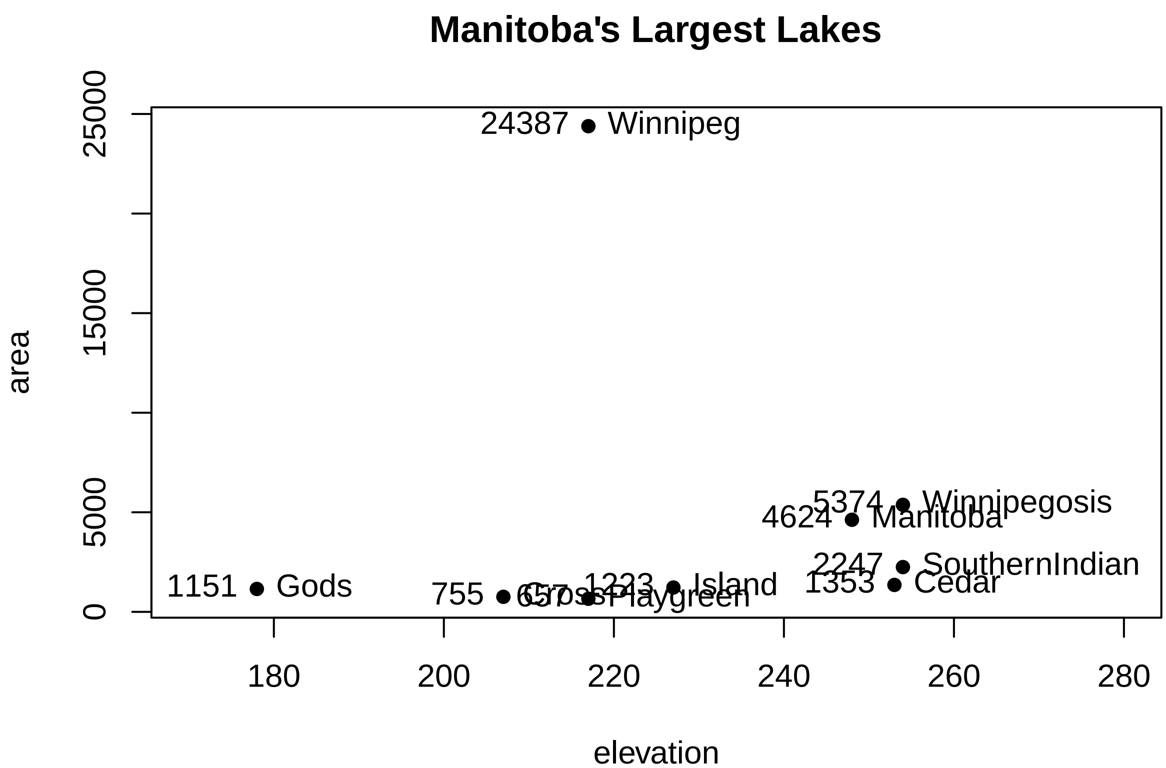


Devise captions that explain the labeling on the points and on the y-axis. It will be necessary to explain how distances on the scale relate to changes in area.

- Here are explanatory captions for the plot:
  - **Y-axis caption**: "The y-axis shows log2(area), where each unit increase represents a doubling of lake area. For example, Winnipeg (log2(area) ~ 14.6) has approximately 2^(14.6-13.4) ~ 2.3 times the area of Winnipegosis (log2(area) ~ 13.4)."
  - **Point labeling caption**: "Lake names are shown to the right of each point, while actual area values (in km^2) appear to the left. The logarithmic transformation compresses the wide range of areas (657-24,387 km^2) into a manageable scale where Winnipeg appears as an extreme outlier."
  - **Scale relationship explanation**: "Vertical distances on this plot correspond to ratios of areas. Moving up by 1 unit means an area is twice as large, while moving down by 1 unit means an area is half as large. The 15-unit range on the y-axis reflects that Winnipeg's area is about 2^15 ~ 32,000 times larger than the smallest lake's area."

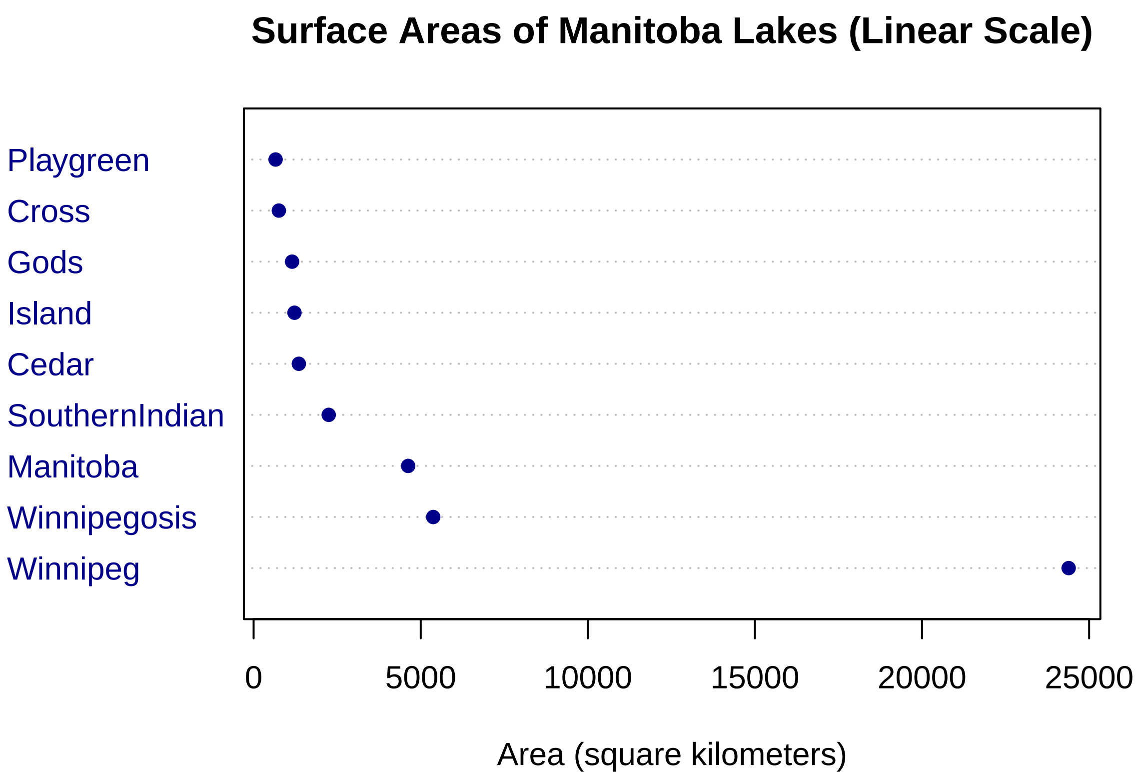
(b) Repeat the plot and associated labeling, now plotting area versus elevation, but specifying `ylog=TRUE` in order to obtain a logarithmic y-scale.

```
plot(area ~ elevation, pch=16, xlim=c(170,280), ylog=T)
text(area ~ elevation, labels=row.names(Manitoba.lakes), pos=4, ylog=T)
text(area ~ elevation, labels=area, pos=2, ylog=T)
title("Manitoba's Largest Lakes")
```

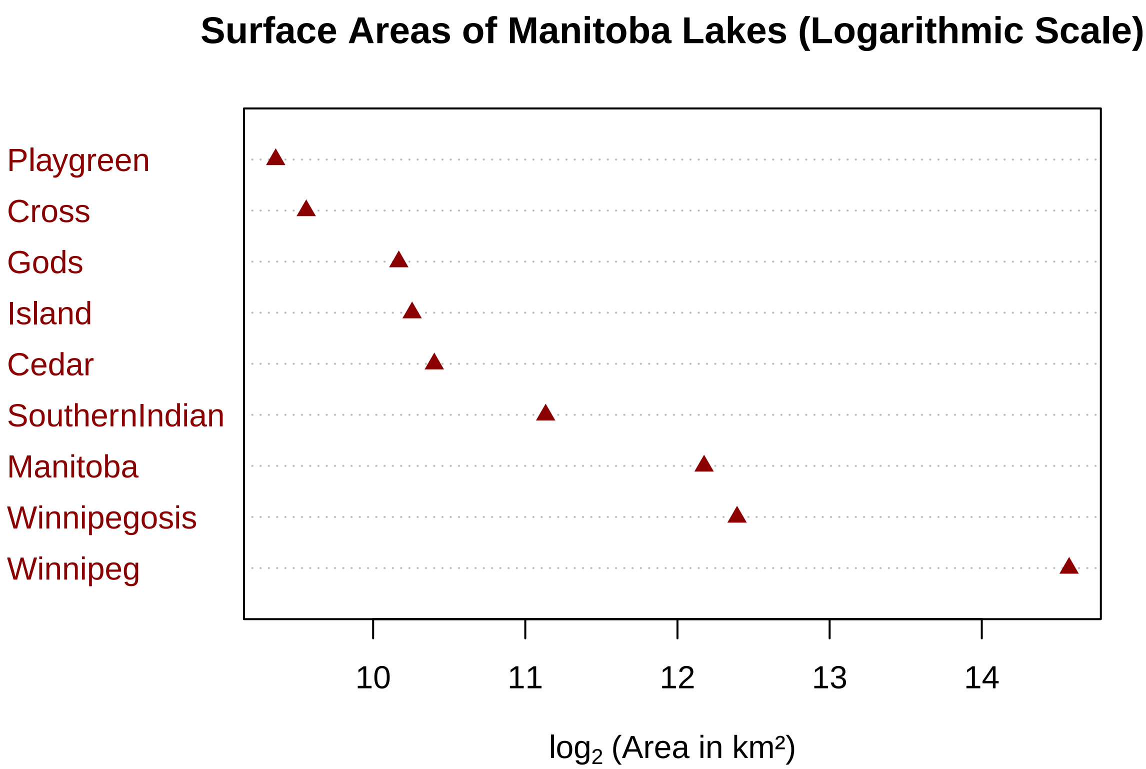


MB.Ch1.7. Look up the help page for the R function `dotchart()`. Use this function to display the areas of the Manitoba lakes (a) on a linear scale, and (b) on a logarithmic scale. Add, in each case, suitable labeling information.

```
# (a) Linear scale dotchart
dotchart(Manitoba.lakes$area,
         labels = rownames(Manitoba.lakes),
         main = "Surface Areas of Manitoba Lakes (Linear Scale)",
         xlab = "Area (square kilometers)",
         pch = 16,
         color = "darkblue")
```




```r
# (b) Logarithmic scale dotchart (preserving default axis)
dotchart(log2(Manitoba.lakes$area),
         labels = rownames(Manitoba.lakes),
         main = "Surface Areas of Manitoba Lakes (Logarithmic Scale)",
         xlab = expression(log[2]~"(Area in km²)"),
         pch = 17,
         color = "darkred")
```



MB.Ch1.8. Using the `sum()` function, obtain a lower bound for the area of Manitoba covered by water.

```
# Calculate lower bound for water coverage
water_area_lower_bound <- sum(Manitoba.lakes$area)

# Print the result with proper formatting
cat("Lower bound for Manitoba's water coverage (major lakes only):",
    format(water_area_lower_bound, big.mark = ","),
    "square kilometers\n")
```

```
## Lower bound for Manitoba's water coverage (major lakes only): 41,771 square kilometers
```