```
R version 3.5.1 (2018-07-02) -- "Feather Spray"
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Platform: x86_64-apple-darwin15.6.0 (64-bit)

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  Natural language support but running in an English locale

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[Workspace loaded from ~/.RData]

> # ######################################################
> #     R Language Reference Notes:
> #     Use head and tail to look at first few and last few records.
> #     Use str and names to look at structure and column names of a data frame.
> #     Use $ notation to look at a particular column name.
> #     Use [] square brackets (row,column) notation to look at a particular value.
>
> #     Also, conditional selection in R:
> #     Select data in I row and J column (one field) for DataFrameX: DataFrameX[I,J]
> #     Alternatively:
> #     Data in I row: DataFrameX[I,] # display row/record I with column names
> #     Data in J column: DataFrameX$J_Column_Name, or DataFrameX[,J]
> #     NOTE: R uses 1 for first record/row. Python uses 0!
>
> #      *** Assignment Requirements ***
>
> #      1. Use Assignment 5 screenshots and R Manual to backward-engineer the following requirements:
> #      2. Resources:
> #            a. R Manual: https://cran.r-project.org/doc/manuals/r-release/R-lang.pdf
> #            b. R for Data Science: https://r4ds.had.co.nz/
> #     3. Use Motor Trend Car Road Tests data:
> #            a. Research the data! https://stat.ethz.ch/R-manual/R-devel/library/datasets/html/mtcars.html
> #            b. url = "http://vincentarelbundock.github.io/Rdatasets/csv/datasets/mtcars.csv"
> #      Note: Use variable "mtcars" to read file into. (See Assignment 5 for reading .csv files.)
>
> # ######################################################
>
> url = "http://vincentarelbundock.github.io/Rdatasets/csv/datasets/mtcars.csv"
> mtcars <- read.csv(file=url, head=TRUE,sep=",")
>
> cat ("\n", "1) Display all data from file:","\n")
```

```
 1) Display all data from file:
> mtcars
                   X  mpg cyl  disp  hp drat    wt  qsec vs am gear carb
1          Mazda RX4 21.0   6 160.0 110 3.90 2.620 16.46  0  1    4    4
2      Mazda RX4 Wag 21.0   6 160.0 110 3.90 2.875 17.02  0  1    4    4
3         Datsun 710 22.8   4 108.0  93 3.85 2.320 18.61  1  1    4    1
4     Hornet 4 Drive 21.4   6 258.0 110 3.08 3.215 19.44  1  0    3    1
5  Hornet Sportabout 18.7   8 360.0 175 3.15 3.440 17.02  0  0    3    2
6            Valiant 18.1   6 225.0 105 2.76 3.460 20.22  1  0    3    1
7         Duster 360 14.3   8 360.0 245 3.21 3.570 15.84  0  0    3    4
8          Merc 240D 24.4   4 146.7  62 3.69 3.190 20.00  1  0    4    2
9           Merc 230 22.8   4 140.8  95 3.92 3.150 22.90  1  0    4    2
10          Merc 280 19.2   6 167.6 123 3.92 3.440 18.30  1  0    4    4
11          Merc 280C 17.8   6 167.6 123 3.92 3.440 18.90  1  0    4    4
12         Merc 450SE 16.4   8 275.8 180 3.07 4.070 17.40  0  0    3    3
13         Merc 450SL 17.3   8 275.8 180 3.07 3.730 17.60  0  0    3    3
14        Merc 450SLC 15.2   8 275.8 180 3.07 3.780 18.00  0  0    3    3
15 Cadillac Fleetwood 10.4   8 472.0 205 2.93 5.250 17.98  0  0    3    4
16 Lincoln Continental 10.4   8 460.0 215 3.00 5.424 17.82  0  0    3    4
17  Chrysler Imperial 14.7   8 440.0 230 3.23 5.345 17.42  0  0    3    4
18           Fiat 128 32.4   4  78.7  66 4.08 2.200 19.47  1  1    4    1
19        Honda Civic 30.4   4  75.7  52 4.93 1.615 18.52  1  1    4    2
20     Toyota Corolla 33.9   4  71.1  65 4.22 1.835 19.90  1  1    4    1
21      Toyota Corona 21.5   4 120.1  97 3.70 2.465 20.01  1  0    3    1
22   Dodge Challenger 15.5   8 318.0 150 2.76 3.520 16.87  0  0    3    2
23        AMC Javelin 15.2   8 304.0 150 3.15 3.435 17.30  0  0    3    2
24         Camaro Z28 13.3   8 350.0 245 3.73 3.840 15.41  0  0    3    4
25   Pontiac Firebird 19.2   8 400.0 175 3.08 3.845 17.05  0  0    3    2
26          Fiat X1-9 27.3   4  79.0  66 4.08 1.935 18.90  1  1    4    1
27      Porsche 914-2 26.0   4 120.3  91 4.43 2.140 16.70  0  1    5    2
28       Lotus Europa 30.4   4  95.1 113 3.77 1.513 16.90  1  1    5    2
29     Ford Pantera L 15.8   8 351.0 264 4.22 3.170 14.50  0  1    5    4
30       Ferrari Dino 19.7   6 145.0 175 3.62 2.770 15.50  0  1    5    6
31      Maserati Bora 15.0   8 301.0 335 3.54 3.570 14.60  0  1    5    8
32         Volvo 142E 21.4   4 121.0 109 4.11 2.780 18.60  1  1    4    2
>
> cat ("\n", "2) Display 1st 10 records:","\n")

 2) Display 1st 10 records:
> head(mtcars)
               X  mpg cyl disp  hp drat    wt  qsec vs am gear carb
1       Mazda RX4 21.0   6  160 110 3.90 2.620 16.46  0  1    4    4
2   Mazda RX4 Wag 21.0   6  160 110 3.90 2.875 17.02  0  1    4    4
3      Datsun 710 22.8   4  108  93 3.85 2.320 18.61  1  1    4    1
4  Hornet 4 Drive 21.4   6  258 110 3.08 3.215 19.44  1  0    3    1
5 Hornet Sportabout 18.7   8  360 175 3.15 3.440 17.02  0  0    3    2
6          Valiant 18.1   6  225 105 2.76 3.460 20.22  1  0    3    1
>
> cat ("\n", "3) Display last 10 records:","\n")

 3) Display last 10 records:
> tail(mtcars)
               X  mpg cyl  disp  hp drat    wt qsec vs am gear carb
27  Porsche 914-2 26.0   4 120.3  91 4.43 2.140 16.7  0  1    5    2
```

```
28   Lotus Europa 30.4   4  95.1 113 3.77 1.513 16.9  1  1    5    2
29 Ford Pantera L 15.8   8 351.0 264 4.22 3.170 14.5  0  1    5    4
30   Ferrari Dino 19.7   6 145.0 175 3.62 2.770 15.5  0  1    5    6
31  Maserati Bora 15.0   8 301.0 335 3.54 3.570 14.6  0  1    5    8
32     Volvo 142E 21.4   4 121.0 109 4.11 2.780 18.6  1  1    4    2
>
> cat ("\n", "4) Display file structure (see notes above):","\n")

 4) Display file structure (see notes above):
> str(mtcars)
'data.frame':    32 obs. of  12 variables:
 $ X   : Factor w/ 32 levels "AMC Javelin",..: 18 19 5 13 14 31 7 21 20 22 ...
 $ mpg : num  21 21 22.8 21.4 18.7 18.1 14.3 24.4 22.8 19.2 ...
 $ cyl : int  6 6 4 6 8 6 8 4 4 6 ...
 $ disp: num  160 160 108 258 360 ...
 $ hp  : int  110 110 93 110 175 105 245 62 95 123 ...
 $ drat: num  3.9 3.9 3.85 3.08 3.15 2.76 3.21 3.69 3.92 3.92 ...
 $ wt  : num  2.62 2.88 2.32 3.21 3.44 ...
 $ qsec: num  16.5 17 18.6 19.4 17 ...
 $ vs  : int  0 0 1 1 0 1 0 1 1 1 ...
 $ am  : int  1 1 1 0 0 0 0 0 0 0 ...
 $ gear: int  4 4 4 3 3 3 3 4 4 4 ...
 $ carb: int  4 4 1 1 2 1 4 2 2 4 ...
>
> cat ("\n", "5) Display column names (see notes above):","\n")

 5) Display column names (see notes above):
> names(mtcars)
 [1] "X"    "mpg"  "cyl"  "disp" "hp"   "drat" "wt"   "qsec" "vs"   "am"
[11] "gear" "carb"
>
> cat ("\n", "6) Display 1st record/row with column names (see notes above):","\n")

 6) Display 1st record/row with column names (see notes above):
> mtcars[1,]
          X mpg cyl disp  hp drat   wt  qsec vs am gear carb
1 Mazda RX4  21   6  160 110  3.9 2.62 16.46  0  1    4    4
>
> cat ("\n", "7) Display 2nd column data (mpg), using column number:","\n")

 7) Display 2nd column data (mpg), using column number:
> mtcars[,2]
 [1] 21.0 21.0 22.8 21.4 18.7 18.1 14.3 24.4 22.8 19.2 17.8 16.4 17.3 15.2 10.4
[16] 10.4 14.7 32.4 30.4 33.9 21.5 15.5 15.2 13.3 19.2 27.3 26.0 30.4 15.8 19.7
[31] 15.0 21.4
>
> cat ("\n", "8) Display column data (cyl), using column name:","\n")

 8) Display column data (cyl), using column name:
> mtcars$cyl
 [1] 6 6 4 6 8 6 8 4 4 6 6 8 8 8 8 8 8 4 4 4 4 8 8 8 8 4 4 4 8 6 8 4
>
> cat ("\n", "9) Display row/column data (3,4), that is, one field, using square bracket notation (see above):","\n")
```

```
 9) Display row/column data (3,4), that is, one field, using square bracket notation (see above):
> mtcars[3,4]
[1] 108
>
> cat ("\n", "10) Display all data for cars having greater than 4 cylinders:","\n")

 10) Display all data for cars having greater than 4 cylinders:
> mtcars[mtcars$cyl>4,]
                   X  mpg cyl  disp  hp drat    wt  qsec vs am gear carb
1          Mazda RX4 21.0   6 160.0 110 3.90 2.620 16.46  0  1    4    4
2      Mazda RX4 Wag 21.0   6 160.0 110 3.90 2.875 17.02  0  1    4    4
4      Hornet 4 Drive 21.4   6 258.0 110 3.08 3.215 19.44  1  0    3    1
5   Hornet Sportabout 18.7   8 360.0 175 3.15 3.440 17.02  0  0    3    2
6             Valiant 18.1   6 225.0 105 2.76 3.460 20.22  1  0    3    1
7          Duster 360 14.3   8 360.0 245 3.21 3.570 15.84  0  0    3    4
10           Merc 280 19.2   6 167.6 123 3.92 3.440 18.30  1  0    4    4
11          Merc 280C 17.8   6 167.6 123 3.92 3.440 18.90  1  0    4    4
12         Merc 450SE 16.4   8 275.8 180 3.07 4.070 17.40  0  0    3    3
13         Merc 450SL 17.3   8 275.8 180 3.07 3.730 17.60  0  0    3    3
14        Merc 450SLC 15.2   8 275.8 180 3.07 3.780 18.00  0  0    3    3
15  Cadillac Fleetwood 10.4   8 472.0 205 2.93 5.250 17.98  0  0    3    4
16 Lincoln Continental 10.4   8 460.0 215 3.00 5.424 17.82  0  0    3    4
17   Chrysler Imperial 14.7   8 440.0 230 3.23 5.345 17.42  0  0    3    4
22    Dodge Challenger 15.5   8 318.0 150 2.76 3.520 16.87  0  0    3    2
23         AMC Javelin 15.2   8 304.0 150 3.15 3.435 17.30  0  0    3    2
24          Camaro Z28 13.3   8 350.0 245 3.73 3.840 15.41  0  0    3    4
25    Pontiac Firebird 19.2   8 400.0 175 3.08 3.845 17.05  0  0    3    2
29      Ford Pantera L 15.8   8 351.0 264 4.22 3.170 14.50  0  1    5    4
30        Ferrari Dino 19.7   6 145.0 175 3.62 2.770 15.50  0  1    5    6
31       Maserati Bora 15.0   8 301.0 335 3.54 3.570 14.60  0  1    5    8
>
> cat ("\n", "11) Display all cars having more than 4 cylinders *and* greater than 4 gears:","\n")

 11) Display all cars having more than 4 cylinders *and* greater than 4 gears:
> mtcars[mtcars$cyl>4 &mtcars$gear>4,]
             X  mpg cyl disp  hp drat   wt qsec vs am gear carb
29 Ford Pantera L 15.8   8  351 264 4.22 3.17 14.5  0  1    5    4
30   Ferrari Dino 19.7   6  145 175 3.62 2.77 15.5  0  1    5    6
31  Maserati Bora 15.0   8  301 335 3.54 3.57 14.6  0  1    5    8
>
> cat ("\n", "12) Display all cars having more than 4 cylinders *and* exactly 4 gears: ","\n")

 12) Display all cars having more than 4 cylinders *and* exactly 4 gears:
> mtcars[mtcars$cyl>4 &mtcars$gear==4,]
             X  mpg cyl  disp  hp drat    wt  qsec vs am gear carb
1      Mazda RX4 21.0   6 160.0 110 3.90 2.620 16.46  0  1    4    4
2  Mazda RX4 Wag 21.0   6 160.0 110 3.90 2.875 17.02  0  1    4    4
10      Merc 280 19.2   6 167.6 123 3.92 3.440 18.30  1  0    4    4
11     Merc 280C 17.8   6 167.6 123 3.92 3.440 18.90  1  0    4    4
>
> cat ("\n", "13) Display all cars having more than 4 cylinders *or* exactly 4 gears: ","\n")

 13) Display all cars having more than 4 cylinders *or* exactly 4 gears:
> mtcars[mtcars$cyl>4 |mtcars$gear==4,]
```

```
                X  mpg cyl  disp  hp drat    wt  qsec vs am gear carb
1          Mazda RX4 21.0   6 160.0 110 3.90 2.620 16.46  0  1    4    4
2      Mazda RX4 Wag 21.0   6 160.0 110 3.90 2.875 17.02  0  1    4    4
3         Datsun 710 22.8   4 108.0  93 3.85 2.320 18.61  1  1    4    1
4     Hornet 4 Drive 21.4   6 258.0 110 3.08 3.215 19.44  1  0    3    1
5  Hornet Sportabout 18.7   8 360.0 175 3.15 3.440 17.02  0  0    3    2
6            Valiant 18.1   6 225.0 105 2.76 3.460 20.22  1  0    3    1
7         Duster 360 14.3   8 360.0 245 3.21 3.570 15.84  0  0    3    4
8          Merc 240D 24.4   4 146.7  62 3.69 3.190 20.00  1  0    4    2
9          Merc 230 22.8   4 140.8  95 3.92 3.150 22.90  1  0    4    2
10         Merc 280 19.2   6 167.6 123 3.92 3.440 18.30  1  0    4    4
11         Merc 280C 17.8   6 167.6 123 3.92 3.440 18.90  1  0    4    4
12        Merc 450SE 16.4   8 275.8 180 3.07 4.070 17.40  0  0    3    3
13        Merc 450SL 17.3   8 275.8 180 3.07 3.730 17.60  0  0    3    3
14       Merc 450SLC 15.2   8 275.8 180 3.07 3.780 18.00  0  0    3    3
15 Cadillac Fleetwood 10.4   8 472.0 205 2.93 5.250 17.98  0  0    3    4
16 Lincoln Continental 10.4   8 460.0 215 3.00 5.424 17.82  0  0    3    4
17  Chrysler Imperial 14.7   8 440.0 230 3.23 5.345 17.42  0  0    3    4
18           Fiat 128 32.4   4  78.7  66 4.08 2.200 19.47  1  1    4    1
19        Honda Civic 30.4   4  75.7  52 4.93 1.615 18.52  1  1    4    2
20     Toyota Corolla 33.9   4  71.1  65 4.22 1.835 19.90  1  1    4    1
22   Dodge Challenger 15.5   8 318.0 150 2.76 3.520 16.87  0  0    3    2
23        AMC Javelin 15.2   8 304.0 150 3.15 3.435 17.30  0  0    3    2
24         Camaro Z28 13.3   8 350.0 245 3.73 3.840 15.41  0  0    3    4
25   Pontiac Firebird 19.2   8 400.0 175 3.08 3.845 17.05  0  0    3    2
26          Fiat X1-9 27.3   4  79.0  66 4.08 1.935 18.90  1  1    4    1
29     Ford Pantera L 15.8   8 351.0 264 4.22 3.170 14.50  0  1    5    4
30       Ferrari Dino 19.7   6 145.0 175 3.62 2.770 15.50  0  1    5    6
31      Maserati Bora 15.0   8 301.0 335 3.54 3.570 14.60  0  1    5    8
32         Volvo 142E 21.4   4 121.0 109 4.11 2.780 18.60  1  1    4    2
>
> cat ("\n", "14) Display all cars having more than 4 cylinders that do *not* have 4 gears:","\n")

 14) Display all cars having more than 4 cylinders that do *not* have 4 gears:
> mtcars[mtcars$cyl>4 |mtcars$gear!=4,]
                X  mpg cyl  disp  hp drat    wt  qsec vs am gear carb
1          Mazda RX4 21.0   6 160.0 110 3.90 2.620 16.46  0  1    4    4
2      Mazda RX4 Wag 21.0   6 160.0 110 3.90 2.875 17.02  0  1    4    4
4     Hornet 4 Drive 21.4   6 258.0 110 3.08 3.215 19.44  1  0    3    1
5  Hornet Sportabout 18.7   8 360.0 175 3.15 3.440 17.02  0  0    3    2
6            Valiant 18.1   6 225.0 105 2.76 3.460 20.22  1  0    3    1
7         Duster 360 14.3   8 360.0 245 3.21 3.570 15.84  0  0    3    4
10         Merc 280 19.2   6 167.6 123 3.92 3.440 18.30  1  0    4    4
11         Merc 280C 17.8   6 167.6 123 3.92 3.440 18.90  1  0    4    4
12        Merc 450SE 16.4   8 275.8 180 3.07 4.070 17.40  0  0    3    3
13        Merc 450SL 17.3   8 275.8 180 3.07 3.730 17.60  0  0    3    3
14       Merc 450SLC 15.2   8 275.8 180 3.07 3.780 18.00  0  0    3    3
15 Cadillac Fleetwood 10.4   8 472.0 205 2.93 5.250 17.98  0  0    3    4
16 Lincoln Continental 10.4   8 460.0 215 3.00 5.424 17.82  0  0    3    4
17  Chrysler Imperial 14.7   8 440.0 230 3.23 5.345 17.42  0  0    3    4
21       Toyota Corona 21.5   4 120.1  97 3.70 2.465 20.01  1  0    3    1
22   Dodge Challenger 15.5   8 318.0 150 2.76 3.520 16.87  0  0    3    2
23        AMC Javelin 15.2   8 304.0 150 3.15 3.435 17.30  0  0    3    2
24         Camaro Z28 13.3   8 350.0 245 3.73 3.840 15.41  0  0    3    4
```

```
25    Pontiac Firebird 19.2   8 400.0 175 3.08 3.845 17.05  0  0    3    2
27       Porsche 914-2 26.0   4 120.3  91 4.43 2.140 16.70  0  1    5    2
28        Lotus Europa 30.4   4  95.1 113 3.77 1.513 16.90  1  1    5    2
29      Ford Pantera L 15.8   8 351.0 264 4.22 3.170 14.50  0  1    5    4
30        Ferrari Dino 19.7   6 145.0 175 3.62 2.770 15.50  0  1    5    6
31       Maserati Bora 15.0   8 301.0 335 3.54 3.570 14.60  0  1    5    8
>
> cat ("\n", "15) Display total number of rows (only the number): ","\n")

 15) Display total number of rows (only the number):
> nrow(mtcars)
[1] 32
>
> cat ("\n", "16) Display total number of columns (only the number): ","\n")

 16) Display total number of columns (only the number):
> ncol(mtcars)
[1] 12
>
> cat ("\n", "17) Display total number of dimensions (i.e., rows and columns): ","\n")

 17) Display total number of dimensions (i.e., rows and columns):
> dim(mtcars)
[1] 32 12
>
> cat ("\n", "18) Display data frame structure - same as info in Python:","\n")

 18) Display data frame structure - same as info in Python:
> str(mtcars)
'data.frame':    32 obs. of  12 variables:
 $ X   : Factor w/ 32 levels "AMC Javelin",..: 18 19 5 13 14 31 7 21 20 22 ...
 $ mpg : num  21 21 22.8 21.4 18.7 18.1 14.3 24.4 22.8 19.2 ...
 $ cyl : int  6 6 4 6 8 6 8 4 4 6 ...
 $ disp: num  160 160 108 258 360 ...
 $ hp  : int  110 110 93 110 175 105 245 62 95 123 ...
 $ drat: num  3.9 3.9 3.85 3.08 3.15 2.76 3.21 3.69 3.92 3.92 ...
 $ wt  : num  2.62 2.88 2.32 3.21 3.44 ...
 $ qsec: num  16.5 17 18.6 19.4 17 ...
 $ vs  : int  0 0 1 1 0 1 0 1 1 1 ...
 $ am  : int  1 1 1 0 0 0 0 0 0 0 ...
 $ gear: int  4 4 4 3 3 3 3 4 4 4 ...
 $ carb: int  4 4 1 1 2 1 4 2 2 4 ...
>
> cat ("\n", "19) Get mean, median, minimum, maximum, quantiles, variance, and standard deviation of horsepower:
","\n")

 19) Get mean, median, minimum, maximum, quantiles, variance, and standard deviation of horsepower:
>
> cat("\t", "a. Mean: ")
        a. Mean: > mean(mtcars$hp, na.rm=TRUE)
[1] 146.6875
>
> cat("\t", "b. Median: ")
        b. Median: > median(mtcars$hp, na.rm=TRUE)
```

```
[1] 123
>
> cat("\t", "c. Minimum: ")
        c. Minimum: > min(mtcars$hp, na.rm=TRUE)
[1] 52
>
> cat("\t", "d. Maximum: ")
        d. Maximum: > max(mtcars$hp, na.rm=TRUE)
[1] 335
>
> cat("\t", "e. Quantiles: ")
        e. Quantiles: > quantile(mtcars$hp, na.rm=TRUE)
   0%   25%   50%   75%  100%
 52.0  96.5 123.0 180.0 335.0
>
> cat("\t", "f. Variance: ")
        f. Variance: > var(mtcars$hp, na.rm=TRUE)
[1] 4700.867
>
> cat("\t", "g. Standard Deviation: ")
        g. Standard Deviation: > sd(mtcars$hp, na.rm=TRUE)
[1] 68.56287
>
> cat ("\n", "20) summary() function prints min, max, mean, median, and quantiles (also, number of NA's, if any.):
","\n")

 20) summary() function prints min, max, mean, median, and quantiles (also, number of NA's, if any.):
> summary(mtcars$hp, na.rm=TRUE)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
   52.0    96.5   123.0   146.7   180.0   335.0
>
> cat ("\n", "Two plots (*must* include *your* name in title): 1) Use qplot(); 2) Use plot()","\n")

 Two plots (*must* include *your* name in title): 1) Use qplot(); 2) Use plot()
> library(ggplot2)
> png("plot_disp_and_mpg_1.png")
> qplot(disp, mpg, data=mtcars,
+     xlab = "Displacement",
+     ylab = "MPG",
+     colour = cyl,
+     main="Meredith McNulty: Displacement vs MPG")
> dev.off()
null device
          1
> png("plot_disp_and_mpg_2.png")
> plot(mtcars$wt, mtcars$mpg,
+     main="Meredith McNulty: Weight vs MPG",
+     xlab = "Weight in Thousands",
+     ylab = "MPG",
+     las=1)
> dev.off()
null device
          1
```