Note:

- Submit a hard copy with a signed, QR-coded coversheet to the SRC and a soft copy of your R code (as Assignment 1) on Canvas. **Ideally**, the soft copy is a .Rmd file (or similar) and the hard copy is produced by "knitting" the .Rmd file (or similar).
- Include everything in the hard copy: R code (tidied up), outputs (including error/warning messages), and your explanations (if any).
- Print some intermediate results to show how your code works step by step, if not obvious.
- Comment your code wherever appropriate, e.g., for functions, blocks of code, and key variables.

1. [10 marks]

Use `seq()`, `rep()` and/or other commonly-used operators/functions and/or the recycling rule, but definitely not `c()`, nor any explicit loop, to create the following sequences.

```
 [1]   0  15  30  45  60  75  90 105 120 135 150 165 180 195 210 225
[17] 240 255 270 285 300 315 330 345
```

```
[1]   1   2   4   8  16  32  64 128 256
```

```
 [1] 1 1 1 1 2 2 2 3 3 4
```

```
 [1] 10 11 12 13 20 21 22 23 30 31 32 33 40 41 42 43
```

```
[1] "x^1/1 + -x^2/2 + x^3/3 + -x^4/4 + x^5/5 + -x^6/6"
```

2. [10 marks]

This question makes use of data on 10,000 electric scooter trips in Austin, Texas.[1] Download the file `"AustinDockless.csv"` from Canvas and run the following code to load the data into an R data frame.

```
> dockless <- read.csv("AustinDockless.csv")
```

The only variables we will use in this assignment are:

- `Trip.Duration` (in seconds),
- `Trip.Distance` (in metres),

[1] `https://data.austintexas.gov/Transportation-and-Mobility/Dockless-Vehicle-Trips/7d8e-dm7r`

- the `Hour` during which the trip occurred,
- `Origin.Cell.ID`, and `Destination.Cell.ID` (the city has been divided up into hexagonal "cells" each with an edge length of 500 feet).

Write R expressions to perform each of the tasks described below.

Find the length of the ten longest trips.

```
 [1] 19355 19263 19038 18394 14507 14451 12779 12601 12472 12263
```

Find the start and end Cell IDs for trips longer than 19km

```
     Origin.Cell.ID Destination.Cell.ID
4669          14074               14074
9518          15019               14227
9621          15019               14228
```

Find the longest trip (distance) between midnight and 8am.

```
[1] 11977
```

Find the average speed and the distance covered for the top ten fastest trips (trips with highest average speed), where average speed is calculated as distance divided by duration.

```
     Trip.Distance     Speed
8909          6145 53.903509
1799           356 19.777778
9885          1286 14.613636
3674          5333 11.346809
978            357 10.818182
193            110 10.000000
4327           645  9.626866
5917          3440  8.775510
5982          3055  8.415978
4776          1245  8.190789
```

BONUS [no marks]: Where in the city did that fastest ride occur? Is there a reasonable explanation for why it is so fast (and so much faster than the next fastest) ?

3. [10 marks]

This question also works with the electronic scooter data. We will just focus on the distance variable `Trip.Distance`.

Calculate the mean and standard deviation of the distance data.

```
> distMean
[1] 1615.266
> distSD
[1] 1674.185
```

Calculate the median and upper and lower quartiles for the distance data (HINT: use the `quantile()` function).

```
> distQuartiles
    25%     50%     75%
 491.75 1142.00 2182.50
```

Generate 10,000 random values from a Normal distribution (HINT: use the `rnorm()` function) with the same mean and standard deviation as the distance data and calculate the median and upper and lower quartiles of these random values.

```
> set.seed(1234)
```

```
> randQuartiles
      25%       50%       75%
 508.9781 1623.0258 2736.4287
```

Generate 1,000,000 random values from a Normal distribution with the same mean and standard deviation as the distance data and, dealing with each consecutive subset of 10,000 values, calculate 100 upper quartiles (one for each of the 100 subsets of 10,000 values)

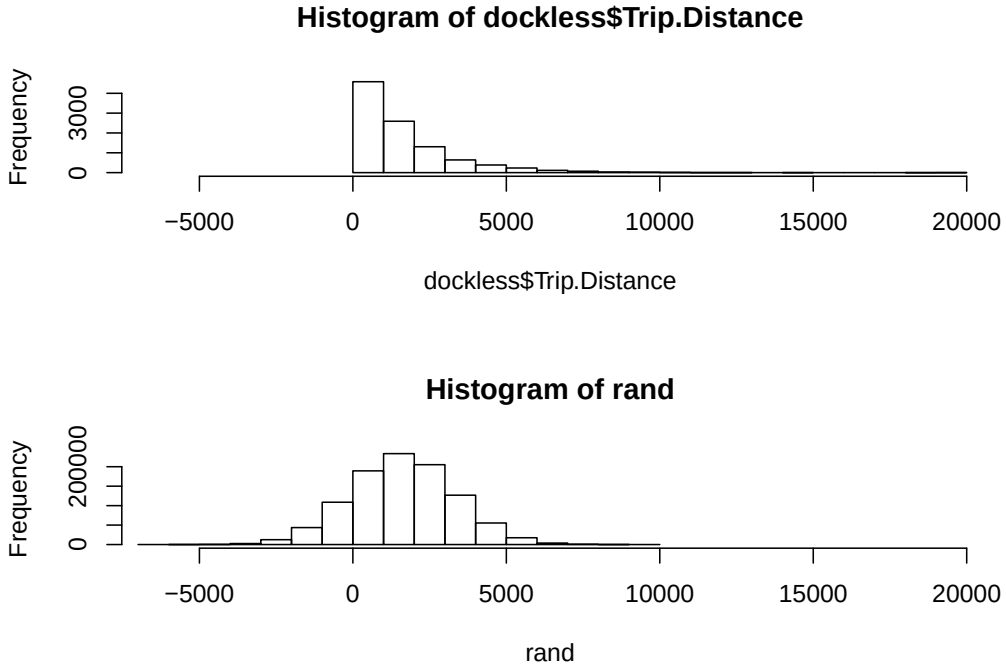
```
> set.seed(1234)
```

```
> uppers
  [1] 2736.429 2748.037 2734.750 2778.251 2727.928 2747.678 2737.341
  [8] 2733.882 2736.504 2772.283 2747.166 2740.335 2737.877 2749.035
 [15] 2742.073 2747.603 2731.202 2745.210 2762.028 2722.479 2755.105
 [22] 2784.287 2770.057 2744.672 2788.803 2732.448 2719.164 2716.093
 [29] 2716.177 2748.662 2796.661 2770.102 2739.757 2696.621 2745.113
 [36] 2758.199 2774.130 2745.969 2738.225 2766.942 2755.778 2757.481
 [43] 2755.060 2768.428 2761.173 2745.528 2742.979 2721.388 2759.575
 [50] 2750.646 2753.603 2747.491 2757.320 2770.252 2740.586 2739.986
 [57] 2727.110 2787.447 2729.941 2744.196 2699.110 2777.860 2740.209
 [64] 2734.215 2767.500 2755.582 2746.498 2755.516 2749.469 2772.825
 [71] 2741.689 2695.096 2733.864 2763.335 2707.142 2758.902 2766.222
 [78] 2740.095 2752.072 2726.040 2753.004 2747.965 2684.081 2757.887
 [85] 2710.427 2748.324 2729.187 2781.094 2770.067 2735.959 2733.398
 [92] 2750.425 2710.730 2767.942 2697.985 2764.782 2704.821 2728.067
 [99] 2786.141 2723.497
```

What proportion of the upper quartiles from the random data are less than the distance upper quartile ?

```
> pval
[1] 0
```

What does that tell us ? (HINT: look at the plots below)



4. [20 marks]

Write a function called `segments` that takes three arguments: `from`, `to`, and `rep`. The function should generate a matrix with two columns, the first column containing `from` values and the second column containing `to` values. The argument `rep` should default to `FALSE`.

Here is the simplest use of the function.

```
> segments(.1, .2)
from   to
 0.1  0.2
```

Write your function so that it satisfies all of the features described below. You should add one feature at a time and check that all previous features remain satisfied when you add a new feature. You should make use of vectorised operators and functions rather than `for` loops whenever possible.

The values in `from` and `to` should all be between -1 and 1. Values outside that range should be "clamped" to 1 with a warning.

```
> segments(.1, 1.2)

Warning in segments(0.1, 1.2):  'to' value(s) larger than 1 reduced to 1

from   to
 0.1  1.0
> segments(-1.2, .1)

Warning in segments(-1.2, 0.1):  'from' value(s) less than -1 raised to -1
```

```
from   to
 0.0  0.1
```

The values in `from` and `to` can be vectors and they should both "recycle" to the longest length.

```
> segments(c(.1, .2), c(.3, .4))
     from  to
[1,]  0.1 0.3
[2,]  0.2 0.4
```

```
> segments(1:4/10, .9)
     from  to
[1,]  0.1 0.9
[2,]  0.2 0.9
[3,]  0.3 0.9
[4,]  0.4 0.9
```

The rows of the matrix should be in order from smallest `from` value to largest `from` value.

```
> segments(4:1/10, .9)
     from  to
[1,]  0.1 0.9
[2,]  0.2 0.9
[3,]  0.3 0.9
[4,]  0.4 0.9
```

Any negative values in `from` and `to` should be treated as values measuring backward from 1.

```
> segments(.1, -.1)
from   to
 0.1  0.9
```

```
> segments(c(.1, .2), c(.7, -.2))
     from  to
[1,]  0.1 0.7
[2,]  0.2 0.8
```

If any `from` values are larger than the corresponding `to` values, they should be swapped.

```
> segments(.9, .1)
from   to
 0.1  0.9
```

If `rep` is `TRUE`, the function should "repeat" the values in the argument until they exceed 1.

```
> segments(.1, .2, rep=TRUE)
     from  to
[1,]  0.1 0.2
[2,]  0.3 0.4
[3,]  0.5 0.6
[4,]  0.7 0.8
[5,]  0.9 1.0
```

```
> segments(c(.3, .1), .2, rep=TRUE)
     from  to
[1,]  0.1 0.2
[2,]  0.2 0.3
[3,]  0.4 0.5
[4,]  0.5 0.6
[5,]  0.7 0.8
[6,]  0.8 0.9
[7,]  1.0 1.0
```