Simple R Functions

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1.

(a) Write functions `tmpFn1` and `tmpFn2` such that if `xVec` is the vector $(x_1, x_2, ..., x_n)$, then `tmpFn1(xVec)` returns vector $(x_1, x_2^2, ..., x_n^n)$ and `tmpFn2(xVec)` returns the vector $(x_1, \frac{x_2^2}{2}, ..., \frac{x_n^n}{n})$.

Here is `tmpFn1`

```
tmpFn1 <- function(xVec){
  return(xVec^(1:length(xVec)))
}

## simple example
a <- c(2, 5, 3, 8, 2, 4)

b <- tmpFn1(a)
b
```

```
## [1]    2   25   27 4096   32 4096
```

and now `tmpFn2`

```
tmpFn2 <- function(xVec2){

  n = length(xVec2)

  return(xVec2^(1:n)/(1:n))
}




c <- tmpFn2(a)
c
```

```
## [1]    2.0000   12.5000    9.0000 1024.0000    6.4000  682.6667
```

(b) Now write a fuction `tmpFn3` which takes 2 arguments x and n where x is a single number and n is a strictly positive integer. The function should return the value of

$$1 + \frac{x}{1} + \frac{x^2}{2} + \frac{x^3}{3} + ... + \frac{x^n}{n}$$

```
tmpFn3 <- function(x, n){
  1 + sum(x^(1:n) / (1:n))
}
```

---

2. Write a funciton `tmpFn(xVec)` such that if `xVec` is the vector $x = (x_1, ..., x_n)$ then `tmpFn(xVec)` returns the vector of moving averages:

$$\frac{x_1 + x_2 + x_3}{3}, \frac{x_2 + x_3 + x_4}{3}, ..., \frac{x_{n-2} + x_{n-1} + x_n}{3}$$

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```
tmpFn <- function(xVec){
  if(length(xVec) < 3){NA}
  i <- c(1:(length(xVec)-2))
  (xVec[i]+xVec[i+1]+xVec[i+2]) / 3.0
}
```

Try out your function. `tmpFn`(c(1:5,6:1))

```
tmpFn(c(1:5,6:1))
```

```
## [1] 2.000000 3.000000 4.000000 5.000000 5.333333 5.000000 4.000000 3.000000
## [9] 2.000000
```

---

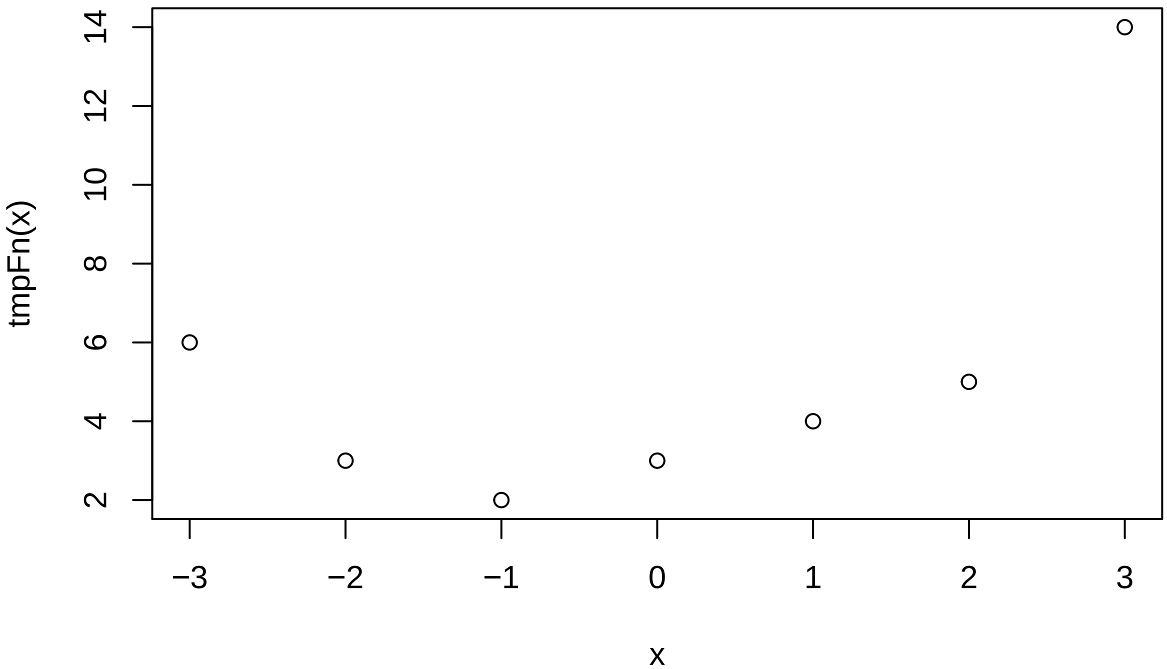
3. Consider the continuous function

$$f(x) = \begin{cases} x^2 + 2x + 3 & if \quad x < 0 \\ x + 3 & if \quad 0 \le x < 2 \\ x^2 + 4x - 7 & if \quad 2 \le x \end{cases}$$

Write a function `tmpFn` which takes a single argument `xVec`. the function should return the vector the values of the function $f(x)$ evaluated at the values in `xVec`.
Hence plot the function $f(x)$ for $-3 < x < 3$.

```
tmpFn <- function(xVec){
  ((xVec^2 + 2*xVec + 3) * (xVec < 0)) +
  ((xVec + 3) * (xVec >= 0) * (xVec < 2)) +
  ((xVec^2 + 4*xVec - 7) * (xVec >= 2))
}

x <- c(-3:3)
plot(x, tmpFn(x))
```



******

4. Write a function which takes a single argument which is a matrix. The function should return a matrix which is the same as the function argument but every odd number is doubled.

Hence the result of using the function on the matrix

$$\begin{bmatrix} 1 & 1 & 3 \\ 5 & 2 & 6 \\ -2 & -1 & -3 \end{bmatrix}$$

should be:

$$\begin{bmatrix} 2 & 2 & 6 \\ 10 & 2 & 6 \\ -2 & -2 & -6 \end{bmatrix}$$

```
matrixFn <- function(aMat){
 aMat + aMat * (aMat %% 2)
}

A <- matrix(c(1,5,-2,1,2,-1,3,6,-3), ncol = 3)
A
```

```
##      [,1] [,2] [,3]
## [1,]    1    1    3
## [2,]    5    2    6
## [3,]   -2   -1   -3
```

```
matrixFn(A)
```

```
##      [,1] [,2] [,3]
## [1,]    2    2    6
## [2,]   10    2    6
```

```
## [3,]   -2   -2   -6
```

---

5. Write a function which takes 2 arguements n and k which are positive integers. It should return the nxn matrix:

$$\begin{bmatrix} k & 1 & 0 & 0 & \cdots & 0 & 0 \\ 1 & k & 1 & 0 & \cdots & 0 & 0 \\ 0 & 1 & k & 1 & \cdots & 0 & 0 \\ 0 & 0 & 1 & k & \cdots & 0 & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ 0 & 0 & 0 & 0 & \cdots & k & 1 \\ 0 & 0 & 0 & 0 & \cdots & 1 & k \end{bmatrix}$$

******

```r
matrixFn2 <- function(n, k){
  # baseMatrix is the two diagonals of "1"s
  # I simply add baseMatrix to the identity matrix times k
  baseMatrix <- abs(
    col(matrix(, nrow = n, ncol = n)) -
    row(matrix(, nrow = n, ncol = n))
    ) == 1
  baseMatrix + diag(n)*k
}

matrixFn2(5,7)
```

```
##      [,1] [,2] [,3] [,4] [,5]
## [1,]    7    1    0    0    0
## [2,]    1    7    1    0    0
## [3,]    0    1    7    1    0
## [4,]    0    0    1    7    1
## [5,]    0    0    0    1    7
```

---

6. Suppose an angle α is given as a positive real number of degrees.

If $0 \leq \alpha < 90$ then it is quadrant 1. If $90 \leq \alpha < 180$ then it is quadrant 2.
if $180 \leq \alpha < 270$ then it is quadrant3. if $270 \leq \alpha < 360$ then it is quadrant 4.
if $360 \leq \alpha < 450$ then it is quadrant 1.
And so on ...

Write a function `quadrant(alpha)` which returns the quadrant of the angle α.

```r
quadrant <- function(alpha){
  alpha <- alpha + (alpha %% 90 == 0)
  ceiling((alpha/90) %% 4)
}

quadrant(c(0,78,90,153,180,199,270,335,360,390,450))
```

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

7.

(a) Zeller's congruence is the formula:

$$f = ([2.6m - 0.2] + k + y + [y/4] + [c/4] - 2c) mod 7$$

where $[x]$ denotes the integer part of x; for example $[7.5] = 7$.

Zeller's congruence returns the day of the week f given:

k = the day of the month
y = the year in the century
c = the first 2 digits of the year (the century number)
m = the month number (where January is month 11 of the preceding year, February is month 12 of the preceding year, March is month 1, etc.)
For example, the date 21/07/1'963 has $m = 5, k = 21, c = 19, y = 63$;
the date 21/2/63 has $m = 12, k = 21, c = 19, andy = 62$.
Write a function `weekday(day,month,year)` which returns the day of the week when given the numerical inputs of the day, month and year.
Note that the value of 1 for f denotes Sunday, 2 denotes Monday, etc.

```r
weekday <- function(day,month,year){
  m <- (month - 2) %% 12
  m <- m + (m == 0) * 12
  # Test 1
  # m
  k <- day
  y <- year %% 100
  c <- floor(year / 100)
  res <- (floor(2.6 * m - 0.2) + k + y + floor(y/4) + floor(c/4) - 2*c) %% 7
  replace(res, which(res %in% 0), 7)
  # Above step necessary because problem assumes modulo returns on range of
  # 1 to mod, but R returns modulo as 0 to mod-1
}

# Test 1
# weekday(,c(1:12),)

weekday(5,2,2018)
```

```
## [1] 2
```

```r
weekday((4:13),rep(2,10),rep(2018,10))
```

```
##  [1] 1 2 3 4 5 6 7 1 2 3
```

(b) Does your function work if the input parameters day, month, and year are vectors with the same length and valid entries?

```
# YES, see above.
```
