Solutions: Exercise 2.1 - Survey of ecological models, Part 1

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Instructions

Create either an R script (.R file) or R Markdown document (.Rmd) to save all of your work for today.

Exercise 1. Refresh your memory / repeat from last exercise

1. We will learn to write our own function - see my example here: I create a function called `my_fun`, which takes two values (x and y), adds them together, and returns the added value.

```
my_fun <- function(x, y) {
    z <- x + y
    return(z)
}
my_fun(17, 3)
```

```
## [1] 20
```

Please choose two numbers for x and y, and use them to execute `my_fun(x,y)`.

Solution

```
my_fun(25, 9)
```

```
## [1] 34
```

2. Your turn! Write a function called `times_seven` - it should take a single argument, multiply that value by 7, and return the new value.

Solution

```
times_seven <- function(x) {
    z <- x * 7
    return(z)
}
times_seven(17)
```

```
## [1] 119
```

3. See the `for` loops I have written below:

```r
# note how the loop changes the value of the variable x for
# each iteration of the loop: first x=1 and 'print(x)' is
# executed. Then x=2, then x=3, and so on.
for (x in 1:5) {
    print(x)
}
```

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

```r
for (i in 1:5) {
    z <- i + 6
    print(z)
}
```

```
## [1] 7
## [1] 8
## [1] 9
## [1] 10
## [1] 11
```

```r
a <- rep(NA, 5)
for (i in 1:5) {
    a[i] <- i
}
a
```

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

```r
b <- c("I", "love", "R")
for (i in 1:length(b)) {
    print(b[i])
}
```

```
## [1] "I"
## [1] "love"
## [1] "R"
```

Your turn - For each of three values of volume, `v <- c(1.6,3,8)`, calculate the *mass*, where `m <- 2.65 * volume ^ 0.9`. Please calculate this in a loop. You can print the values within the loop.

Solution

```r
v <- c(1.6, 3, 8)
for (i in 1:length(v)) {
    m <- 2.65 * v[i]^0.9
    print(m)
}
```

```
## [1] 4.045329
## [1] 7.12287
## [1] 17.21975
```

Exercise 2. Use functions, for loops, and plotting skills to run simulation of mice in the yard

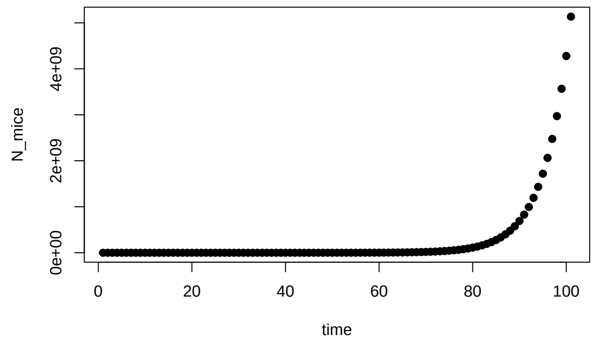
I built a function to calculate the number of mice in a yard using equation 2.4 from **Otto & Day Ch2**:

```
mice <- function(Nt,d,b,m){
  Nt1 <- (1+b)*(1-d)*Nt + m
  return(Nt1)
}
```

4. I would like you to create the following plot of mouse population size (N) over time, using the following values for parameters: $d = 0.7$, $b = 3$, $m = 4$, $N_t = 42$.

Solution

```
## Step 1. Write values for the parameters in the model
## (and initial values of state variables) d - the
## *fraction* of mice in yard eaten by cat / day --> 0-1
d <- 0.7
# b - the *number* of mice born per mouse / day --> N
# (0-infinity)
b <- 3
# m - the *number* of mice arriving in the yard per day -->
# N (0-infinity)
m <- 4
# NO - the initial number of mice in the yard when we begin
# the survey
Nt <- 42

## Step 2. Write a function that will calculate values of
## number of mice from one time step to the next.
mice <- function(Nt, d, b, m) {
    Nt1 <- (1 + b) * (1 - d) * Nt + m
    return(Nt1)
}

## Step 3. Call the function mice(Nt,d,b,m)

## Step 4. Follow the mice population size over some time
## intervals N - a variable where we record the population
## size over time
N <- Nt

for (i in 1:100) {
    Nt1 <- mice(Nt, d, b, m)
    N <- c(N, Nt1)
    Nt <- Nt1
}

# N plot(N)
plot(N, xlab = "time", ylab = "N_mice", pch = 19, col = "black")
```




```
dat <- as.data.frame(N)
dat$time <- as.numeric(rownames(dat))
# library(ggplot2) ggplot2::ggplot(dat,aes(time,N)) +
# geom_point()
```

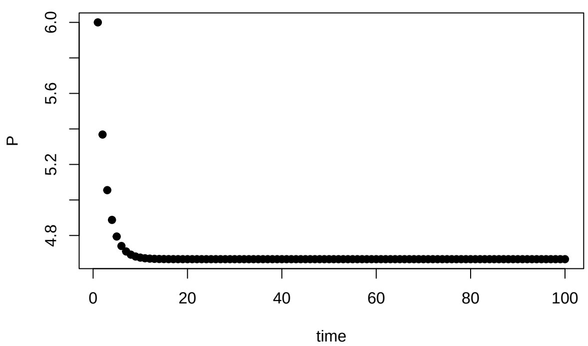
To do this, you should approach the problem in a few steps:

- Step 1. Save d, b, m, and N_t as their own variables.
- Step 2. Write the *mice* function.
- Step 3. Make sure the function works by calling it one time using the values given in Step 1. It should return a value for $N_{t+1} = 54.4$.
- Step 4. Create a new variable called N, which can hold the values generated by the function.
- Step 5. Write a *for* loop that will take the calculated value of N_{t+1}, and use it as the next time step's value of N_t. Repeat this for $i = 100$ time steps.
- Step 6. Use R's *plot* function (or you can use ggplot if you like) to plot N over time.

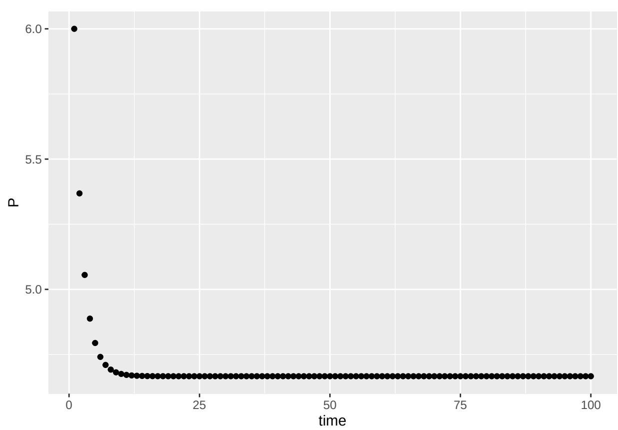
I demonstrate how this can work below. I use a different function as an example, $P(t+1) = \frac{bP(t)}{1+cP(t)}$:

```
# Step 1. Example parameters
b <- 1.7
c <- .15
Pt <- 6

# Step 2. Example equation function
example_equation_function <- function(b,c,Pt){
  Pt1 <- (b*Pt) / (1 + c*Pt)
  return(Pt1)
}

# Step 3. Make sure the function works
Pt1 <- example_equation_function(b,c,Pt)

# Step 4. Create a new variable to hold future values of P
P <- rep(NA,100)

# Step 5. Create a for loop to iteratively calculate P
P[1] <- Pt
for(i in 2:100){
```

```
  P[i] <- example_equation_function(b,c,Pt)
  Pt <- P[i]
}

# Step 6. Plot P over time
plot(P,xlab="time",ylab="P",pch=19,col="black")
```




```
dat <- as.data.frame(P)
dat$time <- as.numeric(rownames(dat))
library(ggplot2)
ggplot2::ggplot(dat,aes(time,P)) + geom_point()
```



Exercise 3. Use functions, for loops, and plotting skills to run simulation of exponential population growth

I show below a simulation for exponential population growth in discrete time,

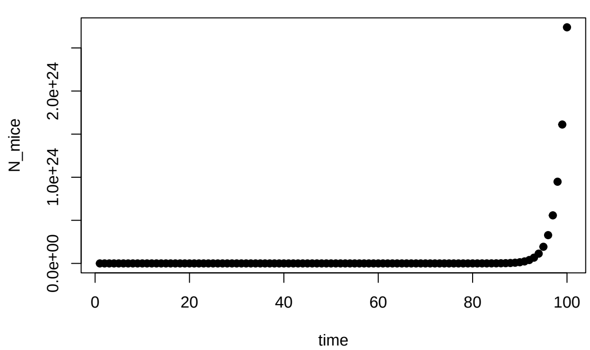
$$n_{t+1} = Rn(t)$$

I created the below plot of population size (n) over time (t) using the following values for parameters: $R = 1.7$, $N_0 = 42$, evaluated for 100 time steps.

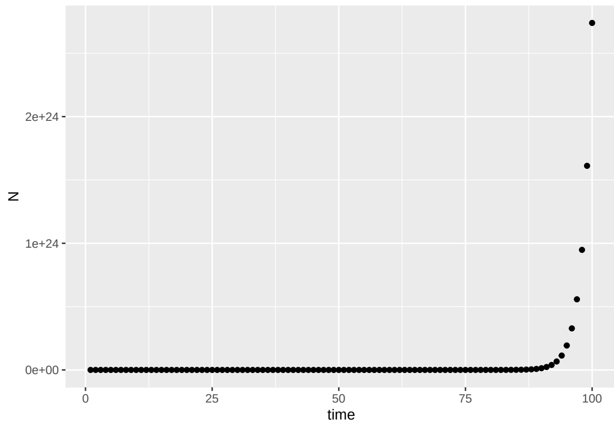
```r
## Step 1. Write values for the parameters in the model
## (and initial values of state variables) R - the
## population growth rate, expressed as the number of
## individuals that replace an individual in the population
## (where R=1 is each individual replacing itself, and
## therefore no change in population size over time) --> N
## (-infinity - infinity)
R <- 1.7
# N0 - the initial population size
N0 <- 42

## Step 2. Write a function that will calculate values of
## number of individuals from one time step to the next.
disc_exp <- function(R, N0) {
    Nt1 <- R * N0
    return(Nt1)
}

## Step 3. Call the function
disc_exp(R, N0)
```

```
## [1] 71.4
```

```r
# Step 4. Create a new variable to hold future values of N
N <- rep(NA, 100)

# Step 5. Create a for loop to iteratively calculate N
N[1] <- N0
for (i in 2:100) {
    N[i] <- disc_exp(R, N0)
    N0 <- N[i]
}

# Step 6. Plot N over time
plot(N, xlab = "time", ylab = "N_mice", pch = 19, col = "black")
```



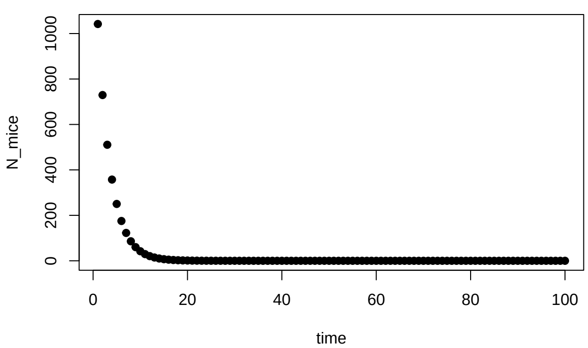
```r
dat <- as.data.frame(N)
dat$time <- as.numeric(rownames(dat))

library(ggplot2)
ggplot2::ggplot(dat, aes(time, N)) + geom_point()
```



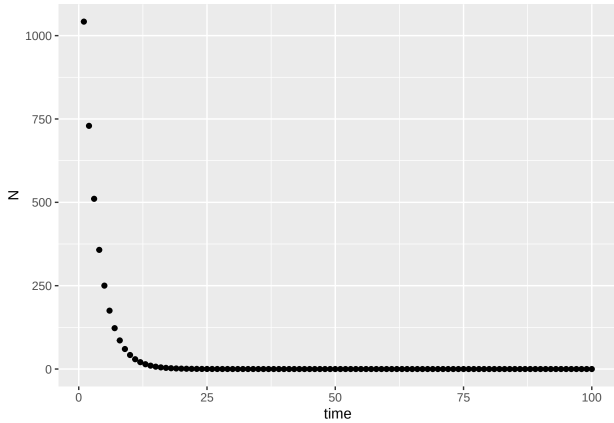
5. Please create a plot for parameters: $R = 0.7$, $N_0 = 1042$.

Solution

```r
R <- 0.7
N0 <- 1042

N <- rep(NA, 100)
N[1] <- N0
for (i in 2:100) {
    N[i] <- disc_exp(R, N0)
    N0 <- N[i]
}
plot(N, xlab = "time", ylab = "N_mice", pch = 19, col = "black")
```



```r
dat <- as.data.frame(N)
dat$time <- as.numeric(rownames(dat))

library(ggplot2)
ggplot2::ggplot(dat, aes(time, N)) + geom_point()
```



6. Please modify the simulation in #5 to create a simulation of the logistic growth model in discrete time (equation 3.5a in Otto & Day Chapter 3), using parameter values $n_0 = 4$, K = 1400, $r = 1.21$, evaluated for 100 time steps:

$$n_{t+1} = n(t) + rn(t)(1 - \frac{n(t)}{K})$$

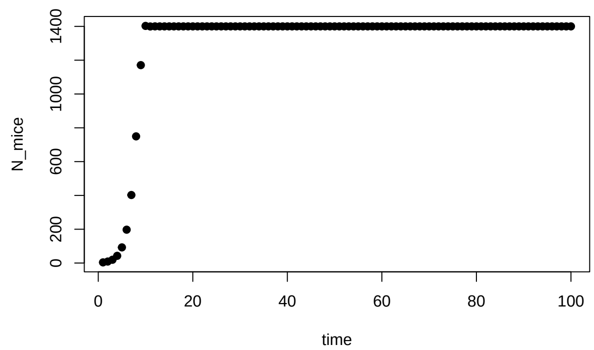
Hint: You can use the following formula:

```r
disc_log <- function(r,Nt=N0,K){
  Nt1 <- Nt + r*Nt*(1-Nt/K)
  return(Nt1)
}
```

Solution

```r
# Step 1. parameters
r <- 1.21
K <- 1400
N0 <- 4

# Step 2. equation function
disc_log <- function(r, Nt = N0, K) {
    Nt1 <- Nt + r * Nt * (1 - Nt/K)
    return(Nt1)
}

# Step 3. Make sure the function works
Nt1 <- disc_log(r, N0, K)

# Step 4. Create a new variable to hold future values of N
N <- rep(NA, 100)
```

```r
# Step 5. Create a for loop to iteratively calculate N
N[1] <- NO
for (i in 2:100) {
    N[i] <- disc_log(r, NO, K)
    NO <- N[i]
}

# Step 6. Plot N over time
plot(N, xlab = "time", ylab = "N_mice", pch = 19, col = "black")
```




```r
dat <- as.data.frame(N)
dat$time <- as.numeric(rownames(dat))

library(ggplot2)
ggplot2::ggplot(dat, aes(time, N)) + geom_point()
```