

Coursework 2

36071280

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Question 1

Q1. We first implement the deterministic model:

```
#Implement the deterministic model
```

```
library(ggplot2)
```

```
# Declaring common constants
```

```
alpha = 0.05  
beta = 0.00012  
gamma = 0.04  
weeks = 103
```

- Set $R_1 = 60$ and $F_1 = 30$.

```
### Setting initial values for Deterministic models
```

```
R1 = 60  
F1 = 30
```

- Using existing functions in R, write the necessary for loop to implement the Lotka-Volterra model that will allow you to project the number of foxes and rabbits at the end of a 2-year period i.e. after 103 more weeks.

```
# Implementing the deterministic model
```

```
for ( w in 1:(weeks-1))  
{  
  R1[w+1] = R1[w] + alpha* R1[w] - beta*R1[w] *F1[w]  
  F1[w+1] = F1[w] + beta* R1[w]* F1[w] - gamma * F1[w]  
}
```

- Print the last few values of the final result of R_t and F_t .

```
tail(R1)
```

```
## [1] 182.32801 139.82668 107.94989 84.03695 66.03831 52.41642
```

```
tail(F1)
```

```
## [1] 2359.197 2316.447 2262.657 2201.461 2135.603 2067.103
```

Question 2

Q2. A stochastic version of the Lotka-Volterra model exists in a similar manner to the stochastic version of the population growth model. In this case, the number of rabbits born is $\text{Binom}(R_t, \alpha)$, the number of rabbits eaten (new foxes) is $\text{Binom}(R_t F_t, \beta)$, and the number of foxes that die is $\text{Binom}(F_t, \gamma)$.

- Set the seed for running your code to 17540

```
### Setting initial values for Stochastic models

set.seed(17540)
sto_R = 60
sto_Fx = 30
```

- Using existing functions in R, write the necessary for loop to implement the stochastic Lotka-Volterra model that will allow you to project the number of foxes and rabbits at the end of a 2-year period i.e. after 103 more weeks, with the same starting values as for the deterministic model.

```
#Implementing the Stochastic model
```

```
for ( w in 1:(weeks-1) )
{
  no_of_foxes_eaten = rbinom(1,sto_R[w]*sto_Fx[w], beta)
  sto_R[w+1] = sto_R[w] + rbinom(1,sto_R[w],alpha) - no_of_foxes_eaten
  sto_Fx[w+1] = sto_Fx[w] + no_of_foxes_eaten - rbinom(1, sto_Fx[w],gamma)
}
```

- Print the last few values of the final result of Rt and Ft

```
tail(sto_R)
```

```
## [1] 179 145 109 83 54 35
```

```
tail(sto_Fx)
```

```
## [1] 2497 2455 2411 2350 2289 2213
```

Question 3

Q3. Now we visualise the results:

- Create a long data frame called LV with three variables; time, group and size. Each row should contain the size at a single time point for one of the four groups generated rabbits and foxes (deterministic model); sto_rabbits and sto_foxes (stochastic model).

```
#Creating the new data frame
```

```
group_names = c('Rabbits','Foxes','sto_Rabbits','sto_Foxes')
LV = data.frame(time=rep(1:weeks,4),
                 group=rep(group_names, each=weeks),
                 size=c(R1,F1, sto_R,sto_Fx))
```

- Using ggplot() visualise the changes over time for the number of rabbits and foxes for both the deterministic and stochastic version of the Lotka-Volterra model. All four lines should be in one single plot.

```
# Visualizing changes
```

```
# Deterministic model is shown in red. Stochastic model is shown in blue.
# Foxes are shown as solid lines. Rabbits are shown as dashed lines.
```

```
ggplot(LV) + geom_line(aes(time, size, color=group, linetype=group), size=0.5) +
  scale_linetype_manual(values=c("solid","dashed","solid","dashed"))+
  scale_color_manual(values=c(rep("red",2), rep("blue",2)))+
  labs(x="Time in weeks ->", y="Population Size ->",
       title="Deterministic model vs Stochastic model")+
```

```
theme(legend.position = "bottom")
```

Deterministic model vs Stochastic model

