Problem 1:

$N(t) = N(0)e^{rt}$

$ln[N(t)] = ln[N(0)e^{rt}]$

$ln[N(t)] = ln[N(0)] + ln[e^{rt}]$

$ln[N(t)] = ln[N(0)] + rt$

$ln[N(t)] - ln[N(0)] = rt$

$\frac{ln[N(t)]}{ln[N(0)]} = rt$

$\frac{ln[N(t)]/ln[N(0)]}{r} = t$

Time to 100 lice

$\frac{ln[100]/ln[10]}{0.1} = 20$ days

Time to 1000 lice

$\frac{ln[1000]/ln[10]}{0.1} = 30$ days

Time to 100,000,000 lice

$\frac{ln[100{,}000{,}000]/ln[10]}{0.1} = 80$ days

Time to 100,000,000,000 lice

$\frac{ln[100{,}000{,}000{,}000]/ln[10]}{0.1}$ = 110 days

As the population increases in size, it starts taking less and less time to add many more individuals to the population. Since this is a model of continuous, exponential growth this is unsurprising.

Problem 2:

$2N(0) = N(0)e^{rt}$

$\frac{2N(0)}{N(0)} = e^{rt}$

$2 = e^{rt}$

$ln[2] = ln[e^{rt}]$

$ln[2] = rt$

$\frac{ln[2]}{t} = r$

$\frac{ln[2]}{50} = r$

$r = 0.01$ ind/year

$N(t) = 6,900,000,000e^{0.01*41}$

N(t) ≈ 10.4 billion individuals

Problem 3:

Approximately 4 years (Increases by 12% in one year, 24% in two years, 36% in three years, and 48% in four years).

Problem 4:

Some causes of death in Eugene include disease, accident, murder, and natural disaster. Although all of these could be affected by density of individuals, the death rate here is probably significantly density-independent. Based on the number of resources and access to healthcare we have, it would probably require a very large population size to start seeing significant effects on the death rate. However, density dependence can be introduced. Increased population size can increase the spread of infectious disease, potentially causing an increase in death rate due to this factor. Additionally with more people and more congestion an increase in traffic accidents could occur and as people live in more crowded environments the potential for natural disasters to inflict more damage could also increase.

Problem 5:

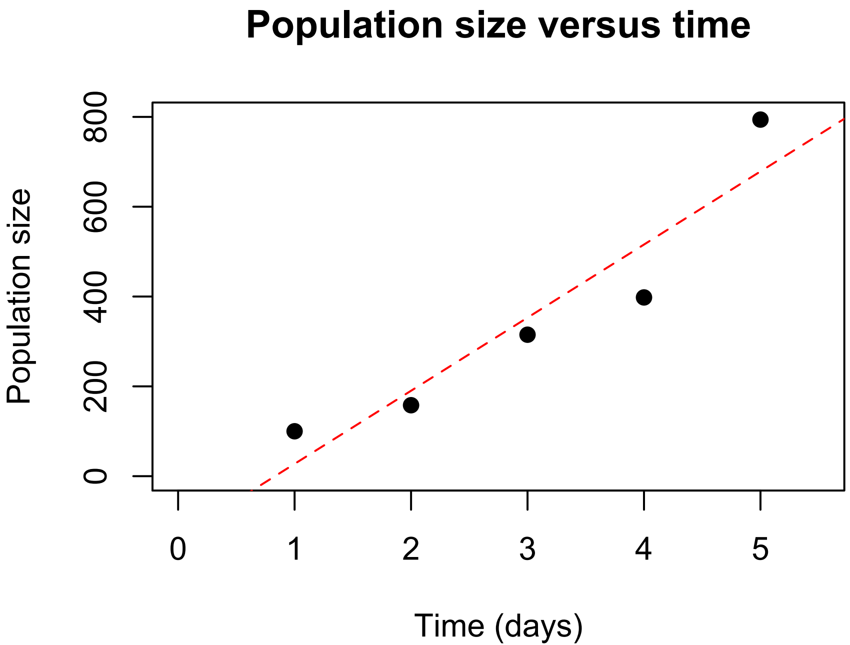
Arabidopsis thaliana is a species of annual plant. Some ecotypes germinate in the fall, overwinter and then flower in the spring; other ecotypes germinate in the spring and flower during the summer. Because this is an annual, all individuals flower once in a year and then die. Population growth in this species would best be modelled by using discrete growth.

Problem 6:

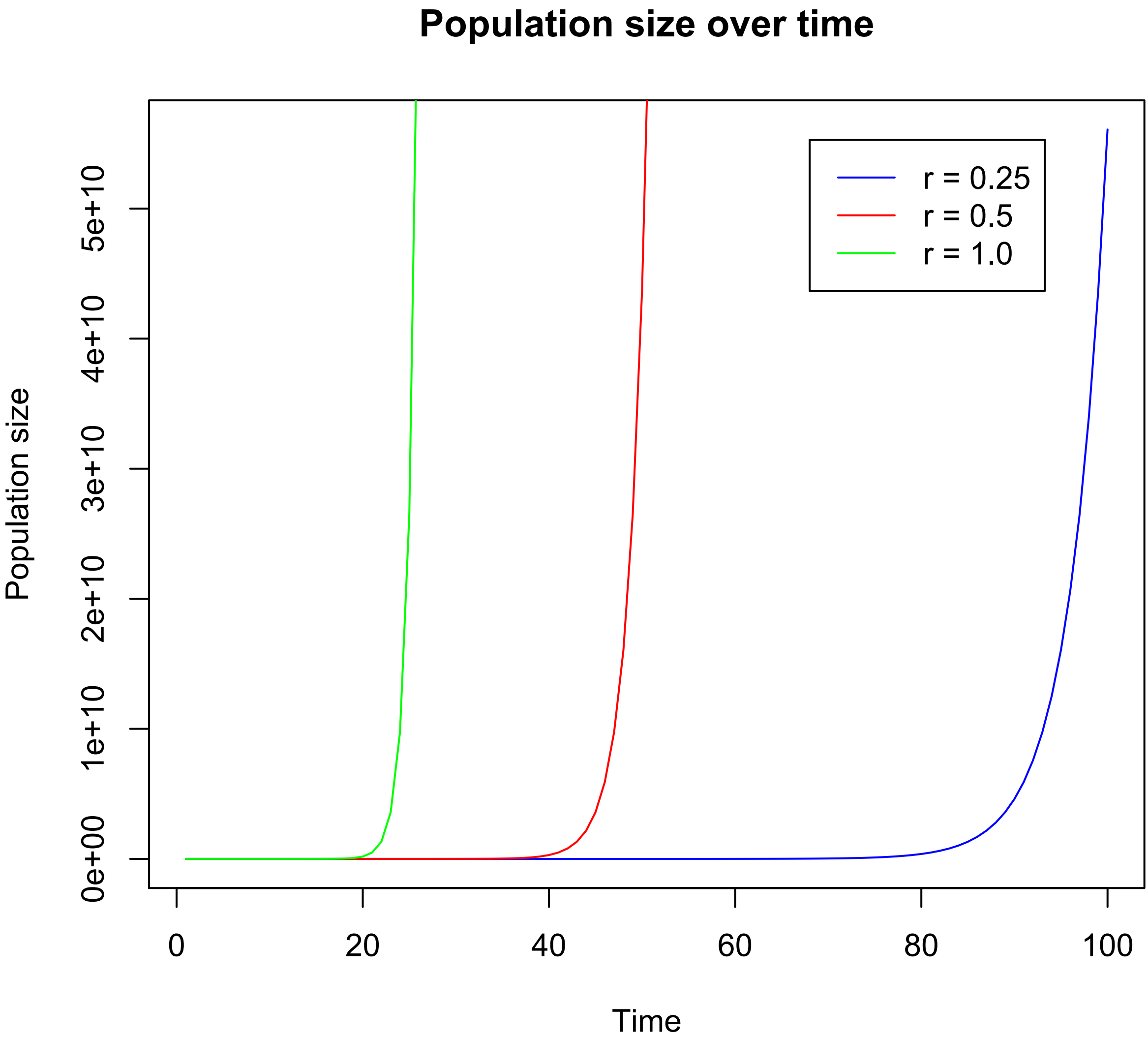
```
> N <- c(100,158,315,398,794) # Define N

> T <- 1:5 # Define T

> fit <- lm(N~T) #fit linear model

> plot(N~T, pch = 19, xlim = c(0,5.5),ylim=c(0,800),    xlab = "Time (days)",
ylab = "Population size (individuals)", main = "Population size versus time")
# Plot N vs. T, including x and y axis labels and a     main title, and set axis
ranges to start at 0

> abline(fit, lty = 2, col = 'red') #add trendline to plot

> summary(fit) #print values for fit. Slope = 162.8

> exp(162.8) #calculate growth rate. lambda = 5.05e+70
```

Problem 7

```
> library(deSolve) #load deSolve library

>  exp.growth <- function(t, y, p){
+    N <- y[1]
+    with(as.list(p), {
+      dN.dt <- r * N
+      return(list(dN.dt))
+    })
+ }  # write function for exponential growth

> p1 <- c('r' = 0.25) # r for first simulation

> p2 <- c('r' = 0.5) # r for second simulation

> p3 <- c('r' = 1.0) # r for third simulation

> y0 <- c('N' = 1) # starting individuals

> t <- 1:100 # number of generations

> sim1 <- ode(y = y0, times = t, func = exp.growth, parms = p1, method =
'lsoda') #simulation 1

> sim2 <- ode(y = y0, times = t, func = exp.growth, parms = p2, method =
'lsoda') #simulation 2

> sim3 <- ode(y = y0, times = t, func = exp.growth, parms = p3, method =
'lsoda') #simulation 3

> plot(sim1, xlab = "Time", ylab = "Population size", main = "Population size
over time", col = "blue") # plot simulation 1 in blue with axes and graph title

> points(sim2, type = "l", col = "red") # add sim2 in red

> points(sim3, type = 'l', col = "green") # add sim3 in green

> legend("topright", legend = c('r = 0.25', 'r = 0.5', 'r = 1.0'), col =
c("blue","red", "green"), lty =1, inset = c(0.1,0.05)) # add legend to plot
```



Population size versus time
Population size
800
600
400
200
0
0
1
2
3
4
5
Time (days)


Population size over time
r = 0.25
r = 0.5
r = 1.0
Population size
0e+00
1e+10
2e+10
3e+10
4e+10
5e+10
0
20
40
60
80
100
Time