MATH 2310
Reliability

This lab will focus on reliability, which we have been learning about in class.

Goals for this assignment:

- Practice using R to calculate reliability and hazard functions based on an assumed failure law
- Learn to visualize hazard functions, and interpret them based on their shape
- Estimate reliability and hazard functions based on data, and compare them to theory

Activity 1

Assume that a certain product can be modeled with a normal failure law having a mean lifetime of 10 years, with a standard deviation of 2 years.

a) In R, define a vector t <- seq(0, 20) representing the years over which we will examine failure probability. Then generate the probability density function f(t) based on the mean and standard deviation lifetimes (hint: the dnorm function is useful here).

b) Calculate the cumulative distribution function F(t) (hint: the pnorm function is useful here).

c) Calculate the reliability function R(t), and plot it as a function of time.

d) Calculate the hazard function z(t), and plot it as a function of time.

e) Analysis: Based on your result, what type of failure rate do products with normal failure laws have (increasing, decreasing, or constant over time)?

Activity 2

In most real-world applications, we will not know the population distribution for product lifetime. Instead, we will have to estimate it. Suppose that we suspect that the lifetime of a particular product should follow an exponential distribution. We collect data on the lifetimes, in years, for a sample of products in the dataset **lifetimes.txt**

a) Let's examine the distribution of lifetimes. In R, construct a histogram of the lifetimes. Does it look reasonable to assume an exponential distribution for this data? (hint: you can read the data into a vector using lifetimes <- read.delim("path/to/lifetimes.txt")$Lifetime)

b) To use an exponential distribution, we need to know λ. Using the relationship between λ and the mean of an exponential, estimate λ for this population based on the sample mean of the data.

c) Now let's examine the reliability and failure rate for these items. Once again create a vector of time values t, this time ranging from 0 to 25, and calculate the reliability function and the failure rate (i.e., the hazard function) based on the exponential distribution, using the estimated value of λ based on your data (hint: just as dnorm and pnorm were helpful in Activity 1, dexp and pexp may be helpful here).

d) Graph the estimated reliability function for this product over time.

e) Graph the estimated hazard function for this product over time. Based on your result, what type of failure rate do products with exponential failure laws have (increasing, decreasing, or constant)?

f) For the exponential distribution, rather than using R's built in functionality, we could also use the formulas we've learned previously for f(t) and F(t) for an exponential distribution to find exact formulas for R(t) and z(t). Find R(t) and z(t) this way. Do your results match the graphs you made?