In class we mathematically derived the expressions for the (distribution) mean and variance of the binomial distribution with parameters \( n, \pi \). We found \( \mu_x = n\pi; \quad \sigma^2_x = n\pi(1 - \pi) \). We noted that they both increase linearly with \( n \). In the prelab, you confirmed this mathematical result through a simulation. You essentially tossed \( n \) fair coins, 1000 times, each time counting the number of heads out of \( n \). You then computed the sample mean and sample variance of the 1000 numbers (of heads out of \( n \)), for different \( n \) values (from 1 to 100), and showed that the sample mean and sample variance vary linearly with \( n \).

a) Now, the mathematical expressions also imply that the distribution mean and variance depend on the \( \pi \) parameter. Again, in class we discussed how the former varies linearly and the latter varies quadratically with \( \pi \). In this part of the quiz we want to confirm that result using a simulation.

The following code is analogous to the code used for the previous simulation, but this one takes 100 values of the \( \pi \) parameter between 0 to 1, and keeps \( n \) constant at 500. But, as you can see, some parts of the code are intentionally left blank. Fill in the blanks, and email the completed code to your TA.

```r
n.trials = 1000 # Number of repeats. 
pi = seq(0,1,length=__) # Values of pi to explore. 
sample.mean = numeric(100) # Generate a vector to store the results 
sample.var = numeric(100) 
  cnt = 1 
  for (i in pi) { 
    head.counts = rbinom(__, __, __) # Number of heads in each of 1000 repeats. 
    sample.mean[cnt] = ___ # Mean (across repeats) of number of heads out of 500. 
    sample.var[cnt] = ___ # Variance (across repeats) of ... 
    cnt = cnt + 1 
  } 
plot(pi, sample.mean, cex = 0.5) 
points(pi, sample.var, col = 2, cex = 0.5)
```

b) In class we have shown that for large \( n \), and small \( \pi \), the binomial distribution is approximately equal to the Poisson distribution with \( \lambda = n\pi \). It turns out that for large \( n \), but midrange \( \pi \) (say 0.5), the binomial distribution with parameters \( n, \pi \) is approximately Normal with parameters \( \mu = n\pi, \) and \( \sigma = \sqrt{n\pi(1 - \pi)} \). In this part of the quiz we want to confirm that with a simulation. To that end, write code to toss \( n = 5000 \) fair coins (i.e., large \( n \)), 1000 times, and each time store the number of heads out of \( n \). Then, make a Normal qq plot for the 1000 numbers.