1) What hash functions did you choose and why (Hint: Cryptographic or noncryptographic)? What is the output range of the hash functions? What is the size of the Bloom filter in each case?

   I choose (SHA 512, SHA 384, SHA 256, SHA 224) cryptographic hash functions, and (SHA 1) the only non-cryptographic hash function from being used. I mainly choose these hash functions because they are uniformly distributed, fast, and independent enough to implement into the bloom filter functions, which are the requirements given to a hash function when implementing bloom filter. All the hash function I selected are from OpenSSl library.

   Output range:

   - SHA 1 : 160 bit value (20 byte)
   - SHA 224 : 224 bit value (28 byte)
   - SHA 256 : 256 bit value (32 byte)
   - SHA 384 : 384 bit value (48 byte)
   - SHA 512 : 512 bit value (64 byte)

   3 hash function uses (SHA 384, SHA 256, SHA1, and the 5 hash function uses (SHA 512, SHA 384, SHA 256, SHA 224, SHA1).

   Bloom Filter size:

   - 3 Hash function : 4070812 bits array
   - 5 Hash function: 3912101 bits array

2) How long does it take for your Bloom Filter to check 1 password in each case? Why does one perform better than other if any?

   To check the password in array of Bloom Filter, both 3 way hash function and 5 way hash function should have a complexity of O(1). Both should have the same complexity, because in order to check the password within the bloom filter, we only need to get the modules of the hash value, and check if the bit array position is 1 or not for each hash function.

   In the context of hashing, the 5 way hash function should take a longer time compared to 3 way hash function, because the 5 way hash function requires to hash 5 times, whereas the 3 way hash function only hash 3 times.

3) What is the probability of False Positive in your Bloom Filter in each case? What is the probability of False Negative in your Bloom Filter?

   (1 - e^((-3*623518)/4070812))^3 = 0.0495 (Note: probability for 3 way hash function)
   (1 - e^((-5*623518) / 4070812))^5 = 0.0439 (Note: probability for 5 way hash function)

   False negative is almost impossible with bloom filter.

4) How can you reduce the rate of False Positives?
   False positives can be reduced by increasing the number of hash function being used, or also by increasing the size of the bloom filter array.