CSC 262
Homework #2
Due at start of class on Wednesday, February 14.

1. **Error Checking**. Disk drives are subject to occasional transient failures that will cause data to be read incorrectly. The low-level device drivers typically include mechanisms to detect and fix such errors. This problem is designed to give you a feel for some of the issues involved in the process.

Suppose that a disk block contains 1024 (1K) bytes of data, $\{B_0 \ldots B_{1023}\}$. Suppose further that an additional byte B_E is used for error checking. The value of this additional byte is equal to the sum of all 1K bytes, mod 256:

$$B_E = \left(\sum_{i=0}^{1023} B_i \right)_{\bmod 256}$$

After reading the block, the checksum is computed and compared to the value stored in the error byte. If it matches, then the read is assumed to be error-free. If it does not match, the read is attempted again.

a. If an error is made while reading just a single byte on the disk block, what is the probability that the error will be detected when the checksum is calculated and compared to B_E? (Assume that in case of an error on a particular byte, the value read is equally likely to be any of the 255 possible incorrect values. Consider how each possible value would change the checksum, and whether or not such a change would be detectable.)

b. Suppose instead that the block is read correctly, but an error is made while reading B_E. Is the answer any different from that given above?

c. What is the probability of detection if errors are made while reading exactly **two** bytes of the block?

d. Assume that the probability of making an error while reading each individual byte is $p = 10^{-6}$ (i.e., one in a million). Assume further that these chances are independent (so that the chance of making an error on a particular byte is unaffected by whether or not there have been errors made already on previous bytes). What is the probability that an error will occur and go undetected? (You may ignore the possibility of 3 or more separate errors taking place. *Extra credit:* what is the probability of such an occurrence?)

Hint: Given an event of probability p and n attempts, the formulae below give the probability of the event happening a certain number of times. For example, with a fair coin, the probability of throwing heads is 50% ($p = 0.5$). On four tosses ($n = 4$), the chance of throwing no heads is $(1\text{-}0.5)^4$ or about 6%. The chance of throwing heads exactly once is $4(0.5)(1\text{-}0.5)^3$, or about 25%. The chance of throwing heads exactly twice is $6(0.5)^2(1\text{-}0.5)^2$, or about 38%.

$$\textit{Probability of no events in } \mathbf{n} \textit{ tries} = (1-p)^n$$

$$\textit{Probability of one event in } \mathbf{n} \textit{ tries} = np(1-p)^{n-1}$$

$$\textit{Probability of two events in } \mathbf{n} \textit{ tries} = \frac{n(n-1)}{2} p^2 (1-p)^{n-2}$$

$$\textit{Probability of } \mathbf{k} \textit{ events in } \mathbf{n} \textit{ tries} = \binom{n}{k} p^k (1-p)^{n-k}$$

2. **Disk Head Scheduling**. Consider the table below, which shows a series of requests for access to particular disk tracks, along with the time at which the request is made. Assume that the action begins at 0 ms with the first request already waiting and the disk head at track 0. Assume further that the disk scheduler has no advance knowledge of requests before the time listed in the table, and that servicing each request takes exactly 10 ms regardless of how far the disk head moves. (The latter is a simplification to make the problem easier to describe.)

Track Requested	24	22	38	3	25	24	22	28	18	33
Time of Request (ms)	0	5	6	9	13	31	32	33	58	59

Compute (i) the **order** in which the track requests would be satisfied, and (ii) the **latency** of each individual request, using each of the following policies. (Hint: Proceed step by step. After a track has been serviced, figure out the current time and the latency from the time the request was issued. Then list all the pending requests, and determine which would be scheduled next under the specified policy.) Finally, compute how many tracks the disk head has travelled by the end.

a. FCFS

b. SSTF

c. LOOK

d. C-LOOK

e. F-LOOK