You may discuss this assignment with other students in the class, but the work you submit must be your own. Please show only the work which is necessary and sufficient to arrive at the solution, i.e. be concise. The four questions have equal weight.

Assignments are due before 5PM on Thursday, 12/8 in the homework drop box next to MCS 135. Solutions will be posted online at 5PM, thus late assignments will not be accepted.

**Question 1 (Multicast Address Allocation):** Unlike unicast addresses, which are (essentially) permanently assigned to hosts, multicast addresses are often allocated dynamically. Therefore, each multicast application must somehow choose an address for its traffic.

(a) One approach would be to create a central authority that would maintain a pool of addresses and “lease them out” to any multicast host on the Internet that requests such an address, much as a DHCP server leases unicast addresses to locally attached hosts. Cite two fundamental problems with this approach.

(b) An alternative approach is for each application to choose addresses at random from the available address space. But one major problem with this approach is the potential for address collision. In this problem, we compute the probability that such collisions occur. Suppose the addresses are allocated randomly from the range 224.2.0.0 to 224.2.255.255, a total of 65536 addresses. If we assume that hosts do not share information about allocated addresses, what is the probability that a collision occurs after \( N \) multicast addresses are independently allocated as a function of \( N \)? For what \( N \) does this probability exceed 1%? (You may want to run a small simulation to check your results).

**Question 2 (ALOHA analysis):** K & R, Problem P24, p. 517.
Question 3 (Ethernet capture effect)
Let $A$ and $B$ be two stations attempting to transmit on an Ethernet. Each has an unlimited number of frames to send. $A$’s frames are numbered $A_1, A_2, \ldots$ and $B$’s frames are numbered $B_1, B_2, \ldots$. Let $T$ be the exponential backoff base unit of time.

Suppose $A$ and $B$ simultaneously attempt to send frame 1, collide, and happen to choose backoff times of $0 \times T$ and $1 \times T$, respectively, meaning $A$ wins the race and transmits $A_1$ while $B$ waits. At the end of this transmission, $B$ will attempt to retransmit $B_1$ while $A$ will attempt to transmit $A_2$. These first attempts will collide, but now $A$ backs off for either $0 \times T$ or $1 \times T$ while $B$ backs off for time equal to one of $0 \times T, \ldots, 3 \times T$.

(a) Give the probability that $A$ wins this second backoff race immediately after this first collision, that is, $A$’s first choice of backoff time for $A_2$ is strictly less than $B$’s.

(b) Suppose $A$ wins this second backoff race, and thus transmits $A_2$. When it is finished, $A$ and $B$ collide again as $A$ tries to transmit $A_3$ and $B$ tries once more to transmit $B_1$. Give the probability that $A$ wins this third backoff race immediately after the first collision.

(c) Give a reasonable lower bound for the probability that $A$ wins all the remaining backoff races. This is known as the Ethernet capture effect.

(d) What then happens to the frame $B_1$?

(e) Suppose that the Ethernet algorithm is modified so that after each successful transmission attempt, a host waits one or two slot times before attempting to transmit again, and otherwise backs off the usual way. Why is the Ethernet capture effect now much less likely?