This assignment is due on February 19th at 9:00 am.

1. **Volunteers Dilemma** A volunteer's dilemma can arise when an individual is deciding whether to help a person in need. Suppose that the benefit to you is 12 if the person is helped, but you incur a cost of 3 by helping. If you do not help you incur no cost. Your choice is between helping and not. Clearly if you are the only person your net benefit for helping is 12-3=9, whereas if you do not help you get no benefit. If there are two people present suppose that the probability of the other person helping if you don't is 1/2. Then the expected benefit to you if you do not help is (1/2)(12)=6. If you help, the net benefit to you is still 9. It seems like you should help.

   (a) If there are three people present, you perceive that if you do not help the probability that one of the others will help is 2/3. If there are 4 people, you perceive that the probability that one of the others will help is 3/4. In general, if there are N people present, you perceive that the probability that another person will help is $(N-1)/N$. Why might this be a reasonable assumption?

   (b) Find the expected payoff to you if you choose not to help in the volunteer's dilemma, for the case where you are in a group of 3,4,5,6,7 and 8 people.

   (c) In what sized groups would you have an incentive to help. In what size groups would you not have an incentive to help?

(d) Assuming that other people are much like you, what does this problem say about the chances that a person in need will get help if there are a large number of people.

(e) The dilemma in this problem arises from our initial assumption that the more people who are present the higher the probability that one of them will help. This is a natural assumption, but this assumption itself leads to an N-person game where people are inclined to volunteer in small groups, but not in large groups. Discuss examples of this phenomena from your own experience, or in the news.

(f) Modify your assumptions in part (a) so that in a group of size N the probability of a victim being helped if you don't help them is $1/N$ instead of $(N-1)/N$, and recalculate the payoffs to you if you choose not to help. What does this model say you should do if you find yourself in a large group and somebody needs help?

2. **Patenting Game** Six firms are considering undertaking a research project that will lead to a patent for one of those firms. The cost of undertaking the research project is \$210 million. The payoff for the firm that wins the patent is \$1000 million. Firms must decide whether to undertake the research or not. Assume that all the firms that do undertake the research have an equal chance of being awarded the patent. For example, if it turns out that two of the firms do the research there is a 50/50 chance that a given firm will get the \$1000 million. The expected payoff for each of those firms will be half of the \$1000 million minus the cost \$210 million for a total of \$290 million. A firm that does not do the research will get zero payoff.

   (a) Complete a table showing the expected payoffs for a firm undertaking research for the cases where 0,1,2,3,4, or 5 other firms are also doing research.

(b) How many firms will undertake the research? This is the Nash equilibrium.

(c) The net social value of the research is the \$1000 million minus the total cost of the research for all the firms. What is the net social value when 0,1,2,3,4,5,6 firms are doing the research?

(d) When is the net social value the highest? This is the efficient solution. Is the Nash equilibrium efficient?