

## 18.440 PROBLEM SET SEVEN, DUE NOVEMBER 9

### A. FROM TEXTBOOK CHAPTER FIVE:

1. Theoretical Exercises: 5.26, 5.28

### B. FROM TEXTBOOK CHAPTER SIX:

1. Problems: 6.30, 6.33
2. Theoretical Exercises: 6.12

### C. FROM TEXTBOOK CHAPTER SEVEN:

1. Problems: 7.34
2. Theoretical Exercises: 7.13, 7.20, 7.24

D. The following is one formulation of a famous “two envelope” paradox. Jill is a money-loving individual who, given two options, invariably chooses the one that gives her the most money in expectation. One day Harry, a trusted (and capable of delivering) individual, offers her the following deal as a gift. He will secretly toss a fair coin until the first time that it comes up tails. If there are  $n$  heads before the first tails, he will place  $10^n$  dollars in one envelope and  $10^{n+1}$  dollars in the second envelope. (Thus, the probability that one envelope has  $10^n$  dollars and the other has  $10^{n+1}$  dollars is  $2^{-n-1}$  for  $n \geq 0$ .) Harry will then hand Jill the pair of envelopes (randomly ordered, indistinguishable from the outside) and invite her to choose one. After Jill chooses an envelope she will be allowed to open it. Once she does, she will be allowed to either keep the money in the first envelope or switch to the second envelope and keep whatever amount of money is in the second envelope. However, if she decides to switch envelopes, she has to pay a one dollar “switching fee.”

1. If Jill finds 100 dollars in the first envelope she opens, what is the conditional probability that the other envelope contains 1000 dollars? What is the conditional probability that the other envelope contains 10 dollars?
2. If Jill finds 100 dollars in the first envelope she opens, how much money does Jill expect to win from the game if she does not switch envelopes? (Answer: 100 dollars.) How much does she expect to win (net, after the switching fee) if she *does* switch envelopes?

3. Generalize the answers above to the case that the first envelope contains  $10^n$  dollars (for  $n \geq 0$ ) instead of 100.
4. Jill concludes from the above that, no matter what she finds in the first envelope, she will expect to earn more money if she switches envelopes and pays the one dollar switching fee. This strikes Jill as a bit odd. If she knows she will always switch envelopes, why doesn't she just take the second envelope first and avoid the envelope switching fee? How can she be maximizing her expected wealth if she spends an unnecessary "switching fee" dollar no matter what? How does one resolve this apparent paradox?