ECON 251: Problem Set 11
Due Friday December 2 by 11:00 PM

Instructions. Each part of a problem is worth one point. Don't forget to answer the last two questions, as they are each worth one point. Unless otherwise stated, you can always assume that goods are continuously divisible: there is no need to consume an integer number of units of any good. Once you have finished, please submit your completed problem set on gradescope. To do this, you will either need to upload a pdf of your entire problem set or an image (for example, a picture that you take with your phone) of your work for each problem. If you upload a pdf, you will need to tag each problem on the appropriate page of the document. Please show your work and draw a box around your final answer. You are free to work together with your classmates, but the work that you upload must be your own.

1. Find all the pure strategy Nash equilibria in the normal-form game depicted below.

<div align="center">

Player 2

	left	right
up	0,0	1,8
down	8,1	6,6

Player 1

</div>

2. Find all the pure strategy Nash equilibria in the normal-form game depicted below.

<div align="center">

Player 2

	left	right
up	0,7	0,9
down	0,6	0,6

Player 1

</div>

3. Consider the hawk-dove game depicted below.

<div align="center">

Player 2

	hawk	dove
hawk	0,0	10,2
dove	2,10	x,4

Player 1

</div>

   (a) Find all the pure strategy Nash equilibria if $x < 10$.

   (b) If Player 1 plays hawk with probability p and dove with probability $1 - p$, what value of p would make Player 2 indifferent between playing hawk and dove?

(c) In the mixed strategy Nash equilibrium, the probability that Player 2 plays hawk is 0.6. What is x?

4. A village contains one or more farmers. Each farmer raises goats that she grazes on the village common. The cost of buying and caring for each goat is c. The value of the goat (when it is sold at the end of the summer) depends on the amount of grassy land available for the goat to graze on. Since the total size of the village common is fixed, the value of each goat depends on the total number of goats being grazed (and hence the area of the common available for each goat). If the total number of goats is G, the value of each goat is given by $v(G) = 60 - G$.

Each farmer chooses g_i, the number of goats that she wants to graze on the common. She chooses g_i to maximize revenues minus costs.

(a) If a single seeking to maximize revenues minus costs were deciding how many goats to graze on the common (and there were no other farmers in the village), how many goats would she choose to raise? Assume goats are continuously divisible (so the optimal g_i need not be a whole number of goats).

(b) Suppose the village consists of two farmers, Farmer i and Farmer j. If Farmer i grazes g_i goats and Farmer j grazes g_j goats, the value of each goat is $v(G) = 60 - (g_i + g_j)$ and Farmer i's revenue from raising goats is $g_i [60 - (g_i + g_j)]$ (the number of goats times the value of each goat raised). If the two farmers move simultaneously when deciding how many goats to graze on the common, what is Farmer i's best response if Farmer j raises g_j goats?

(c) If the two farmers move simultaneously when deciding how many goats to graze on the common, what is the Nash equilibrium? How many goats will Farmer i choose to graze?

5. Consider an economy that includes three firms. For $i = 1, 2, 3$, let q_i indicate the quantity of output produced by firm i. Thus, total output is $Q = q_1 + q_2 + q_3$. Inverse demand is given by

$$P(Q) = a - Q$$
$$= a - (q_1 + q_2 + q_3)$$

Each firm's cost function is: $C_i(q_i) = cq_i$. Thus, firms have constant marginal costs, and the marginal cost is the same for all three firms. Firms make production decisions sequentially, as in the Stackelberg model of duopoly. Firm 1 chooses q_1 first, then Firm 2 chooses q_2 after observing q_1, and then Firm 3 chooses q_3 after observing q_1 and q_2.

(a) What is Firm 3's best response after observing q_1 and q_2?

(b) In the subgame perfect Nash equilibrium of this game, how much output does Firm 1 choose to produce?

6. Which of your classmates did you work with on this problem set?

7. Did you attend Jamie's TA office hours, or get help from her over email or outside of her regular office hours?