Intermediate Microeconomic Theory
ECN 100B (Section B), Fall 2019

Professor Brendan Price

Final Exam

Name: ___________________________

ID number: _____________

- Write your answers on the exam itself, using only the space provided for each question.
  - If you run out of space for a question, write "see extra space" in the space provided for that question, then finish your answer in the extra graded space at the end of the exam. Be sure to write the question #. You may lose credit if we can't tell which question you're answering.
  - We've also included ungraded scrap space for pure scrap work. Answers written in this ungraded space will not be graded under any circumstances.
- Show your work on every question that requires a calculation. We will award partial credit as appropriate. Correct results without adequate work will receive little or no credit.
- Simplify all mathematical expressions as much as possible.
- There are six pages with questions (pages numbered 2, 3, 4, 5, 6, 7). After the exam starts, make sure that you have all of the pages and that your exam booklet is stapled properly. If there is a problem with your exam, we will give you a new copy.
- The exam is graded out of 60 points. Each question is worth the indicated number of points.
- You will have 120 minutes. You must drop your pen/pencil immediately when time is up. If you keep writing after time is called, we will deduct points.
- As a reminder: UC Davis has a strict code of Academic Conduct. Any violations, including copying or attempting to copy from another student, will result in a score of 0.
- Good luck!

Do not turn this page until I tell you to start.

1. **The American Dream (10 pt.)**

Juanita has just moved to Winters, and she is deciding whether to create the town's first Bolivian restaurant. Entering the market requires a fixed cost $FC > 0$, as well as variable costs $VC(Q) = 4Q$. If Juanita enters, she will be a uniform-pricing monopolist.

a. (4 pt.) If Juanita's restaurant is popular, then demand is high and $p(Q) = 16 - Q$. Assuming that Juanita chooses to enter, determine her profit-maximizing quantity Q_h^* and price p_h^* (where the "h" means "high"). Calculate her profit π_h. (Your expression for profits should include "$-FC$".) What is the consumer surplus?

Juanita's profits are $\pi = (16-Q)Q - 4Q - FC$. The FOC is $16 - 2Q - 4 = 0$, which implies $Q_h^* = 6$ and $p_h^* = 10$. Juanita's profit is $\pi_h = 36 - FC$. The consumer surplus equals $\frac{1}{2}(6)(16-10) = 18$.

b. (3 pt.) If demand is low, then $p(Q) = 8 - Q$. Assuming that Juanita chooses to enter, calculate her quantity, price, and profits Q_l^*, p_l^*, and π_l ("l" means "low"). Then compute consumer surplus.

Juanita chooses $Q_l^* = 2$ and $p_l^* = 6$. She makes profits $\pi_l = 4 - FC$. Consumer surplus equals $\frac{1}{2}(2)(8-6) = 2$.

Juanita must make her entry decision before knowing whether her restaurant will be popular. If she enters, then she immediately learns which demand curve she is facing (before she has to pick Q). She estimates there is a 50% chance demand will be high and a 50% chance demand will be low.

c. (2 pt.) Calculate Juanita's expected profit from entering. Assuming she wants to maximize her expected profit, find the value FC^* that makes her indifferent about entering vs. not entering.

If Juanita enters, her expected profits are

$$\mathbb{E}(\pi) = \frac{1}{2}\pi_h + \frac{1}{2}\pi_l = 20 - FC$$

If she stays out, her profit is zero. She is indifferent if $FC = 20$.

d. (1 pt.) Entrepreneurs like Juanita aren't the only people who benefit from the creation of new firms. In fact, it's socially optimal for Juanita to enter the market as long as $FC < x$. Find x.

Even though Juanita would be a monopolist, her restaurant would create some consumer surplus. If demand is high, consumer surplus equals 18. If demand is low, consumer surplus is 2. So, the expected consumer surplus is $\frac{1}{2} \times 18 + \frac{1}{2} \times 2 = 10$. Expected social surplus equals $\mathbb{E}(\pi) + \mathbb{E}(\text{CS}) = 30 - FC$, so it's socially optimal for Juanita to enter as long as $FC < 30$.

2. **X-Men (4 pt.)**

Answer each question using the payoff matrix below.

		Wolverine		
		Howl	Scowl	Shave
Magneto	Tackle	6, (9)	(12), 5	(8), −4
	Cackle	(7), (7)	8, 1	−6, 2
	Nap	0, 2	4, 1	(8), (3)

a. (2 pt.) Suppose this is a static game. Circle all payoffs corresponding to a player's best response, then list all pure strategy Nash equilibria (or write "none" if there aren't any). Be sure to write the *strategies*, not payoffs.

The PSNEs are (Cackle, Howl) and (Nap, Shave).

b. (2 pt.) Suppose Magneto moves first. In this game's subgame-perfect Nash equilibrium, which action does Magneto choose? What are the equilibrium payoffs?

Magneto chooses Nap, Wolverine responds by playing Shave, and the equilibrium payoffs are (8, 3).

3. **Deal or no deal? (6 pt.)**

For each situation, indicate whether the agent wants to buy the good being described by choosing one of these four options: "definitely buys", "definitely doesn't buy", "indifferent", or "not enough information". (Each option may be used once, more than once, or not at all.) If the question refers to a utility function $u(w)$, assume that $w > 0$. You don't have to show your work here.

a. (1 pt.) A risk-neutral agent is offered an actuarially fair car insurance policy.
Indifferent.

b. (1 pt.) Someone with the utility function $u(w) = 6\sqrt{w}$ is deciding whether to buy a lottery ticket. The transaction is a fair bet.
Definitely doesn't buy.

c. (1 pt.) Someone with the utility function $u(w) = w^2$ is deciding whether to buy a lottery ticket. The ticket costs \$10. Its expected value is \$5, and it has positive variance.
Not enough information.

d. (1 pt.) Someone with a convex utility function is deciding whether to buy a stock portfolio at a price equal to the expected value of the portfolio. (The portfolio has positive variance.)
Definitely buys.

e. (1 pt.) A candy bar costs \$2. My reservation price is \$1.
Definitely doesn't buy.

f. (1 pt.) Someone with the utility function $u(w) = \ln(w)$ is deciding whether to buy pet insurance. The insurance premium is \$20, and the expected claim is \$30.
Definitely buys.

4. **Age of the Machine? (4 pt.)**

   a. (2 pt.) A new chain of coffee shops called Starbots uses a mixture of human workers (L) and robot workers (K). As the cost of renting a robot declines ($r \downarrow$), will demand for human workers increase, decrease, or is the answer "ambiguous" (could go either way)? Explain your answer.

   It's ambiguous. As r declines, the substitution effect will cause Starbots to shift away from humans and towards robots, but the scale effect will cause Starbots to expand production, potentially (if humans and robots are imperfect substitutes) increasing its demand for humans. Either force could dominate.

   b. (2 pt.) You run a factory with the production function $q(L, K) = 3L + 4K$. Your boss at corporate headquarters has asked you to produce $q = 12$ units of output at the lowest possible cost. If $w = 10$ and $r = 12$, find the cost-minimizing combination L^* and K^*. What is the total cost?

   This is a linear production function. Each unit of capital is 1/3 more productive than each unit of labor, but it costs only 1/5 more. So capital offers more "bang for your buck". To produce $q = 12$ units, you should choose $L^* = 0$ and $K^* = 3$. This will cost \$36 total. (Using labor would have cost you \$40.)

5. **Good workers are hard to find (6 pt.)**

   The Olive Drive Barber Shop produces haircuts using labor as its only input, with production function $q(L) = 4\ln(L)$. It sells haircuts in a competitive market at a price $p = 15$. The barber shop can hire as many units of labor as it wants at a constant wage rate $w = 10$.

   a. (2 pt.) Compute the marginal <u>physical</u> product of labor (MPPL) as a function of L. Compute the marginal <u>revenue</u> product of labor (MRPL) as a function of L.

   MPPL: $q'(L) = \frac{4}{L}$. MRPL: $pq'(L) = \frac{60}{L}$.

   b. (2 pt.) Write the shop's profit-maximization problem. Find the profit-maximizing choice L^*.

   $\max_L \; pq(L) - wL \implies \max_L \; 60\ln(L) - 10L$. FOC: $\frac{60}{L} = 10 \implies L^* = 6$.

   In class, we assumed firms can freely adjust L in response to "short-run" changes in market conditions. In practice, hiring new workers takes time, and labor (like capital) may be fixed in the short run.

   Suppose that p increases. (The wage w doesn't change, and there is still no capital.)

   c. (1 pt.) In the short run, suppose L stays at the value L^* you found in part b. Relative to their values when $p = 15$, the MPPL will <u>not change</u> (rise/fall/not change) and the MRPL will <u>rise</u> (rise/fall/not change).

   d. (1 pt.) In the long run, Olive Drive will adjust its choice of L to a new optimum. Relative to their values when $p = 15$, the MPPL will <u>fall</u> (rise/fall/not change) and the MRPL will <u>not change</u> (rise/fall/not change).

6. **Eggs in a basket (6 pt.)**

Avalon and Camelot are equally promising companies: each share of either Avalon or Camelot stock is worth \$5 with probability $\frac{1}{2}$ and \$0 with probability $\frac{1}{2}$. The stock prices are uncorrelated.

a. (2 pt.) Find the expected value and variance of a portfolio consisting of two shares of Avalon.

Expected value: $\mathbb{E}(2X_A) = \frac{1}{2}(10) + \frac{1}{2}(0) = 5$. Variance: $\text{Var}(2X_A) = \frac{1}{2}(10-5)^2 + \frac{1}{2}(0-5)^2 = 25$.

b. (3 pt.) Find the expected value and variance of a portfolio consisting of one share of Avalon and one share of Camelot. If she can buy both portfolios at the same price, which of these two portfolios—the one in part a or the one in part b—would a risk-averse investor prefer to own?

Expected value: $\mathbb{E}(X_A + X_C) = \frac{1}{4}(10) + \frac{1}{2}(5) + \frac{1}{4}(0) = 5$. Variance: $\text{Var}(X_A + X_C) = \frac{1}{4}(10 - 5)^2 + \frac{1}{2}(5-5)^2 + \frac{1}{4}(0-5)^2 = 12.5$. A risk-averse investor would prefer the portfolio in part b.

c. (1 pt.) Thanks to the "law of large numbers", a financial analyst claims that investors can virtually eliminate the risks of stock ownership by holding a highly diversified portfolio consisting of a small share of every stock in the economy. Is the analyst right? Explain your answer.

The analyst is wrong: diversification can eliminate the idiosyncratic risk from owning any particular stock, but not the aggregate risk that the whole stock market will rise/fall in value.

7. **Just in case (4 pt.)**

Sally starts with wealth $w = 100$, consisting of \$25 cash plus an old iPhone worth \$75. But she drops her phone all the time, and there is a 20% chance that it breaks. (If that happens, she loses \$75.)

a. (3 pt.) Suppose that Sally's utility function is $u(w) = \sqrt{w}$. Compute Sally's expected utility. Then compute her certainty equivalent for the "lottery" of having a working vs. broken phone. If Apple sells a \$22 case that eliminates the risk of breaking her phone, would Sally buy it?

Expected utility: $\mathbb{E}(u(w)) = \frac{4}{5}\sqrt{100} + \frac{1}{5}\sqrt{25} = 9$. Certainty equivalent: $u(\text{CE}) = 9 \implies \sqrt{\text{CE}} = 9 \implies \text{CE} = 81$. Sally is indifferent between "playing the lottery" and having \$81 for sure, so she would not buy a \$22 case.

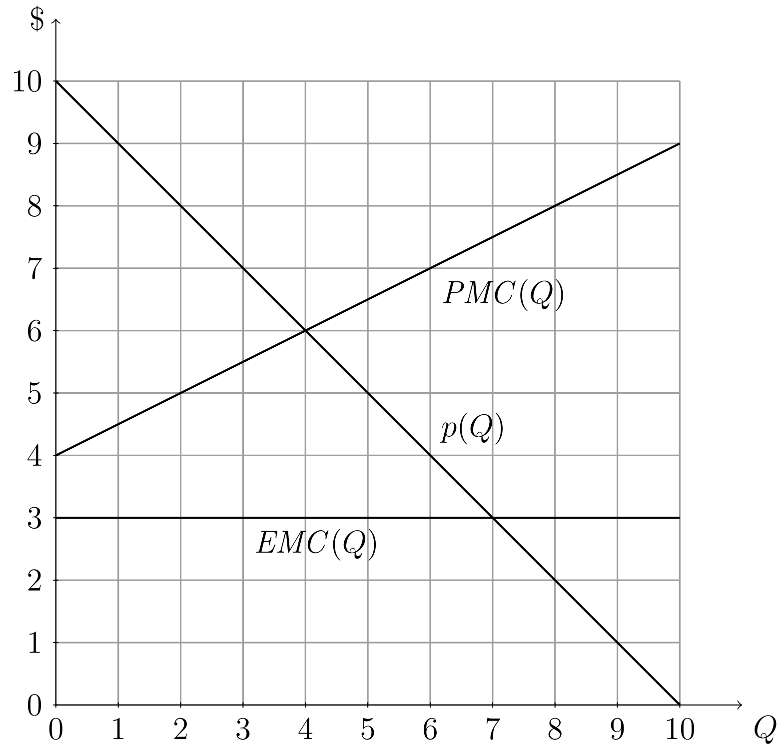
b. (1 pt.) If Sally's utility function is $u(w) = w$, how much is she willing to pay for the case?

Quick solution: a risk-neutral agent only cares about the expected value of the financial loss, which is $\frac{1}{5} \times 75 = 15$. Longer solution: the WTP is the price p^* that solves

$$\text{expected utility w/o case} = \text{expected utility with case}$$
$$\frac{4}{5} \times 100 + \frac{1}{5} \times 25 = 100 - p \implies p^* = 15$$

8. **Negative externalities (10 pt.)**

Answer each question using the graph below. (You do not need to show your work here.) $p(Q)$: demand. $PMC(Q)$: private marginal cost. $EMC(Q)$: external marginal cost.



a. (3 pt.) In the competitive equilibrium,

- the quantity sold (Q_c) equals 4.
- the consumer surplus equals 8.
- the producer surplus equals 4.

b. (2 pt.) Under perfect price discrimination,

- the quantity sold (Q_{ppd}) equals 4.
- the total revenue is 32.

c. (3 pt.) At the social optimum,

- the quantity (Q_s) equals 2.
- the social marginal cost equals 8.
- the total surplus equals 3.

d. (2 pt.) We can achieve the social optimum using a corrective *tax* (tax or subsidy) equal to 3.

9. **"Movin' Out" (10 pt.)**

Ayako and Bao are graduating this quarter, but first they have to clean their apartment. (The messier they leave it, the louder their landlord yells at them, and the guiltier they feel.) Let

$$Q = q_A + q_B$$

denote total time spent cleaning, where q_A and q_B are time spent by Ayako and Bao, respectively. Each roommate receives private marginal benefits given by

$$p_A(Q) = 12 - Q \qquad \text{and} \qquad p_B(Q) = 18 - Q$$

(Ayako took macro with Professor Caramp, so she's used to loud voices.)

a. (2 pt.) Express the social marginal benefit in terms of Q. (Remember: it may have two parts.)

The SMB curve is $p(Q) = \begin{cases} 30 - 2Q & \text{if } Q \leq 12 \\ 18 - Q & \text{if } Q > 12 \end{cases}$.

b. (2 pt.) Suppose the marginal cost is 20 for both people. Find the socially optimal quantity (Q^{soc}). What will Ayako and Bao do in the Nash equilibrium (q_A^{Nash} and q_B^{Nash})?

The social optimum occurs where the SMB equals 20. This intersection happens on the first part of the curve, so we get $p(Q) = 30 - 2Q = 20 \implies Q^{\text{soc}} = 5$. But each roommate's PMB is less than her PMC, so choosing zero is strictly dominant for both roommates: $q_A^{\text{Nash}} = q_B^{\text{Nash}} = 0$.

c. (2 pt.) Now suppose that Ayako's marginal cost is 14 and Bao's marginal cost is 15. Find the socially optimal (i.e., Pareto efficient) quantities q_A^{soc} and q_B^{soc}.

Since Ayako's MC is smaller than Bao's, it is socially optimal (i.e., Pareto-efficient) for Ayako to do all the work. Ayako's MC intersects the SMB curve at $Q = 8$ (on the first part of the curve), so the social optimum is $q_A^{\text{soc}} = 8$ and $q_B^{\text{soc}} = 0$.

d. (3 pt.) Now suppose each roommate doesn't mind cleaning a little, but hates cleaning a lot: Ayako's marginal cost is $MC_A(q_A) = q_A$, and Bao's is $MC_B(q_B) = q_B$. Find both best-response functions, then find the Nash quantities q_A^{Nash} and q_B^{Nash}. (The answer is an interior solution.)

Given some guess $\hat{q}_B$ about Bao's intentions, Ayako chooses q_A to equate her PMB to her MC: $12 - q_A - \hat{q}_B = q_A \implies q_A^* = BR_A(\hat{q}_B) = 6 - \frac{1}{2}\hat{q}_B$. Similarly, Bao's best-response function is $18 - \hat{q}_A - q_B = q_B \implies q_B^* = BR_B(\hat{q}_A) = 9 - \frac{1}{2}\hat{q}_A$. In equilibrium, both guesses are right, so $q_A^* = \hat{q}_A$ and $q_B^* = \hat{q}_B$. Solving the system of equations gives $q_A^* = 2$ and $q_B^* = 8$.

e. (1 pt.) If the building has a members-only gym with lots of exercise machines, we might call the gym a "club good". To be a club good, the gym must be <u>non-rival</u> and <u>excludable</u>.