14.01 Principles of Microeconomics
Final Assignment, Spring 2020
due March 12th (5pm EDT)

(Please Print) Last Name: ________________________ **First Name:** ____________________________

Kerberos ID: _____________________________ **MIT ID number:** _____________________________

Instructions—Please read carefully!

Please print out this assignment and answer each question in the space below it. The pages we include marked as ungraded may be used for scrap work—do not write final answers on those sheets as they will NOT be graded. (If you are unable to print this document, write your answers on blank pages in a similar configuration as that of the assignment. Be sure to include all of the information on the first page, too.) At the end, scan in your entire assignment, including the scrap work pages, and upload it to the website. Please upload it with plenty of time to make sure that you can get it in on time even if you experience some technical difficulties.

This final assignment has a total of **180 points**. Some of the questions require verbal answers, and we include a maximum length for each answer. Do not exceed the listed maximum—your answer will not be graded if you do.

Parts of this assignment will be challenging, including some exercises that are different from ones you have done on problem sets. A passing grade will **not** require substantially correct answers on all of the problems.

Finally, you can consult course resources or other non-interactive resources, such as textbooks or online lectures notes. You may not seek assistance from any interactive source, with the exception of asking clarifying questions in private mode on Piazza. Thus, while this is an assignment, you cannot work in groups and there will be no office hours during the duration of this assignment. Please sign below to affirm that you understand the rule and will abide by it.

Signature: ____

DO NOT WRITE IN THE AREA BELOW:

Q1 ___ **/30** **Q2** ___ **/24** **Q3** ___ **/32** **Q4** ___ **/24** **Q5** ___**/40** **Q6** ___**/30**

Total _____ **/180**

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1 Question 1: 30 pts.

Over the course of the semester, we drew on many economics papers, classic and recent, theoretical and empirical, to enrich our understanding. Choose one of those papers to read and produce a "book report." We provide a list of the papers on the website. Your report should summarize the methods and main findings of the paper. Feel free to include your own thoughts or opinions, if you would like. Your report should not exceed this space provided. Unlike the rest of the exam, it will be graded on a full-credit/no credit basis.

2 Question 2: 24 pts.

Provide concise answers in the spaces below.

a) We talked about the extreme result of the Bertrand model as describing a force that firms have to try to "escape," in order to charge prices above marginal cost. Name three ways we discussed that firms can escape Bertrand and price above marginal cost. Explain each with a sentence, 50 words total.

Solution: (only 3 are needed) 1 point/reason, 1 point/explanation

1. **Identical products: firms try to differentiate their products from their competitors; for example, different brands of the same product such as detergent; different detergents have different formulas and they advertise their differences;**
2. **Consumers know both products: consumers will rarely know the prices of all the firms providing a product or service (for example haircuts);**
3. **Switch immediately as soon as one is a tiny bit lower: this is not possible if there are any transportation costs (for example when grocery shopping people will not go to a second grocery store even if they find a slightly higher price for bread);**
4. **Firms can only set price once: firms sell in multiple time periods and they are rarely restrictions on changing prices over time;**
5. **Firms can meet all demand immediately: firms might even choose to sell fewer products to not engage in Bertrand competition (for example the Marriott hotel mentioned in pset 5 – the hotel might choose to not serve all the demand in Kendall square in order to soften competition);**
6. **Firms' marginal costs are constant and identical: different firms will have different levels of efficiency which will result in different costs.**

b) The Cournot model had firms competing in quantities, sort of an odd concept. When could it make sense to assume that firms choose quantities, not prices? Explain in no more than 40 words.

Solution: Quantity choices make sense when a firm needs to make the production decision before knowing prices – for example farmers choose how much to plant, hotels choose the number of rooms to build.

c) Firms can charge above marginal cost by differentiating their products from their competitors' products. What model(s) did we see that described that phenomenon? In general, how do you think this compulsion to differentiate is disciplined? (In other words, why don't all firms just differentiate themselves enough that they can charge the monopoly price?) Explain in a couple of sentences, no more than 40 words.

Solution: (3 points for model, 3 points for explanation) The model of product differentiation we saw in class was the Hotelling model. If the transportation cost is not too high, the firms will not be able to differentiate themselves enough to charge monopoly price. This is because with a lower transportation cost, the consumers are not "captive" to either firm.

d) In thinking about competition, economists often use the basic Bertrand model and the basic monopoly pricing model as two ends of a spectrum. Firms price at marginal cost at the low end of the spectrum, with a markup according to the Lerner Index at the high end. Did we discuss any models which offered a “bridge” between those two extremes, in other words, describing factors that, as they change, induce a smooth transition from one extreme to the other? Explain in three sentences or less, no more than 50 words.

Solution: (3 points for model; 3 for explanation) The model that we discussed was the Stahl search model. In that model we had a proportion of the population that knew all the prices without paying a search cost and the rest of the population needed to pay a search cost to discover the price charged by a firm. When there are no shoppers we are in the Diamond model with monopoly price; as the proportion of ”shoppers” increases the prices move towards marginal cost pricing.

3 Question 3: 32 pts.

Illuminati Coffee is in the business of growing coffee on the island of Vieques and selling it to upscale retail coffee shops around the world.

1. Residual demand for Illuminati's product is

$$Q_c = 100 - P_c$$

where quantity is in hundreds of pounds and price is in dollars per hundred pounds. Illuminati's marginal costs of production are \$60 per hundred pounds. What amount of coffee will Illuminati produce and at what price?

Solution: (4 points – 2 for setting up the problem; 1 for quantity; 1 for price) We solve the profit maximization problem:

$$\max_{P_c}(P_c - 60)(100 - P_c)$$

$$160 - 2P_c = 0$$

$$P_c = 80$$

$$Q_c = 20$$

2. Modern open planting cultivation of coffee, which Illuminati uses, leads to important wildlife habitats being destroyed. There is a single firm, Vieques Escapes, in the business of eco-tourism. People especially love to visit Vieques for the wildlife, such as the exotic bird populations and the bioluminescent bay. Unfortunately. demand for tours suffers from coffee cultivation, since tourists like to see exotic birds, and are not very interested in coffee plantations.

Over the years, the number of coffee plantations was has increased, and at the same time, Vieques Escapes was randomly experimenting with the price for their tours. As a result, they collected the following data on the demand for tours:

Quantity of coffee	Price of the Tour	Tours Sold
5	30	35
10	25	35
15	35	20
20	30	20

You are a consultant for Vieques Escapes and they show you the data. You see a linear relationship and suggest that demand takes the form

$$Q_t = \alpha - \beta P_t - \gamma Q_c$$

where Q_c is coffee production, Q_t is the number of tourists visiting, and P_t is the price for the tours. What is your best guess of the demand function (i.e., the values of α and β)?

Your friend argues that in 14.01 he learned that the (price, quantity) points we observe are the result of equilibrium, so it would not be appropriate to estimate demand just from these observations, without any instruments. Is his point valid? Why or why not?

Solution: (10 points total; 2 points each for γ, α, β; 2 points for each of the two factors below) The point would be valid, if we had factors shifting demand of tours, which we cannot account for. In this case

- **We have data on demand shifter in the amount of coffee produced, and we do not have any information that demand could have shifted due to other factors. So, we can control for the observable demand shifter.**
- **The variation in prices is random. Thus, it traces out the demand curve.**

Fitting equation on the points given, we find

$$Q_t = 70 - P_t - Q_c$$

3. Tourism has marginal cost of \$20 per tour. Given the amount of coffee produced you found in part 1, and demand from part 2, calculate the profit-maximizing number of tours sold, and price of a tour.
Solution: (4 total; 2 points for setting the problem; 1 point for quantity and 1 for price) The profit maximization problem is:

$$\max_{P_t}(70 - P_t - 20)(P_t - 20)$$

$$70 - 2P_t = 0$$

$$P_t = 35$$

$$Q_t = 15$$

4. After some government upheaval, a new provincial governor comes to power in Vieques. She cares about both Illuminati's and Vieques Escapes' profits. (In other words, she wants to impose some regulations that will maximize total profits.) What are the respective amounts of coffee production and ecotours that her regulations should impose?
Solution: (4 total; 2 points for setting up the problem; 1 for each quantity) We now need to maximize:

$$\max_{Q_c, P_t}(40 - Q_c)Q_c + (70 - P_t - Q_c)(P_t - 20)$$

$$40 - 2Q_c - P_t + 20 = 0$$

$$70 - Q_c + 20 - 2P_t = 0$$

Solving the system of equations, we have $P_t = 40$, $Q_c = 10$, $Q_t = 20$: it is profit-maximizing to sell more tours at a higher price, at the expense of coffee production.

5. If we were to take a broader view than the governor of Vieques, what other quantities might we include in our calculation? Can you produce a calculation for the socially optimal amount of coffee production?
Solution: (10 total; 3 points each for figuring out that adding the CS of buyers

and tourists is necessary; 2 point for setting up maximization problem; 2 points for conclusion) We need to add the consumer surplus of coffee buyers and tourists. The consumer surplus of coffee buyers is:

$$CS_c = \frac{1}{2} \cdot Q_c^2$$

Consumer surplus of tourists is:

$$CS_t = \frac{1}{2} \cdot (70 - P_t - Q_c)^2$$

We need to maximize:

$$\max_{Q_c, P_t} (40 - Q_c)Q_c + (70 - P_t - Q_c)(P_t - 20) + \frac{1}{2}Q_c^2 + \frac{1}{2}(70 - P_t - Q_c)^2$$

$$40 - 2Q_c - P_t + 20 + Q_c - 70 + P_t + Q_c = 0$$

$$70 - Q_c + 20 - 2P_t - 70 + P_t + Q_c = 0$$

$$P_t = 20$$

from the second equation. However, the first equation turns into

$$-10 = 0$$

which, of course, has no solution. The derivative of total surplus with respect to Q_c is negative. This means that to maximize total surplus, we want to make Q_c as small as possible, setting it to 0. The total surplus which is possible to extract from the tourism is higher that the one from the coffee.
For the social optimum, Coffeeland should completely preserve its wildlife, and only sell tours to the island.

4 Question 4: 24 pts.

Note to the graders: *Penalize algebra mistakes by 1 point. For wrong areas/intuition, deduct all points.*

Suppose that the market for steel is competitive. Demand in tons (marginal benefit) for steel is given by $Q_d = 1200 - 4P$ for a price in dollars per ton, and supply (marginal cost) is given by $Q_s = -240 + 2P$.

1. Suppose that the government sets a tax of \$30 per unit of steel on the producer side.

   (a) Compute the equilibrium price(s) before and after the tax is in place.
   Solution: (4 total – 2 for P before tax; 2 for each P after tax) Before the tax is implemented, the equilibrium is given by:

   $$Q_d = Q_s \iff 1200 - 4P = -240 + 2P \iff$$

   $$P^* = Q^* = 240$$

   The tax places a wedge between the price the producers receive and the price the consumers pay.

   $$\tau = 30 = P_d - P_s = (300 - \frac{Q}{4}) - (120 + \frac{Q}{2}) \iff$$

   $$Q_t = 200, P_d = 250, P_s = 220$$

   (b) Compute the deadweight loss that is created from imposing the tax. **Solution: (4 points for the DWL calculation) The DWL is given by area ABC in the graph below:**

   $$DWL_t = \frac{1}{2} \cdot 40 \cdot 30 = \$600$$

   Steel production creates sludge which causes a marginal damage of \$12 per unit of steel produced.

2. (a) What is the socially efficient production of steel?
   Solution: (4 points - set-up and numbers) Since there is damage associated with steel production, the SMC is given by:

   $$SMC = PMC + MD = 132 + \frac{Q}{2}$$

   To find the efficient level of production we need to equate MB (demand) with the SMC.

   $$SMC = MB \iff$$

   $$132 + \frac{Q}{2} = 300 - \frac{Q}{4}$$

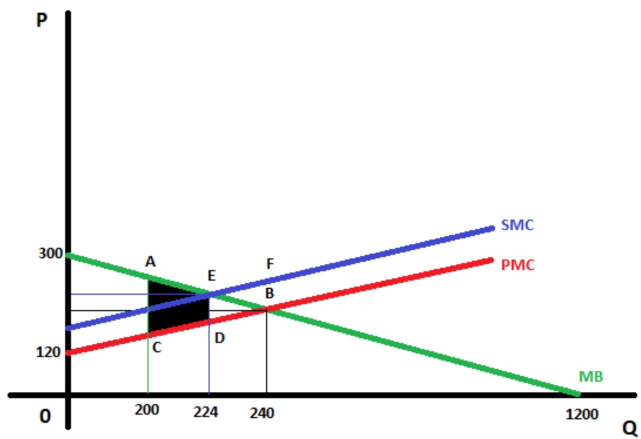
   $$Q^e = 224, P^e = 244$$

(b) Compute the deadweight loss in the market if there is no intervention by the government.
Solution: (4 points) The DWL is given by area BEF in the graph below:

$$DWL_{ext} = \frac{1}{2} \cdot (252 - 240) \cdot (240 - 224) = \$96$$

(c) At what level should the government set the tax τ per unit of steel if it wants to implement the socially efficient level of production?
Solution: (4 points) It should set the tax at $\tau = \$12$ per unit. This will raise the cost of the firm to be equal to the SMC. Hence, it will choose to produce at the efficient level.

3. Compute the (actual) deadweight loss in the market if the government instead sets the tax at \$30 as it originally intended. What is the intuition for the difference in the deadweight loss from your previous calculation?



Solution: (3 points for DWL, 1 for explanation) The tax over-corrects for the externality. The DWL is given by the shaded area in the graph below. Algebraically:

$$DWL = \frac{1}{2} \cdot (224 - 200) \cdot [(244 - 232) + 30] = \$504$$

The DWL is larger than when the government did not intervene at all. The tax is too high and is over-correcting for the externality. If the government doesn't compute the externality correctly, instead of solving the problem it could cause even more damage by intervening.

Note to the graders: Also acceptable if they compared to the initial DWL.

5 Question 5: 40 pts.

Consider the health insurance market in a certain town. Suppose that all people in this town have an initial wealth of \$1000. They are at risk of falling ill, in which case they would incur medical costs of \$1000. The probability that person i falls ill is $q_i \in (0,1)$ – so with probability $1 - q_i$ this person doesn't incur any medical costs. Everyone in this town has a utility function over money given by $u(x) = x^{1-\sigma}$ with $\sigma \in (0,1)$ where x is in \$1000s. Health insurance companies can offer a full insurance policy at a price \$$p$. Suppose that health insurers are risk neutral, and there are infinite potential entrants to the market.

1. Plot the utility function $u(x)$ (for $x \in [0,1]$) for various values of σ (you could use for example, $\sigma = 0.25,\ 0.5,\ 0.75$). Are the people in this town risk averse or risk loving? How does their attitude towards risk depend on σ?
   Solution: (4 points – 2 point for risk averse and 2 for higher sigma) individuals are risk averse. Higher σ makes the utility function more concave, so they are more risk averse.

2. For what prices \$$p$ will household i purchase the health insurance policy? How does your answer depend on q_i and σ? Briefly explain the intuition.
   Solution: (12 points – 3 for EU w/o insurance; 3 w/ insurance; 2 for initial inequality; 2 for final inequality; 2 for explanation) The expected utility without insurance is

$$\begin{aligned} EU\,(without\ insurance) &= q_i 0^{1-\sigma} + (1-q_i)\,1^{1-\sigma} \\ &= 1 - q_i \end{aligned}$$

   The expected utility with insurance is

$$EU\,(with\ insurance) = (1-p)^{1-\sigma}$$

   The household buys the insurance policy if

$$\begin{aligned} (1-p)^{1-\sigma} &\geq 1 - q_i \\ \iff & \ p \leq 1 - (1-q_i)^{\frac{1}{1-\sigma}} \end{aligned}$$

   The maximum price that the household is willing to pay increases with q_i because insurance becomes more valuable if they are more likely to fall ill. It also increases with σ because a more risk averse household is willing to pay more for insurance.

Suppose that half the population is at high risk of falling ill, $q_H = 0.4$, while the other half of the population has a low risk of falling ill, $q_L = 0.2$. Health insurance companies, however, cannot distinguish which individuals are high risk and which are low risk, so they will have to set the same price for everyone. Suppose for now that $\sigma = 0.1$.

3. We first want to analyze if we can have an equilibrium in which everyone in this town is insured.
   (a) For which prices \$$p$ would everyone buy health insurance?
   Solution: (2 points) everyone will buy health insurance if the price is

$$p \leq 1 - (1-0.2)^{\frac{1}{1-0.9}} \cong 0.22$$

   because if the low risk households are willing to buy it, then so are the high risk households.

(b) If everyone buys health insurance, what are the expected costs incurred by health insurance companies?
Solution: (2 points) normalizing the population to 1, the expected costs are (in \$1000s)

$$\frac{1}{2}0.2 + \frac{1}{2}0.4 = 0.3$$

(c) Is there an equilibrium in which everyone is insured? Explain the intuition.
Solution: (2 points) No, the maximum price that can be charged for an insurance policy that everyone buys is 0.22, but the expected costs incurred by the insurance company are 0.3 (these are in \$1000s).

(d) Is this a case of adverse selection or moral hazard? Briefly explain your answer.
Solution: (2 points) this is a case of adverse selection because individuals know their own types (high or low risk), but the insurance company doesn't know it.

4. Let us now analyze if we have an equilibrium in which only the high risk households are insured.

(a) For which prices \$$p$ would only the high risk individuals buy health insurance?
Solution: (3 points – 2 for inequality; 1 for price range) high risk individuals will buy the insurance if its price is

$$p \leq 1 - (1 - 0.4)^{\frac{1}{0.9}} \cong 0.43$$

so for prices $p \in [0.22, 0.43]$ only the high risk individuals will buy the insurance.

(b) If only high risk individuals buy health insurance, what are the expected costs incurred by health insurance companies?
Solution: (2 points) The expected costs for every insured individual are 0.4 (in \$1000s).

(c) Is there an equilibrium in which only high risk individuals are insured?
Solution: (2 points) Yes, with a price $p = 0.4$, the insurance company breaks even and the high risk individuals buy the insurance.

5. Repeat parts 3.a-3.c for $\sigma = 0.9$. Briefly explain the intuition in no more than 30 words of why your results are different from the case $\sigma = 0.1$.
Solution: (9 points total – 7 points as before; 2 for intuition) everyone will buy health insurance if the price is

$$p \leq 1 - (1 - 0.2)^{\frac{1}{1-0.9}} \cong 0.89$$

Normalizing the population to 1, the expected costs are

$$\frac{1}{2}0.2 + \frac{1}{2}0.4 = 0.3$$

Now we do have an equilibrium with a price $p = 0.3$ in which everyone is insured. The difference with part 3 is that now agents are more risk averse, and they are therefore willing to pay more for insurance. Therefore, the low risk individuals are willing to purchase the insurance even when its price is well above their expected medical costs due to the adverse selection problem.

6 Question 6: 30 pts.

In this exercise, you will explore some of the ideas behind expected utility theory. I include some background reading in the file called "BergerBook." It has an excerpt from a classic book on Bayesian analysis by statistician James Berger. For the purposes of this problem, the most important information is in section 2.3, The Utility of Money. (As an aside, Bayesian analysis, a branch of statistics, is an excellent example of the applicability of utility theory outside the field of economics. Bayesians use utility theory because they want to quantity how costly mistakes in statistical analysis are, or equivalently, how valuable getting estimates correct is. So they often specify a cost function, the negative of a utility function, associated with their estimates to help them decide what the best estimate of some unknown quantity is. A timely example would be trying to estimate how effective social distancing measures are. A Bayesian would want to specify a function that exhibits high economic costs from excessive social distancing if the estimate of the effect is too low as well as high costs in terms of lives lost from inadequate social distancing if the estimate of the effect is too high.)

a) Construct your own utility for changes in monetary fortune over the interval from -$1000 to $1000 and graph it.
Solution: (4 points) We would expect the utility to be increasing and have diminishing marginal returns.

b) Without referring to your utility function from part a), decide whether you prefer a one-quarter chance at $250/a three-quarters chance at $0 or a one-half chance at $40/a one-half chance at $70. Is your answer consistent with your utility function? If not, make a modification.
Solution: (8 points total) Mentioning that the expected utility from the preferred gamble should be higher (4 points) and updating the utility function to be consistent (4 points).

c) Without referring to your utility function from part a), decide whether you prefer a one-half chance at $1000/a one-half chance at -$1000 or a one-half chance at $50/a one-half chance at -$50. Is your answer consistent with your utility function? If not, make a modification.
Solution: (8 points total) Mentioning that the expected utility from the preferred gamble should be higher (4 points) and updating the utility function to be consistent (4 points).

d) Construct a utility function for the grade you would have received in this class, if we were still giving letter grades. (Include at least one consistency check.)
Solution: (6 points total) The utility function can be discrete – increasing in grades.

e) Now that the class will be graded pass/no record, could you still construct a utility function over those two grades? Explain in 20 words or fewer.
Solution: (4 points total) No, we could not check transitivity of preferences so we do not necessarily have a utility function.