

Economics 101  
 Fall 2017  
 Answers to Homework 5  
 Due:12/12/17

Directions:

- The homework will be collected in a box before the lecture.
- Please place your name, TA name, and section number on top of the homework (legibly). Make sure you write your name as it appears on your ID so that you can receive the correct grade.
- Late homework will not be accepted so make plans ahead of time.
- Show your work. Good luck!

**Please realize that you are essentially creating “your brand” when you submit this homework. Do you want your homework to convey that you are competent, careful, and professional? Or, do you want to convey the image that you are careless, sloppy, and less than professional? For the rest of your life you will be creating your brand: please think about what you are saying about yourself when you submit any work for someone else.**

Part I: Production Theory (Questions from the last Homework)

1) Bob owns a sausage business in Madison. The quantity of sausages that his company can produce ( $q$ ) depends on the amount of capital ( $K$ ) and labor ( $L$ ) that he employs. The units of capital represent the number of machines his business owns. The units of labor represent the number of employees he hires. His costs of employing the capital and labor are given in dollars. The following table describes the production and costs for given levels of  $K$  and  $L$ .

K	L	q	FC	VC	TC	AFC	AVC	ATC	MC	MPL
3	0	0	\$30		\$30	-	-	-	-	-
3		4	\$30						\$7.5/unit of output	2 units of output/unit of labor
3	3	12								
3		15			\$90					
3	6	20								
3	7	22								
3		25		\$135						
3	10	26								

a. How much does each machine (unit of K) cost?

a. In the first row, Bob is only employing capital. The total cost for three units of capital is \$30, so each unit of K costs \$10.

b. How much does each unit of labor cost? (Assume the wage is constant.)

b. From the second row MPL, we know that to produce 2 units of sausage, Bob needs to hire one unit of labor. Moving from row 1 to row 2, output increases from  $q = 0$  to  $q = 4$ , so Bob must have hired two units of labor.

Now the MC column tells us that when we moved to this row and produced 4 additional units, Bob's cost is \$7.5 per unit. Total costs therefore must have increased by \$30. Bob did not employ any additional capital, so this \$30 increase in total costs must have come from the cost of hiring the two units of labor. The cost per unit of labor is therefore \$15.

c. Fill out all the other missing pieces of information in the table. Do calculations to three places past the decimal where necessary.

c.

K	L	q	FC	VC	TC	AFC	AVC	ATC	MC	MPL
3	0	0	\$30	\$0	\$30	-	-	-	-	-
3	2	4	\$30	\$30	\$60	7.5	7.5	15	\$7.5/unit of output	2 units of output/unit of labor
3	3	12	\$30	\$45	\$75	2.5	3.75	6.25	1.875	8
3	4	15	\$30	\$60	\$90	2	4	6	5	3
3	6	20	\$30	\$90	\$120	1.5	4.5	6	6	2.5
3	7	22	\$30	\$105	\$135	1.364	4.773	6.136	7.5	2
3	9	25	\$30	\$135	\$165	1.2	5.4	6.6	10	1.5
3	10	26	\$30	\$150	\$180	1.154	5.769	6.923	15	1

d. As Bob hires more workers, does the marginal product of those workers increase? Does the marginal product of labor begin to diminish at some point?

d. As Bob hires more workers, the MPL initially increases, until it reaches  $MPL = 8$  units of output per unit of labor for the third worker. Then as Bob continues to hire more labor (labor greater than four workers) the MPL begins to diminish.

e. Can we tell whether Bob's business will be operating in the short run? What about in the long run? What piece of information do we still need to learn to know for sure about the answers to these two questions?

e. We can't tell whether Bob will be able to stay in the business unless we know what price he can sell sausages for. In order to operate in the short run, the price of sausages needs to be above the minimum point of the AVC. The minimum point on the AVC occurs at that quantity where  $AVC = MC$ . In the long run in order to operate Bob will need to be able to cover all of his costs so the price must be equal to or greater than the minimum of the ATC. The minimum of the ATC occurs at that quantity where  $ATC = MC$ . We also know that entry of firms will occur in this industry in the long run until profits are equal to zero: this means that Bob will produce at quantity where  $ATC = MC = \text{price}$ .

f. What is the Shutdown price for Bob?

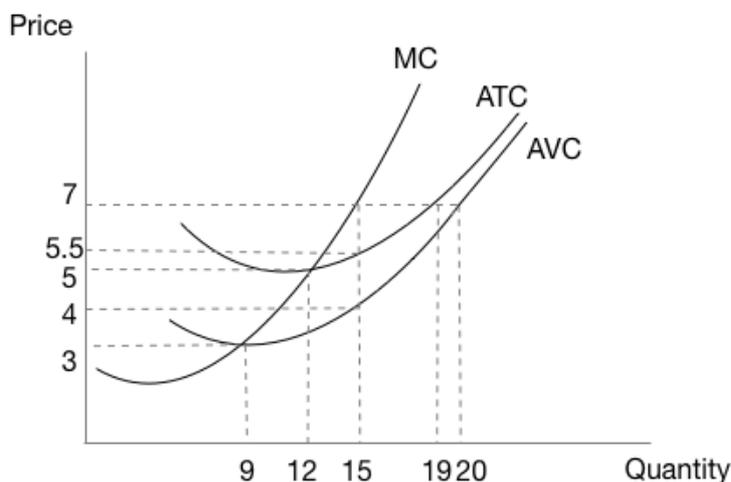
f. The Shutdown price is the price at the minimum of AVC. Here the shutdown price is  $P = \$3.75$ .

g. What is the Breakeven Price for Bob?

g. The Breakeven Price is the price at the minimum of ATC. To stay in business in the long run, Bob needs to earn at least  $P = \$6$ .

## Part II: Perfect Competition

2) The figure below depicts the cost structure of a t-shirts company in a competitive market.



a. What is the fixed cost for this company?

a. When quantity is 15, ATC is \$5.5 per unit of output and AVC is \$4 per unit of output, so total cost is  $15 * \$5.5 = \$82.50$ . Total variable cost is  $15 * \$4 = \$60$ , so the fixed cost is total cost - total variable cost =  $\$82.50 - \$60 = \$22.50$ .

b. When the price level is \$7, what is the profit for this profit-maximizing firm?

b. When the price level is \$7, the optimal quantity to produce for the firm is 15 units of output. This is because when the quantity is less than 15 units, the marginal cost of producing the last unit is lower than the price level, and when the quantity is greater than 15 units, the marginal cost of producing the last unit is higher than the price level. So when the quantity is 15 units, the firm is maximizing profit. When the quantity is 15 units, the average total cost (ATC) for the firm is \$5.50 per unit of output, so the total profit is  $(7 - 5.50) * 15 = \$22.50$ .

c. What are the Breakeven and Shutdown prices for this firm?

c. The Breakeven-price for the firm is the price at the minimum of ATC, which is the intersection point of MC and ATC, so for this firm the Breakeven price is \$5. The Shutdown price is the price at the minimum of AVC, which is the intersection point of MC and AVC, so for this firm the Shutdown price is \$3.

d. Assume there are many t-shirts companies in the market that are identical to one another and the market is perfectly competitive. Given this information, what is the long run equilibrium price in this market, and how many t-shirts will each firm produce in the long run?

d. In the long run equilibrium, firms will be making zero profits, so the equilibrium price must be the breakeven price, which is \$5. When the price is \$5, it is optimal for firms to set the quantity level such that  $MC = 5$ . Each firm in this market in the long run will therefore produce 12 t-shirts.

### Part III: Short-Run and Long-Run

3) Consider a perfectly competitive market with a market demand curve given by equation  $P = 4000 - 2Q$  where P is the price per unit and Q is the total quantity in the market. Each firm in the market has the same total cost given by  $TC = 242 + 128q + 2q^2$  where q is the quantity produced by a representative firm. The Marginal Cost for the representative firm is given by the equation  $MC = 128 + 4q$ .

Consider the Short-Run first. Suppose you know that the current short run price in the market is \$200 per unit.

a. What is the market quantity given this short run price?

a. Plug the short run price into the Market Demand equation:

$$200 = 4000 - 2Q$$

$$Q=1900 \text{ units of output}$$

b. What is the representative firm's level of production in this market?

b. To find the short-run level of production recognize first that the market price is the price the firm takes since it is a price-taking firm. The firm's Marginal Revenue curve is given by  $MR = 200$ . To find the firm's level of production you need to equate the firm's MR to the firm's MC. Thus,  $MR = 128 + 4q$  or  $200 = 128 + 4q$  and therefore  $q = 18$  units of output.

c. What is the representative firm's level of profits in the short-run given this market price?

c. The firm's TR = (\$200 per unit)(18 units) = \$3600. The firm's TC =  $242 + 128(18) + 2(18)^2$ . Or, the firm's TC = \$3194. The firm's profits are therefore equal to \$406.

d. Describe the difference between short run and long run economic profits for the firm and give an explanation for why there is a difference between these two economic profits.

d. In the long run the perfectly competitive firm must earn zero economic profits while in the short run it is possible for the firm to earn positive, negative, or zero economic profits. When a perfectly competitive firm earns positive economic profits in the short run this results in entry of firms in the long run until that point where the equilibrium price decreases to the level that leaves the firm earning zero economic profits. When a perfectly competitive firm earns negative economic profits in the short run this results in the exiting of firms in the long run until that point where the equilibrium price increases to the level that leaves the remaining firms earning zero economic profits.

e. Rounding to the nearest whole number, how many firms are operating in the short-run in this market?

e. The total amount produced is  $Q = 1900$  units of output. The amount each firm produces is  $q = 18$  units of output. Therefore, the number of firms is  $1900/18$  is 106 firms (rounded to the nearest whole number).

Suppose now the market is operating in the Long Run. Assume the market demand stays at its initial level.

f. What is the break-even price in the long-run for a representative firm in this industry?

f.  $ATC = TC/q = (242 + 128q + 2q^2)/q$

To find the break-even price, set  $MC = ATC$ .

$128 + 4q = (242 + 128q + 2q^2)/q$ .  $q = 11$ . Now, plug in this quantity into the MC equation to find the break-even price.  $MC = 128 + 4*11 = 172$ . So, the price of \$172 is the break-even price.

g. What is the long-run market quantity in this market?

g. To find this quantity use the market demand curve and the break-even price you have just calculated. Thus,  $P = 4000 - 2Q$  or  $172 = 4000 - 2Q$  or  $Q = 1914$  units of output.

h. How many firms will be in this industry in the long-run?

h. The number of firms in the industry is equal to  $1914/11$  or 174 firms.

#### Part IV: Monopoly

4) Suppose there is a monopolist in the market for cheese curds. The monopolist's marginal cost equation is given by  $MC = 2 + 2Q$  where  $Q$  is the quantity of units of cheese curds. The demand curve is given by  $P = 10 - Q$  where  $P$  is the price per unit of cheese curds.

a. What is the monopolistic price and quantity in the cheese curd market? Show how you found your answer. Find the monopolist's total revenue. Calculate the value of consumer surplus in this market.

a. The profit maximizing quantity for the monopolist is that quantity where  $MC = MR$ . The marginal revenue curve for the monopolist has the same y-intercept as the demand curve and a slope that is twice as steep as the demand curve's slope. Hence,  $MR = 10 - 2Q$ . Therefore, to find the profit maximizing quantity we have:

$$10 - 2Q = 2 + 2Q$$

So  $Q = 2$  units of cheese curds. To find the profit maximizing price, plug 2 into the demand curve function as the optimal quantity and you find that  $P = \$8$  per unit of cheese curds. Total revenue at this profit maximizing price and quantity =  $8 \times 2 = \$16$ . Consumer surplus =  $(10 - 8) \times 2 / 2 = \$2$ .

b. Suppose the monopoly acted as a competitive firm. Find the price and quantity it would sell. Calculate the value of consumer surplus and the value of producer surplus. Note: these numbers are a trifle "ugly": do the math with fractions and it is okay for you to have improper fractions in your answers.

b. For a competitive market,  $P = MC$ . So:

$$2 + 2Q = 10 - Q$$

Or,  $Q = 8/3$  units of cheese curves and  $P = \$22/3$  per unit of cheese curds.

Consumer surplus =  $(10 - 22/3) \times 8/3 \times 1/2 = 4/3 \times 8/3 = \$32/9$ .

Producer surplus =  $(22/3 - 2) \times 8/3 \times 1/2 = 8/3 \times 8/3 = \$64/9$ .

c. Suppose this monopolist implements a first degree price discrimination to increase the monopolist's profits. Calculate the profit when this monopolist practices first degree price discrimination. Again, the numbers are a trifle ugly here: stick with fractions but remember to include your units of measurement!

c. When monopolist practices first degree price discrimination, it captures total surplus as its profit. Profit =  $32/9 + 64/9 = 96/9 = \$32/3$ .

5) Consider a monopolist that sells its product to two different types of buyers. Assume initially that the monopolist is unable to distinguish whether a particular buyer belongs to group A or group B (the two types of buyers). The monopolist knows the following information where  $P$  is the price per unit of output,  $Q_a$  is the quantity provided to group A, and  $Q_b$  is the quantity provided to group B.

Demand for product from group A:  $P = 100 - Q_a$

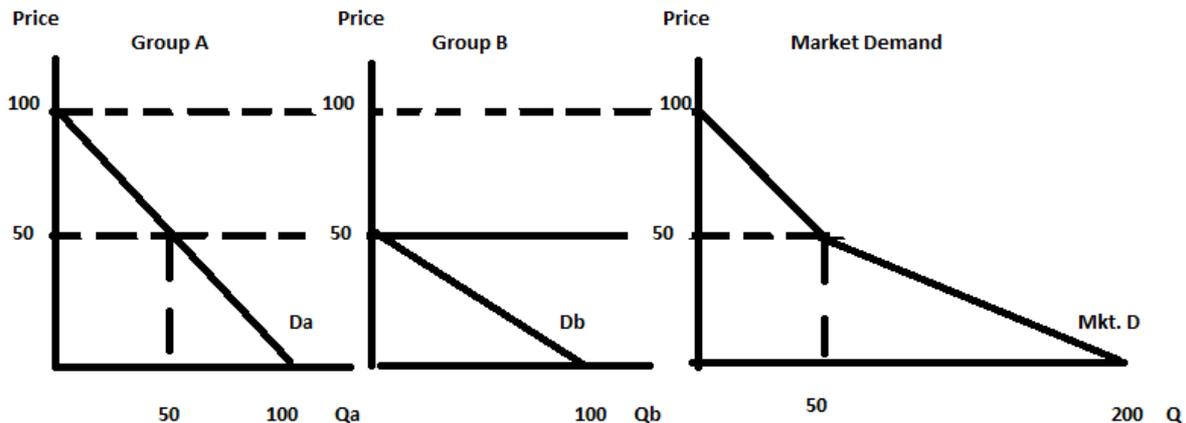
Demand for product from group B:  $P = 50 - (1/2) Q_b$

Marginal Cost =  $MC = \$10$  per unit of output:  $MC = 10$

The average total cost of producing a unit of output is \$10 per unit and constant. There are no fixed costs.

a. Find the market demand curve for this monopolist. This market demand curve will be the horizontal summation of the two group demand curves. Provide all equations and ranges needed to describe this market demand curve. Draw an image that include three horizontally oriented graphs: the first graph the demand of group A, the second graph the demand of group B, and the third graph the market demand curve.

a. Here are the graphs:



There are two segments to the market demand:

for quantities between 0 and 50, the market demand is  $P = 100 - Q$ ;

for quantities between 50 and 200, the market demand is  $P = (200/3) - (1/3)Q$

b. If this firm acts as a single price monopolist, what price will the monopolist charge and how many units will the monopolist produce? What will be the monopolist's profit? Show how you found your answer. The numbers here may not be pretty: it is okay to use improper fractions and I would encourage you to do the work with fractions rather than with decimals!

b. The single price monopolist selects the profit maximizing quantity by producing that quantity where  $MR = MC$  and then goes to the demand curve to find the price it will charge per unit of the good. In this problem, there are actually two marginal revenue curves, so we will need to evaluate which  $MR$  is the relevant one to use.

For the top segment of the market demand curve the  $MR$  curve is given by the equation:  $MR = 100 - 2Q$ . Setting this equal to  $MC$  we get:

$$MR = MC$$

$$100 - 2Q = 10$$

$$90 = 2Q, Q = 45 \text{ units of output}$$

$$P = 100 - Q = 100 - 45 = \$55 \text{ per unit of output}$$

$$\text{Profit} = TR - TC = (45)(55) - (45)(10) = \$2025$$

For the bottom segment of the market demand curve the  $MR$  curve is given by the equation  $MR = (200/3) - (2/3)Q$ . Setting this equal to  $MC$  we get:

$$MR = MC$$

$$(200/3) - (2/3)Q = 10$$

$$200 - 2Q = 30$$

$$170 = 2Q, Q = 85 \text{ units of the good}$$

$P = (200/3) - (1/3)(85) = 115/3 = \$115/3$  per unit of output = approximately \$38.33 per unit of output.

Profit = TR - TC =  $(85)(115/3) - (85)(10) = \$7225/3 =$  approximately \$2408.33

It clearly is far more profitable for this firm to produce  $Q = 85$  units of the good and sell it for \$38.33 per unit of the good.

c. Now, suppose this monopolist can distinguish whether a particular buyer is in group A or group B. That is, this monopolist decides to practice third degree price discrimination. How many units in all will this monopolist produce now? What price will buyers in group A pay and how many units will group A get? What price will buyers in group B pay and how many units will group B get? What will be the value of profits for the firm from group A? What will be the value of profits for the firm from group B? What will be the total value of profits for the third-degree price discriminator? Show your work, but enter your findings in the following table.

<b>Price for group A</b>	
<b>Quantity for group A</b>	
<b>Price for group B</b>	
<b>Quantity for group B</b>	
<b>Profit from sales to group A</b>	
<b>Profit from sales to group B</b>	
<b>Total profit for third degree price discriminators</b>	

c. We already know the total amount of the good the third-degree monopolist will produce: 85 units. The monopolist reasons that this is the profit maximizing amount given the total market demand curve, its MR curve, and its MC curve. The third-degree monopolist must just decide how many of these units are sold to group A and how many are sold to group B.

Let's start with group A: we know that the monopolist perceives its MC as  $MC = 10$ . The firm also knows that group A's MR curve is  $MR = 100 - 2Q_a$  (the firm gets this MR curve the same way every monopolist we have studied gets their MR curve: the same y-intercept and twice the slope of the demand curve). Equating  $MR = MC$ :

$$100 - 2Q_a = 10$$

$Q_a = 45$  units of output

To find the price for group A use the demand curve for group A:

$$P = 100 - Q_a$$

$P_a = 100 - 45 = \$55$  per unit of the good

Profit from group A =  $TR_a - TC_a = (45)(55) - (45)(10) = \$2025$

Now for group B: we know that the monopolist perceives its MC as  $MC = 10$ . The firm also knows that group B's MR curve is  $MR = 50 - Q_b$  (the firm gets this MR curve the same way every monopolist we have studied gets their MR curve: the same y-intercept and twice the slope of the demand curve). Equating  $MR = MC$ :

$$50 - Q_b = 10$$

$Q_b = 40$  units of output

Note: that  $Q_a + Q_b = 45 + 40 = 85$  units of output!

To find the price for group B use the demand curve for group B:

$$P = 50 - (1/2)Q_b$$

$P_b = 50 - (1/2)(40) = \$30$  per unit of the good

Profit from group B =  $TR_b - TC_b = (40)(30) - (40)(10) = \$800$

Total profit for the third-degree price discrimination =  $2025 + 800 = \$2825$

Price for group A	\$55
Quantity for group A	45 units
Price for group B	\$30
Quantity for group B	40 units
Profit from sales to group A	\$2025
Profit from sales to group B	\$800
Total profit for third degree price discrimination	\$2825

d. Does this firm benefit from practicing third degree price discrimination? Write a short paragraph and offer an argument pro or con with respect to this question. Use data to support your position.

d. The third-degree monopolist earns greater profits by selling the good at two different prices than at a single price. As a single price monopolist, the profits are equal to \$2408.33 and as a third-degree monopolist with two different prices the monopolist earns \$2825.

#### Part V: Natural Monopoly

6) There is a natural monopoly in the market for minions driven by Doctor Gru. The marginal cost is constant and equals \$10 per unit of output. The Demand in the market is given by the equation  $P = 100 - Q$  where  $P$  is the price per unit and  $Q$  is the market quantity. The marginal revenue equation for this natural monopoly is given by the equation  $MR = 100 - 2Q$  (pause and see if you understand why this is the equation for the marginal revenue curve for this firm). Average total cost equals \$25 per unit of output at a quantity of 45 units of output and the average total cost curve intersects the Demand curve at the quantity of 80 units of output and a ATC value of \$20 per unit of output.

a. Suppose the natural monopoly is not regulated. Find the price, total output and profit for this natural monopoly when it is not regulated.

a. If the monopolist is not regulated, it produces where  $MR = MC$ .

$100 - 2Q = 10$ , or  $Q = 45$  units of output.

Inserting this quantity into the demand curve, the unregulated price is  $P = 100 - 45 = \$55$  per unit of output.

To calculate the profit, calculate the Total Revenue first:  $TR = 55 * 45 = \$2475$ . Now, calculate the TC:  $TC = ATC * Q = 25 * 45 = \$1125$ . Profit is then equal to  $2475 - 1125 = \$1350$ .

b. Suppose now that the monopoly is regulated so that it breaks even. Find the price, total output and profit of the natural monopoly.

b. If the monopolist is regulated so that it breaks even it will produce where  $ATC = Demand$ . This occurs at the quantity = 80 units of output.

The monopolist will be regulated to charge a price of \$20 per unit of output.

Then, the Total Revenue =  $20 * 80 = \$1600$

The Total Cost =  $ATC * Q = 20 * 80 = \$1600$

So, the profit = \$0 because the monopolist is regulated so that it breaks even.

Part VI: Game Theory

7) Consider the following two-player game. Bart and Liza, who are good friends, are each choosing whether they want to go to the doughnut store or the ice-cream store. Each will make their choice based upon which choice gives them the greatest utility.

a. Find the dominant strategies in the following game. Bart's utility is listed first and Liza's second in each cell of the payoff matrix.

		Liza	
		Ice-Cream Store	Doughnut Store
Bart	Ice-cream Store	3,3	4,6
	Doughnut Store	8,2	0,8

a. Bart has no dominant strategy. Liza's dominant strategy is going to the Doughnut Store. For Liza, no matter what strategy Bart chooses, she will always prefer the Doughnut Store. For Bart, if Liza chooses the ice-cream store, then he prefers the doughnut store; if Liza chooses the doughnut store, then he prefers the ice-cream store.

b. Find the dominant strategies for each player in the following game. Bart's utility is listed first and Liza's second in each cell of the payoff matrix.

		Liza	
		Ice-Cream Store	Doughnut Store
Bart	Ice-cream Store	10,3	4,6
	Doughnut Store	8,2	0,0

b. Bart's dominant strategy is going to the ice-cream store. Liza has no dominant strategy: if Bart is assumed to choose the ice-cream store, then Liza prefers the doughnut store; if Bart is assumed to choose the doughnut store, then Liza prefers the ice-cream store.

c. Find the dominant strategies for each player in the following game. Bart's utility is listed first and Liza's second in each cell of the payoff matrix.

		Liza	
		Ice-Cream Store	Doughnut Store
Bart	Ice-cream Store	3,8	2,3
	Doughnut Store	8,2	0,8

c. Neither Bart or Liza have a dominant strategy in this game.

d. Find the dominant strategies for each player in the following game. Bart's utility is listed first and Liza's second in each cell of the payoff matrix. There is now a third option for both Bart and Liza: they can go to the Apple Store.

		Liza		
		Ice-cream Store	Doughnut Store	Apple Store
Bart	Ice-cream Store	6,1	40,9	5,10
	Doughnut Store	3,15	35,17	0,19
	Apple Store	0,10	7,12	3,14

d. Bart's dominant strategy is go to the ice-cream store. Liza's dominant strategy is go to the Apple Store.

### Part VII: Externality

8) a. Consider the first year PhD office. It is shared by 25 first-year PhD candidates. The office has a big ping-pong table. There is a Ping-Pong tournament going on in the office. Describe the positive and negative externalities related to the situation in the first year PhD office.

a. The negative externality is the noise that distracts from studying in the office. The positive externality is getting exercise and training your eyes after 12 hour day in the office with no windows, making new friendships through sharing an activity, stress relief for the whole group, creating happy memories. There are a lot of potential answers you might have here: the negative externality includes the aspects of this activity that create costs or negative benefits to others; the positive externality includes the aspects of this activity that create positive benefits to others.

b. Suppose the UW Stadium holds games every weekend. Since matches are between different teams from different universities across the country, the number of people coming to see the game is large. Describe the externalities (positive and negative) related to holding the games in Madison.

b. The negative externality is the congestion on roads and the traffic due to the increased number of visitors. Also, parking lots for all the apartment buildings get rented so that people who live there cannot park their cars. The city of Madison reaps lots of positive benefits from this influx of people to see the games: restaurants and hotels have added business, the local governments may collect taxes and fees from visitors, people may visit Madison and decide it is a beautiful place to live and work. There are many potential answers to this question.

9) Consider a market where a good is produced in such a way that it generates significant pollution. Currently the companies producing the good do not pay the cost of this pollution that they create: for example, imagine that the companies create really toxic water that they simply discharge into the economy's water supply. This market can be described by the following equations:

Marginal Social Benefit Curve (MSB):  $P = 1000 - 3Q$

Marginal Private Cost Curve (MPC):  $P = 100 + 2Q$

Externality Cost per unit of the good produced = \$100 per unit

a. Given the above information, how much of this good will be produced in this market and what price will the good sell for? What is the total cost of the externality generated by this good to this economy? Show your work.

a. To find the market quantity and market price, we equate  $MSB = MPC$ :

$$1000 - 3Q = 100 + 2Q$$

$$Q = 180 \text{ units of the good}$$

$$P = 1000 - 3Q = 1000 - 3(180) = \$460 \text{ per unit of the good}$$

$$\text{Cost of the externality} = (180 \text{ units of the good})(\$100 \text{ per unit of the good}) = \$1800$$

b. If this market were regulated so that the externality was internalized, that is, if the companies had to cover all of their costs of production including pollution, how many units of the good would be produced (the socially optimal amount of the good)? What price would the product sell for under these circumstances?

b. To find the socially optimal amount of the good, we equate  $MSB = MSC$ :

$$1000 - 3Q = 200 + 2Q$$

$$Q_{\text{socially optimal}} = 160 \text{ units of the good}$$

$$P_{\text{socially optimal}} = 1000 - 3(160) = \$520 \text{ per unit of the good.}$$

c. If the government levied an excise tax in order to internalize this externality, what would be the optimal amount per unit for this excise tax?

c. If the excise tax per unit equaled the size of the externality cost per unit the market would produce the socially optimal amount of the good. That is, the excise tax should be \$100 per unit of the good.

d. Quantity the deadweight loss (DWL) to society from having this market fail to correct the externality. Show your work.

$$d. DWL = (1/2) \cdot b \cdot h = (1/2)(520 - 420)(180 - 160) = (1/2)(100)(20) = \$1000$$

10) Consider a market composed of two individuals: Bob and Sue. They both enjoy public parks and recognize that public parks are a good example of a public good. You have the following information about Bob and Sue's demands for this good and the cost of providing this good:

$$\text{Bob's demand for public parks: } P = 100 - 2Q$$

$$\text{Sue's demand for public parks: } P = 60 - 2Q$$

$$\text{Marginal Social Cost (MSC) of providing public parks: } MSC = \$20 \text{ per park}$$

a. What does it mean for a good to be non-rival? Use your own words and provide at least one example of a good that is non-rival.

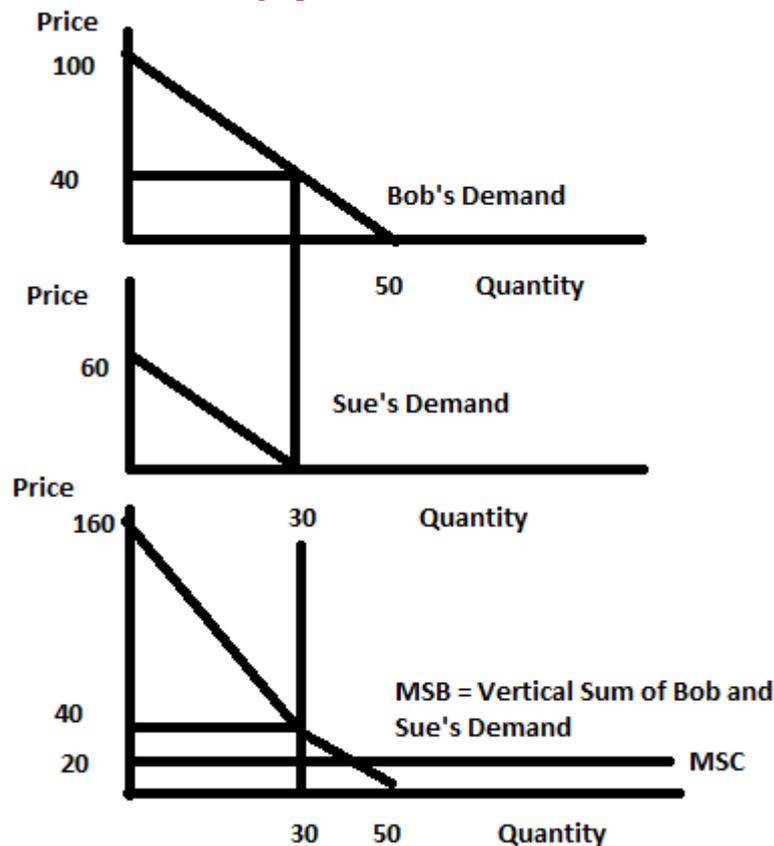
a. A good is non-rival if another person can consume the same unit at the same time without a reduction in benefits to either of the consumers. For instance, you and I are non-rivals with regard to radio signals: you can listen to the radio signal at the same time as I do and neither of us is impacted by the other one's consumption of the good. We are non-rivals.

b. What does it mean for a good to be non-excludable? Use your own words and provide at least one example of a good that is non-excludable.

b. A good is non-excludable if you can enjoy consuming the good even if you do not pay for it. I can enjoy the benefits of a tornado siren even if I did not contribute to paying for the siren. I may be visiting a community when the siren goes off: I still get the benefits of the siren even though I did not pay for it.

c. Find the market demand curve (the Marginal Social Benefit, MSB) and the marginal social cost (MSC) for the public good. For the MSB curve, this will require you to vertically sum the two individual demand curves. Draw a diagram with a graph of Bob's demand curve, another graph directly below this for Sue's demand curve, and a third graph directly below this for the market demand curve. For each quantity of the public parks add together the price that Bob is willing to pay and the price that Sue is willing to pay. Once you have gotten the graphs done, then write the equation or equations for the MSB. Provide the relevant ranges if there are multiple equations.

c. Here's the set of graphs:



The MSB curve is composed of two linear segments. The top segment for quantities less than or equal to 30 units is given by the equation:  $MSB = 160 - 4Q$ . The lower segment for quantities between 30 units and 50 units is given by the equation:  $MSB = 100 - 2Q$ .

d. Find the socially optimal amount (where  $MSB = MSC$ ) of public parks. Then determine the price that Bob will pay per park and the price that Sue will pay per park. Show your work.

d. The socially optimal amount occurs where  $MSB = MSC$ . Thus,

$$100 - 2Q = 20$$

$Q_{\text{socially optimal}} = 40$  public parks

When  $Q = 40$ , Sue is unwilling to pay anything. That's too many parks for her! So  $P_{\text{sue}} = \$0$  per public park. When  $Q = 40$ , Bob is willing to pay  $P_{\text{bob}} = 100 - 2Q = 100 - 2(40) = \$20$  per public park, which is exactly what the marginal social cost of providing a public park is!

e. Suppose that the MSC changes to  $MSC' = \$48$  per public park. What is the new social optimal amount of public parks? What price will Bob pay per park and what price will Sue pay per park? Show your work.

e. The socially optimal amount occurs where  $MSB = MSC'$ . Notice that we now have to use the top segment of the MSB curve. Thus,

$$160 - 4Q = 48$$

$$4Q = 112$$

$Q_{\text{socially optimal}} = 28$  public parks

$P_{\text{sue}} = 60 - 2Q = 60 - 2(28) = \$4$  per public park

$P_{\text{bob}} = 100 - 2Q = 100 - 2(28) = \$44$  per public park

Note: Bob is going to pay more per public park because Bob values public parks more than does Sue. Notice also that the sum of what Bob pays per park and what Sue pays per park is equal to the marginal cost of providing the public park.