Final Exam - Solutions

You have until 5pm to complete the exam, be certain to use your time wisely. Answer all questions directly on the exam. You must show all of your work to receive full credit. Non-graphing calculators may be used. You may leave answers as fractions. Unless a problem says otherwise, you can assume that firms can produce fractions of units and charge non-integer prices (so a firm could produce 82.4 units and sell at a price of $5.325 per unit). Remember to put your name on the exam. Good luck!

Name: **ID Number:**

1. (10 points) There is one electric company providing power to a small town. The town is tyring to determine how to best regulate the electric company.

   (a) Why might it be efficient to allow the electric company to have a natural monopoly rather than having multiple companies providing electricity to the town? Be certain to fully explain your answer.

   > The provision of electricity is likely to involve high fixed costs for infrastructure and building power plants. Once these investments in fixed costs are made, marginal costs will be fairly low. This suggests that for an individual electric company average costs will be high initially and then gradually fall as the number of customers increases. Declining average costs imply that it is cheaper to have one firm serve all of the customers than to split the customers among multiple firms. To put this in more algebraic terms:
   >
   > $$\frac{dAC(y)}{dy} < 0$$
   >
   > Therefore, for any n greater than one:
   >
   > $$AC(y) < AC(\frac{y}{n})$$
   >
   > $$y \cdot AC(y) < y \cdot AC(\frac{y}{n})$$
   >
   > $$y \cdot AC(y) < \sum_{i=1}^{n} \frac{y}{n} \cdot AC(\frac{y}{n})$$
   >
   > The expression on the left gives total cost of serving y customers with a single firm. The expression on the right gives the total cost of serving y customers when splitting the demand evenly across $n > 1$ firms. Clearly total cost is lower when using a single firm. So the same number of customers could be served at a lower total cost using a single firm. Reducing costs while holding everything else constant will increase total surplus, making the outcome more efficient. Of course this greater efficiency may not be realized if the single firm is allowed to price like a monopolist.

(b) Suppose that the local government can observe all of the electric company's costs. The government decides to regulate the prices the electric company charges with traditional rate-of-return regulation. Prices are set such that the electric company can cover its costs and receive a 5% return on its investments. Prices are adjusted frequently by the government to maintain the 5% return. Explain why adjusting the prices less frequently might lead to more efficient outcomes.

> The issue is the incentives for the electric company to reduce its costs. With frequent price adjustments, any cost reductions made by the firm will quickly lead to the government lowering prices. The firm doesn't get to take advantage of higher returns from cost saving measures and therefore has no incentive to try to reduce costs. If price adjustments occur less frequently, the firm will be able to realize a higher rate of return from cost reductions for a longer period of time (up until the next price adjustment). Therefore the firm would have incentives to lower costs and operate more efficiently.

2. (15 points) There is a local factory that currently has no pollution controls at all and emits 500 units of pollution from its smokestacks. The factory can reduce the amount of pollution it emits by installing smokestack scrubbers. The more the firm spends on these scrubbers, the greater the reduction in pollution. The firm's marginal costs of reducing pollution by one more unit are given by the following marginal cost function:

$$MC(R) = \frac{1}{10}R \tag{1}$$

where R is the total reduction in pollution. Each unit of pollution produces $10 of harm to the community.

(a) Suppose the local government decides to use fines to get to the factory to reduce pollution. The firm must pay an amount F per unit of pollution. If the government sets the fine at $20 per unit of pollution, how much will the firm spend on reducing pollution and how many units of pollution will the firm still produce?

The firm will reduce pollution up to the point where the marginal cost of a further reduction would exceed the fine for a unit of pollution. Beyond this point, it would be cheaper to pollute and pay the fine rather than spend money on pollution reductions. To find this point where the firm stops investing in pollution controls and starts polluting, we can simply set the marginal cost of pollution reductions equal to the fine:

$$MC(R) = F$$

$$\frac{1}{10}R = 20$$

$$R = 200$$

If the firm is reducing its pollution by 200 units, it means that it is still producing 300 units of pollution $(500 - R)$. The total cost of the pollution reductions will be equal to the area under the marginal cost curve over those 200 units of reductions:

$$C(R) = \frac{1}{2}(MC(200) - MC(0))(200 - 0)$$

$$C(R) = \frac{1}{2}(20 - 0)(200 - 0)$$

$$C(R) = 2000$$

(b) Is a fine of $20 efficient? If so, explain way. If not, calculate the deadweight loss generated by setting F at $20 rather than its socially efficient level.

The fine is clearly not efficient. It led to reductions in pollution for which the marginal cost of reduction exceeded the marginal benefit. The efficient level of reductions would be where the marginal cost of reduction exactly equals the marginal benefit of $10:

$$MC(R) = MB(R)$$

$$\frac{1}{10}R = 10$$

$$R = 100$$

All of the reductions in pollution between 100 and 200 units of reduction are generating a deadweight loss. The size of this deadweight loss is equal to the area between the marginal benefit and marginal cost curves between $R = 100$ and $R = 200$:

$$DWL = \frac{1}{2}(MC(200) - MB(200))(200 - 100)$$

$$DWL = \frac{1}{2}(20 - 10)(200 - 100)$$

$$DWL = 500$$

(c) Suppose that the government was choosing between using a fine and a standard (specificying the exact amount of pollution the factory can produce) to achieve the efficient level of pollution. Which of these two approaches would the firm prefer? Fully explain your answer. Assume that both the fine and the standard would be set correctly to achieve the efficient level of pollution.

Both approaches would lead to the same reductions in pollution and therefore the same total costs to the firm of pollution controls. The one difference between them is that under the fine, the firm will have to pay an additional amount on top of the pollution controls to pay the fine associated with the remaining units of pollution. Under the standard, the firm does not have to pay anything for these units of pollution. The difference between the two is therefore simply a transfer from the firm to the government in the case of the fines that doesn't take place in the case of the standard. Clearly the firm would prefer the standard and not having to make this transfer to the government.

3. (15 points) There are two gas stations in town. Both gas stations have no fixed costs and constant marginal costs equal to $1 per gallon of gasoline sold. Demand for gasoline in the town is given by the following demand function:

$$D(p) = 100 - 50p \tag{2}$$

where $D(p)$ is the number of gallons of gasoline demanded at a price of p per gallon. In the absence of any collusion, the two gas stations compete by posting prices. The gas station posting the lower price gets all of the demand. If they post the same price, they split demand evenly.

(a) Suppose that the two firms decide to collude, agreeing on a price that they will both charge and then splitting demand evenly between them. What price will they charge and what will the profits per firm be?

The two firms will seek to maximize total profits. This occurs at the monopolist's price. To find this price, we first need to find the monopolist's marginal revenue curve. One approach is to recognize that the marginal revenue curve has the same intercept as the inverse demand curve but a slope that is twice as steep:

$$D(p) = 100 - 50p$$

$$g = 100 - 50p(g)$$

$$p(g) = 2 - \frac{1}{50}g$$

$$MR(g) = 2 - \frac{1}{25}g$$

A more formal way to do this is to derive the marginal revenue function from the total revenue function:

$$R(g) = g \cdot p(g)$$

$$R(g) = g(2 - \frac{1}{50}g)$$

$$R(g) = 2g - \frac{1}{50}g^2$$

$$MR(g) = \frac{dR(g)}{dg} = 2 - \frac{1}{25}g$$

Now that we have the marginal revenue function, we can find the monopoly quantity and price:

$$MR(g) = MC(g)$$

$$2 - \frac{1}{25}g = 1$$

$$\frac{1}{25}g = 1$$

$$g = 25$$

$$p(25) = 2 - \frac{1}{50} \cdot 25$$

$$p(25) = \frac{3}{2}$$

The two firms will split the quantity of 25 evenly. So each firm will sell 12.5 gallons of gas at \$1.50 a gallon. Individual firm profits will be:

$$\pi = g \cdot (p(g) - AC(g))$$

$$\pi = \frac{25}{2} \cdot (\frac{3}{2} - 1)$$

$$\pi = \frac{25}{4}$$

(b) Explain why the outcome in part (a) is inefficient, using specific numbers if possible.

Notice that for every gallon of gasoline between the 25 gallons sold and efficient quantity of 50 gallons (where $p(g) = MC(g)$), the marginal benefit exceeds the marginal cost. An easy way to see this is that the demand curve lies above the marginal cost curve over that entire range. Producing these additional gallons of gasoline would therefore lead to a net increase in total surplus, implying that 25 gallons was not the efficient level of gasoline.

(c) The government decides to make this act of collusion illegal. If the firms get caught colluding, they will have to pay a fine equal to F and forfeit any profits they earned through collusion. The government can spend money on monitoring to increase the probability of catching the firms colluding. The probability of catching the firms as a function of M, the amount of money spent on monitoring, is:

$$p(M) = \frac{1}{1 + (\frac{1}{2})^M} \tag{3}$$

Write down an expression giving an individual firm's expected profits from colluding as a function of M and F.

We know from part (a) that if the firms collude and are not caught, the profits of an individual firm will be $\frac{25}{4}$. So the expected profits of collusion will be these profits multiplied by the probability of not getting caught plus the profits when the firm is caught multipled by the probability of getting caught:

$$E(\pi) = (1 - p(M))\frac{25}{4} + p(M)(-F)$$

$$E(\pi) = (1 - \frac{1}{1 + (\frac{1}{2})^M})\frac{25}{4} - \frac{1}{1 + (\frac{1}{2})^M}F$$

(d) At the government's current choice of M and F, both M and F are positive but no firms are being caught despite collusion taking place. How would you recommend the government adjust M and F? Be certain to fully explain your answer.

If the firms are still choosing to collude, it means their expected profits from collusion must be positive (they would earn zero profits if they choose not to collude). To prevent collusion, the government needs to adjust M and F to reduce these expected profits from collusion to the point where they become negative. This could be done by increasing M, increasing F or increasing both. Increasing M is costly while increasing F is not, so it makes sense to increase F to the point where expected profits become negative. However, the government can do even better than this. Notice that even if the government spends no money on monitoring, the probility of catching colluding firms is still $\frac{1}{2}$. The government could drop monitoring costs down to zero and still catch colluding 50% of the time. The government could then set the fine at anything greater than $\frac{25}{4}$ to stop the firms from colluding without spending any money on monitoring.

4. (10 points) Suppose that there are two firms polluting the local water supply. A regulator decides to control pollution by issuing permits to the firms. The permits a firm holds determine the amount of pollution the firm can produce. If a firm has n permits, it is allowed to produce no more than n units of pollution.

   (a) Explain why letting the firms trade permits should lead to a more efficient outcome than not allowing the firms to trade permits.

   > If firms are allowed to trade permits, they will be traded from the firm with high marginal costs of pollution reduction to the firm with low marginal costs of pollution reduction. A firm with high marginal costs is willing to pay anything up to those marginal costs to get another permit, a firm with low marginal costs is willing to accept any amount above its marginal costs to give up a permit so a deal can be made. This trading of permits will lead to the same overall reduction in pollution, meaning the same overall benefits to the environment, as when permits are not tradeable but at a lower cost to the firms. Achieving the same benefits at lower overall costs implies a more efficient outcome.

   (b) Explain why allowing firms to trade permits is not a sufficient condition for ensuring that the efficient level of pollution reductions takes place.

   > Trading permits will lead to the most efficient allocation of a given number of permits but that does not mean that the total number of permits is efficient. To achieve the efficient level of pollution, the total number of permits has to be set such that the firms' marginal costs of pollution reductions are equal to marginal benefits of pollution reductions once the permits have been allocated and traded.

5. (15 points) The demand for lawnmowers (L) is given by the following inverse demand function:

$$p(L) = 100 - \frac{1}{10}L \tag{4}$$

A firm's marginal cost of producing an additional lawnmower is \$20. Every extra lawnmower in use produces both air and noise pollution. The marginal costs of these forms of pollution to society get worse as the number of lawnmowers increases. The marginal costs of the pollution to the community are given by the following function:

$$MC_{\text{poll}} = \frac{1}{10}L \tag{5}$$

where L is the total number of lawnmowers in use.

(a) In the absence of any government regulation, how many lawnmowers will be sold and what will the total cost of pollution to the community be from those lawnmowers? Assume that the market for lawnmowers is competitive.

Given that the market for lawmowers is competitive, the equilibrium will be where the firms' marginal costs intersect the demand curve:

$$p(L) = MC_{\text{firm}}(L)$$

$$100 - \frac{1}{10}L = 20$$

$$\frac{1}{10}L = 80$$

$$L = 800$$

So 800 lawnmowers will be sold. The total environmental costs of these lawn-mowers will be equal to the area under the MC_{poll} curve up to a quantity of 800:

$$C_{\text{poll}}(800) = \frac{1}{2}(MC_{\text{poll}}(800) - MC_{\text{poll}}(0))(800 - 0)$$

$$C_{\text{poll}}(800) = \frac{1}{2}(80 - 0)(800 - 0)$$

$$C_{\text{poll}}(800) = 32000$$

(b) What is the socially efficient number of lawnmowers?

The socially efficient number of lawnmowers will be where the demand curve intersects the social marginal cost curve, which includes both the firm's marginal costs and the marginal costs from the pollution:

$$p(L) = MC_{\text{social}}(L)$$

$$p(L) = MC_{\text{firm}}(L) + MC_{\text{poll}}(L)$$

$$100 - \frac{1}{10}L = 20 + \frac{1}{10}L$$

$$\frac{1}{5}L = 80$$

$$L = 400$$

Notice that the socially efficient quantity is smaller than the equilibrium quantity found in part (a).

(c) If a regulator wanted to use a quantity tax to achieve the efficient number of lawnmowers, what should the size of the quantity tax be? Assume that the quantity tax is placed on producers.

The quantity tax should be equal to the difference between the social marginal cost and the firm's marginal cost at the socially efficient quantity. This way the tax will shift the firm's marginal cost curve up to intersect the demand curve at the socially efficient quantity. We already found the socially efficient quantity of 400 in the previous part, now we just need to calculate the difference between the firm marginal cost and social marginal costs at that quantity:

$$t = MC_{\text{social}}(400) - MC_{\text{firm}}(400)$$

$$t = (MC_{\text{firm}}(400) + MC_{\text{poll}}(400)) - MC_{\text{firm}}(400)$$

$$t = MC_{\text{poll}}(400)$$

$$t = \frac{1}{10} \cdot 400$$

$$t = 40$$

6. (10 points) Currently, the patent length for a new drug is 20 years. If the patent length were increased to 30 years, explain what you would expect to happen to:

   (a) Levels of research and development in the pharmaceutical industry

   (b) Consumer surplus in the pharmaceutical market

   Be certain to discuss all of the effects on these quantities, not just the net effect. So if consumer surplus increases for one reason but decreases for another, discuss both reasons even if the effects cancel each other out.

   > With longer patents, firms will receive monopoly profits from a new drug for a longer period of time, increasing the total expected profits from engaging in research and development. These increased incentives for research and development activities will lead to an increase in the level of research taking place.

   > For consumers, consumer surplus will decrease because consumers will face high monopoly prices on drugs for a longer period of time before generics can compete, bringing down price and increasing quantity. However, consumer surplus will potentially increase if the higher levels of research and development lead to new drugs that otherwise would never be created. These new drugs would provide consumers with surplus, even at high monopoly prices, that they would not have if the drugs were never created.

7. (15 points) Suppose that two internet providers, firm A and firm B, are bidding to win an exclusive franchise to provide internet access to Williamsburg. Bidding works in the following way. The government announces a high price per customer. If both firms are willing to provide service at that price, the government lowers the price by \$1 and once again sees if both firms will provide service at that price. This continues until one firm drops out. The remaining firm wins the franchise. The lowest price at which both firms would provide service is the price that the winning firm must charge. The firm must meet whatever the customer demand is at that price.

Firm A has high fixed costs for its proposed infrastructure but then low marginal costs of adding additional customers. Firm B has lower fixed costs ($FC_B < FC_A$) but higher marginal marginal costs than firm A ($MC_A < MC_B$). Both firms have constant marginal costs. The demand curve for internet service is linear and downward sloping. On a graph with price on the vertical axis and number of internet customers on the horizontal axis, show the following (be certain to clearly label everything on the graph):

(a) The average cost and marginal cost curves for both firms

(b) The demand curve

(c) The price and quantity of internet service that will result from the bidding process

(d) The efficient quantity of internet service

(e) The deadweight loss generated by being at the price and quantity resulting from the bidding process

There are two ways that you could have drawn this graph depending on whether the intersection of the two average cost curves occurred to left or to the right of where the average cost curves intersect the demand curve. Graphed below is the case where the intersection of the average cost curves occurs to the left of the intersection of these curves with the demand curve. Graphing the other way is also perfectly correct and would receive full credit.

There are several key features of the graph. First, both marginal cost curves should be horizontal lines with the marginal cost curve for firm A being below the marginal cost curve of firm M. Second, both average cost curves should start high and then approach their respective marginal cost curves (since marginal cost is constant, average variable cost is the same as marginal cost in this case and the average cost curve always approaches the average variable cost curve as quantity gets large). The average cost curve for firm A should initially be above the average cost curve of firm B due to firm A's higher fixed costs.

The bidding process will end when the price drops to the point where the higher average cost curve intersects the demand curve. This is shown on the graph as the point (y_{bid}, p_{bid}). Below this price, firm B would drop out of the bidding process as they would be losing money. So firm A will win the franchise and serve y_{bid} customers at a price of p_{bid}. However, the marginal benefits to consumers beyond y_{bid} exceed the marginal costs of firm A all the way up to y_{eff}. By not serving these additional customers, there is a deadweight loss generated equal to the shaded area on the graph.

price

p_{bid}

p_{eff}

DWL

$AC_B(y)$

$MC_B(y)$

$AC_A(y)$

$MC_A(y)$

$p(y)$

y_{bid} y_{eff} customers
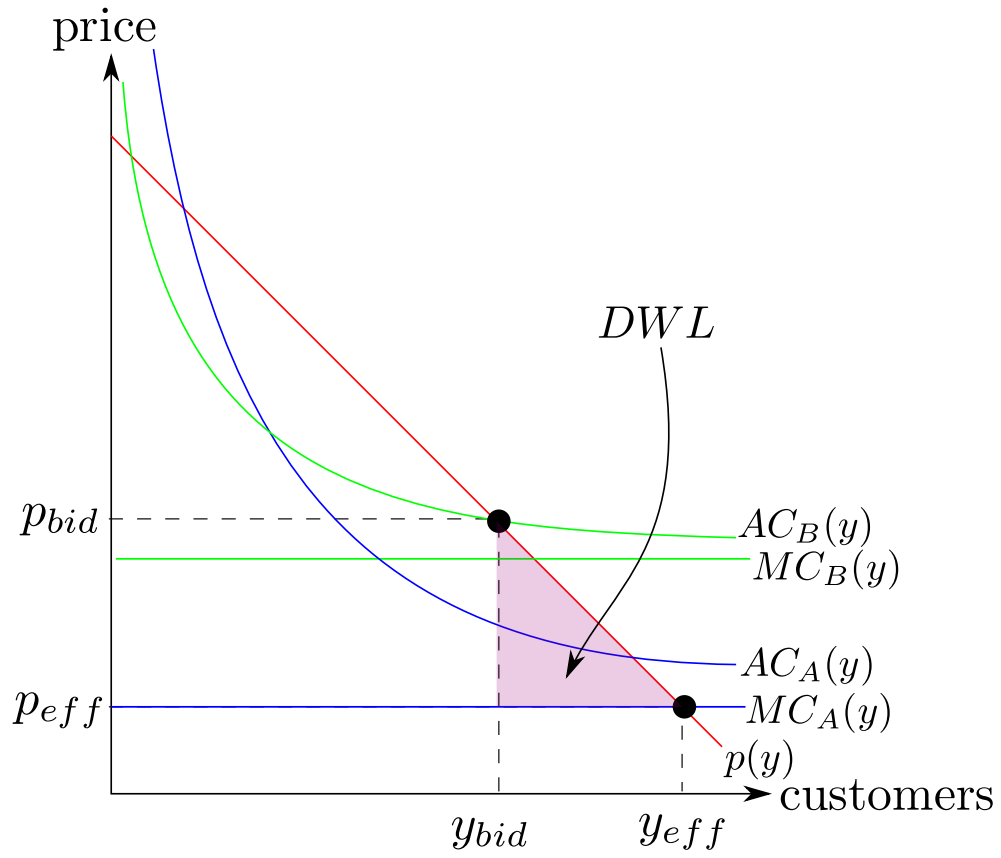
8. (10 points) Below are essay questions related to the group projects. Choose one and only one question to answer. You may not choose a question related to the topic that you presented.

> For all of the essay questions, there are multiple ways to answer the question correctly and receive full credit. Below I will simply highlight a few key points to keep in mind with each question.

(a) Explain two different ways that higher auto safety standards could be achieved, only one of which should be related to direct regulation of the industry by the government. Which of these two ways would you expect to lead to the most efficient outcome? Be certain to fully explain your answer.

> Among the things you could have discussed were simply market forces leading to higher safety standards (manufacturers competing with each other on safety features to attract customers) and the use of lawsuits (where the threat of paying large settlements could induce manufacturers to maintain higher safety standards). When discussing which of your proposed ways to achieve higher standards is more efficient, you should argue for which one would get the manufacturers closest to the level of saftey standards at which the marginal cost of making cars safer is just equal to the marginal benefit to consumers of that extra safety.

(b) Why might granting exclusive franchise rights to a cable television provider lead to inefficient outcomes compared to allowing free entry of firms into the cable television market? Your answer should cover inefficiencies generated by the franchise bidding process itself and by the level of service provided after that bidding process has been completed.

> The bidding process can lead to excessive money spent on lobbying to win the franchise and the promising of perks and investments of interest to local officials but of questionable value to society. Once an exclusive franchise is granted, there is no competition to provide incentives for the cable company to provide high quality customer service, fix outages quickly, etc.

(c) Suppose that Williamsburg introduced a living wage law, setting a minimum local wage based on the poverty line. Discuss how the introduction of this law would affect the efficiency and equity of the local labor market.

> Your answer should address the potential problem of having workers willing to work for a wage less than the living wage and employers willing to pay that wage but not willing to pay the living wage. The pairing of these workers and employers would not happen under the living wage regulations even though it would generate surplus. As for equity, your answer should consider that some workers will earn higher wages than in the absence of the living wage, employers will be paying higher wages than in the absence of the living wage, and a subset of workers will potentially lose their jobs that they had before the living wage was introduced.

(d) Provide one argument for and one argument against Dominion Virginia Power being allowed to charge fees to customers who install solar power systems.

An argument for charging fees is that those customers still benefit from the infrastructure paid for by Dominion Virginia Power and without the fees, Dominion Virginia Power would be unable to recoup the costs of its investments. An argument against the fees would be that they discourage the use of alternative energy sources. Reducing the incentives to explore alternative energy sources could lead to inefficient outcomes in the long run by reducing innovation.

(e) Provide an argument for whether Google should or should not be allowed to keep its search results algorithm secret. Your argument should focus on economic efficiency.

Your argument needs to address some aspect of why keeping the algorithm secret either leads to an inefficient reduction in economic activity (fewer searches, fewer alternative search engines, less innovation because either firms can't improve on Google's model, etc.) or helps maintain efficient levels of economic activity (promoting Google's incentives to innovate, forcing other firms to innovate rather than rely on Google's technology, etc.).

(f) Suppose that a lobbyist for the online gambling industry makes the following claim:

"People choose to gamble online because it increases their utility; they wouldn't make bets if it didn't provide them with some benefit. Restricting their ability to gamble would therefore lead to an inefficient outcome."

Do you agree or disagree with this statement? Be certain to fully explain your answer.

If you think that gamblers are fully informed and actually making correct calculations about their expected utility from gambling, then preventing them from gambling is preventing economic activity that provides both parties (gambler and website) with benefits. This would indeed be inefficient. You could argue against this by discussing gamblers not being fully informed, not properly calculating their odds, being subject to addiction and so on in ways that mean they aren't actually maximizing their utility by gambling.

(g) In class we discussed the reasons for blocking mergers that lead to a firm controlling too large a share of a market and for preventing collusion among firms. Given these reasons, why does the government allow sports teams to effectively collude with one another?

One possible reason to allow teams to collude is that there are a variety of unique aspects to sports that require teams to cooperate more than firms in other industries. Teams need to be able to agree on schedules, they need to agree to rules for how games will be played, and so on. Without some level of cooperation, a sports league could not function. Typical firms do not face these types of coordination issues.