Suggested Solutions Midterm

Part A: Numerical Questions

1- MC(Q) = 20 + 3Q ; MB(Q) =120 – 2Q ; MSB(Q) = 120 – Q.

a) **Socially optimal level of output (Q*):** MSB(Q) = MC (Q) => 120 – Q = 20 + 3Q => Q* = 25

b) **Competitive equilibrium output (Qc) :** MB(Q) = MC(Q) => 120 – 2Q = 20 + 3Q => Qc = 20

Competitive equilibrium price (Pc): MC(Qc) = > 20 +3(20) => Pc = 80

Deadweight loss (DWL): $\int_{20}^{25}[MSB(Q) - MC(Q)]dQ = \int_{20}^{25}[100 - 4Q]dQ = 100Q - 2Q^2\Big|_{20}^{25} = 50$

c) **Consumer surplus (CS)** : $\int_{0}^{20}[MB(Q) - Pc]dQ = \int_{0}^{20}[(120 - 2Q) - 80)]dQ = 40Q - Q^2\Big|_{0}^{20} = 400$

Producer surplus (PS) : $\int_{0}^{20}[Pc - MC(Q)]dQ = \int_{0}^{20}[80 - (20 + 3Q)]dQ = 60Q - \frac{3}{2}Q^2\Big|_{0}^{20} = 600$

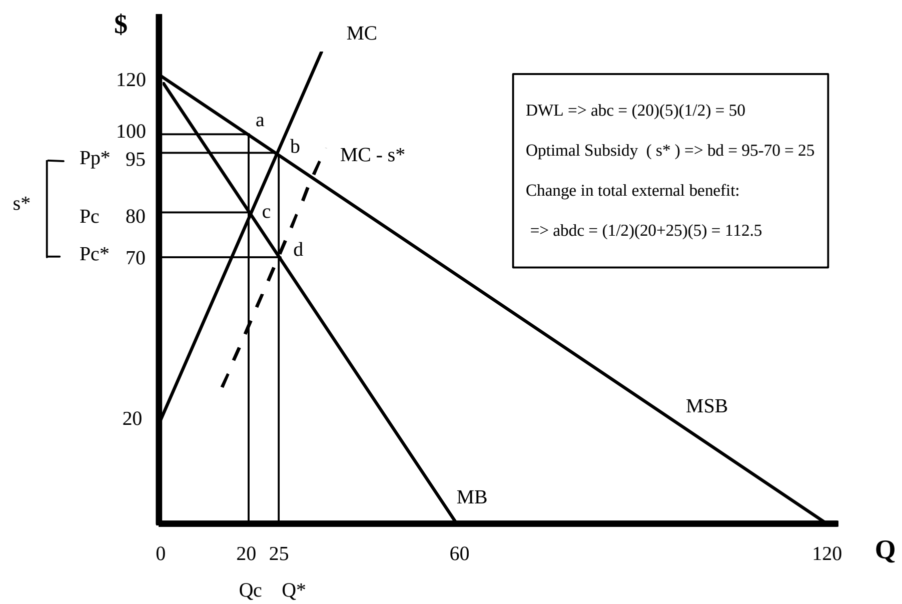
d) **Optimal unit subsidy (s*):**

MC(Q*) - s* = MB(Q*) => s* = MC (Q*) - MB(Q*) => s* = [20 + 3(25)]- [120 - 2 (25)] = 25

e) **Marginal external benefit:**

MEB(Q) =[MSB(Q) - MB(Q)] = (120 - Q) - (120 - 2Q) = Q => MEB(Q) = Q

Change in the total external benefits: $\int_{20}^{25}MEB(Q)dQ = \int_{20}^{25}QdQ = \frac{1}{2}Q^2\Big|_{20}^{25} = 112.5$



2-

Individual Demand	Income Group	# of individuals in income group
$P_h = 40 - q$	High	3
$P_L = 20 - q$	Low	2

Aggregate demand of the "low income" group => $AD_L = 2\,P_L = 2\,(20\text{-}q) = 40 - 2\,q.$

Aggregate demand of the "high income" group => $AD_h = 3\,P_h = 3\,(40\,\text{-}q) = 120\text{-}\,3q.$

Aggregate demand for the public good => $AD = \begin{cases} 120 - 3q & \text{if } q \geq 20 \\ 160 - 5q & \text{if } q < 20 \end{cases}$

Marginal cost => $MC = 5q$

a) **Efficient output level (q*):** $AD = MC \Rightarrow 160 - 5q = 5q \Rightarrow q^* = 16$

b) **Total cost of providing q* (TC):** $\int_0^{16} MC(q)dq = \int_0^{16}(5q)dq = \frac{5}{2}q^2\Big|_0^{16} = 640$

c) **Minimum uniform fee (F_{min}):**

The minimum uniform fee that just covers costs is $\dfrac{\text{Total Cost}}{\#\text{ of people}} = \dfrac{640}{5} = 128$

Consumer surplus of a typical "low income" person:

The consumer surplus (CS) of any individual is equal to the maximum total willingness to pay (WTP) for an amount of a good, minus the uniform fee (F_{min}) that the person has to be pay for it. Thus, for a typical person in the "low income" group, the maximum willingness to pay for q*=16 is

$$WTP_L = \int_0^{16} P_L(q)\,dq = \int_0^{16}(20 - q)dq = 20q - \tfrac{1}{2}q^2\Big|_0^{16} = 192$$

Similarly, for a typical person in the "high income" group, the maximum willingness to pay for q*=16 is

$$WTP_h = \int_0^{16} P_h(q)\,dq = \int_0^{16}(40 - q)dq = 40q - \tfrac{1}{2}q^2\Big|_0^{16} = 512$$

Hence, the consumer surplus for a typical person in the "low income" group is

$CS_L = WTP_L - F_{min} = 192 - 128 = 64$

and the consumer surplus of a typical person in the "high income" group is

$CS_H = WTP_h - F_{min} = 512 - 128 = 384$

d) **Maximum uniform fee w/o exclusion (F_{ne}):**

The maximum uniform fee a concessionaire could charge without excluding anybody is equal to the willingness to pay of a typical person in the "low income" group.

$F_{ne} = WTP_L = 192$

Concessionaire's profits under the uniform fee F_{ne}: $\pi_{ne} = 5(192) - 640 = 320$

e) **Profit maximizing uniform fee (F*):**

Does the uniform fee of $F_{ne} = 192$, obtaining $\pi_{ne} = 320$, maximize profits?

Let's consider the case in which the concessionaire charges a uniform fee equal to the willingness to pay of a typical person in the "high income group". Thus, the uniform fee is F_e = WTPh = 512.

Note that with this fee, individuals in the low income group (two individuals) will be excluded from the market because their maximum individual willingness to pay is only 192.

Consequently, the concessionaire's profits under this fee are $\pi_e = 3(512) - 640 = 896$

Since $\pi_{ne} < \pi_e$, the concessionaire is better off by charging F_e instead of F_{ne} .

However, are $\pi_e = 896$ the maximum profits that the concessionaire could have?

The answer is no. Note that since the concessionaire knows that the "low income" group is going to be excluded anyway, the firm finds a new equilibrium quantity without taking into consideration the aggregate demand of the "low income" group. Thus, the new equilibrium quantity is

$AD_h = MC \Rightarrow 120 - 3q = 5q \Rightarrow q = 15$.

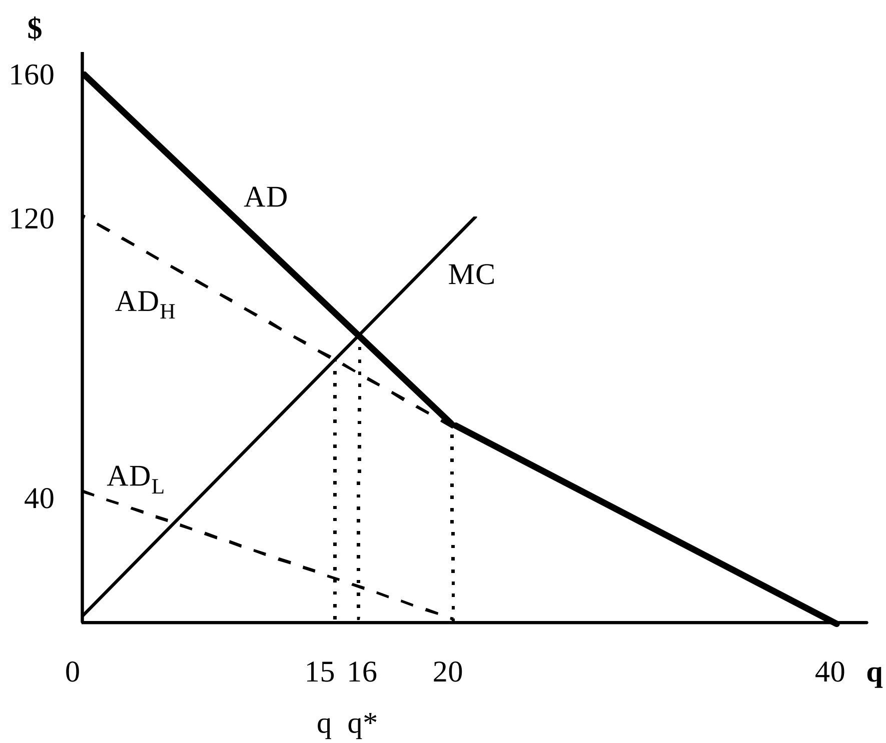
The total cost of producing q =15 is $\int_0^{15} MC(q)dq = \int_0^{15} (5q)dq = \frac{5}{2}q^2\Big|_0^{15} = 562.5$

The total willingness to pay for q=15 by a "high income" individual is $\int_0^{15}(40 - q)dq = 40q - \frac{1}{2}q^2\Big|_0^{15} = 487.5$

Hence, the uniform fee will be set equal to F* = 487.5, and the concessionaire's profits are

$\pi^* = 3(487.5) - 562.5 = 900$

Note that $\pi^* = 900 > \pi_e = 896 > \pi_{ne} = 320$. Therefore, the uniform fee of F* = 487.5 is indeed profit maximizing.



Part B: Essay Questions

The essays were graded according to the following criteria:

- Completeness with which you addressed the question asked
- Correctness
- Number of points you raised (essay I only)
- Completeness with which you discussed each point
- Clarity of your presentation

Some things you could have included I your responses and a few comments:

ESSAY I

The desirability of a tax or a standard should be decided primarily on efficiency goals. If the world were a perfect, simple place, taxes and standards would enable the EPA to achieve the optimal amount of ozone-causing pollutants with equal efficiency. The only considerations would then be political-economic. A standard would increase the producers' surplus, leaving the government treasury unaffected. A tax would reduce the producers' surplus, but improve the Treasury's position which may allow it to reduce distortionary taxes elsewhere in the economy; thereby improving not only aggregate welfare in this sector, but aggregate welfare in other sectors. Consumers' surplus is reduced in either case.

The world is not such a simple place. Assuming there is no Coasian solution to this problem - which there isn't because of the large number of people affected, the heterogeneity of the polluters and the physical difficulty in determining the perpetrators - there still remain a large number of considerations. These include:

- Uncertainty (Weitzman)

  When there is uncertainty, the tax/standard the government sets is likely to be suboptimal, resulting in too much or too little pollution and hence some deadweight loss. Whether standards are preferred to taxes depends on the relative slope of the uncertain marginal benefit curve. If the marginal benefit curve is elastic compared to the marginal cost curve, then standards lead to a lower deadweight loss. If the marginal benefit curve is inelastic compared to the marginal cost curve, taxes result in a lower social loss and are the preferred tool. Uncertainty in the marginal cost curve does not create this dilemma since the level of pollution and the deadweight loss will be the same under both policies.

- Heterogeneity of the abatement costs

  Given all the different possible sources of ozone-causing pollution, this is likely to apply. If firms have different pollution-control costs, it makes sense to have the firms that can most efficiently reduce pollution do so before asking the less efficient firms to do so. This will minimize the social costs of controlling pollution. A uniform standard, in which all firms are allowed to produce the same amount of pollution, does not recognize this principle. Firms with higher pollution control costs will be paying more for the last unit of pollution abated than more efficient firms are paying for the marginal unit of abatement. The total costs of achieving the same level of pollution could be reduced by redistributing the pollution rights, giving more to the firm that benefits more from not having to reduce pollution and less to the firm that benefits less from having to reduce pollution. When taxes are used, each firm abates until their marginal cost of abatement equals the amount of the tax. Thus, when the desired amount of pollution is reached, all firms have the same marginal costs of abatement. It is no longer possible to take advantage of one firm's lower marginal costs to reduce the total costs of controlling pollution because, at that point, all firms have the same marginal cost. Therefore, taxes would be preferred to standards if firms have different marginal costs of controlling pollution. Notice that combining the standard with tradable permits will achieve the same result as a tax if the market for these permits is efficient and has no transaction costs involved in buying and selling permits.

- Dynamic efficiency (clean technologies and conservation technologies)

  At a given point in time, there are a number of production technologies available. These technologies give firms different marginal benefits from being able to pollute. Cleaner technologies allow firms to reduce their pollution (the horizontal intercept of the MAC/MB curve is further to the left). These cleaner technologies may also allow firms to reduce their pollution in a less costly manner (the MAC/MB curve is flatter even though it has the same horizontal intercept). If the cost of adopting these new technologies is less than the social gain from reduced pollution that they would imply, then it is socially desirable for firms to use these technologies. However, in the absence of environmental policies, firms have no reason to use cleaner technologies. Why should they spend money to reduce the amount of pollution they produce or reduce their costs of cleaning up pollution if they don't have to pay for the pollution they produce and they don't have to reduce their pollution? That would mean incurring costs without any benefits for the firm even though society would realize a net gain. The EPA would then want to choose policies that would encourage firms to do what is in the social interest and adopt these cleaner technologies. A tax would be a more effective policy in this case. Under a standard, firms have reason to adopt a less costly abatement technology because their costs of achieving the set standard will be less. Under the tax, firms have even more reason to adopt the alternative technology. Not only would they save money because the would be spending less to reduce pollution to a certain level, they will save money from paying less tax on the remaining amount of pollution they still produce. This is so, even if the tax rate is the same, because the firm will want to produce less pollution. So, if the EPA is interested in minimizing the costs of achieving the optimal level of pollution over time, it will want to implement a tax.

- Market structure

Returning to the perfect world we had in the introduction, we notice that the argument presented there assumed a perfectly competitive market. If the market is not perfectly competitive, then it is no longer obvious that a tax is an appropriate instrument. The optimal tax may be a negative tax, i.e., a subsidy. It depends on whether the market (monopoly, monpsony, middleman) is producing too much or too little. If the optimal policy is a subsidy, then firms in the industry will be realizing abnormal profits. This may entice new entrants - this may not be relevant in the monopoly case - and result in too many firms producing too much output and too much pollution. The optimal standard will be just as effective here as it was above and there is some justification for a standard over an incentive-based system.

Less formal considerations relate to the enforcement and monitoring costs of the two policies and whether efficiency will be the goal rather than political-economic factors such as employment and prices. Suppose firms are heterogeneous not only in terms of their marginal abatement costs, but also in terms of their labor-intensity and their pollution-intensity per unit of output. Then, the Hochman-Zilberman model shows that a standard that achieves the same level of aggregate pollution as a tax will have a higher level of output and more labor-intensive firms will remain in the industry. The higher level of output implies lower prices of the produced good (Supply is higher, so we move down the demand curve. Price must fall to encourage people to buy the extra output.). The presence of firms that use more labor per unit of output means there will be a higher level of employment. If politicians have any say in whether the EPA chooses taxes or standards, and if people vote for politicians that promise low prices and high employment, then politicians will want to implement standards in order to get elected or re-elected.

ESSAY II

The government could use a variety of techniques to assess the monetary benefits of preservation, some of which are more applicable than others to valuing the amenity at hand. The most relevant are probably the interview and the travel cost methods. These and others are listed and discussed below.

- Interview

Asks people directly or indirectly how much they would be willing to pay to preserve the Headwaters area. This method may not reveal true willingness to pay or accept for a variety of reasons. The questions are subject to interpretation and the respondent may answer differently than anticipated. Different questions designed to elicit the same values may get different answers.

People may be unfamiliar with the good and not have well-formed preferences. They may answer strategically rather than truthfully (If they think they will have to pay the amount of their answer for a public good, they could understate their preferences; if they think they won't have to pay, they could overstate them.)

- Travel cost

It is reasonable to assume that people would not visit a site if the opportunity costs (travel and time) of getting there exceeds the benefits they would derive from being there. Thus, the travel cost, in some sense, reflects the price of the visit. We may construct a demand curve - higher travel costs imply a high price and should get fewer visits, and so forth. The problem is that by attributing all costs to the site, the method assumes the individual does not benefit from the journey itself. If there are such benefits, we will overestimate the value. On the other hand, people may have been willing to spend more than what they actually had to in order to get there. We would then be underestimating the value. Nor does this method assess the value of the benefits that do not require a trip to the site, such as bequest, existence, option etc. (You could get these values from interviews, which is an important point favoring of that technique.)

- Hedonic

Uses traded commodities that have the amenity in question as an attribute that affects the market price of the commodity. Through statistical regression analysis, we can determine how much the price of that commodity changes in the presence or absence of the attribute under study. That price change reflects the utility derived from the attribute and can be used to impute a value to it. The difficulty here will be finding appropriate market goods. One could think of comparing the prices of houses near the forest and those further away. Yet, there may not be any houses close enough to the forest to capitalize its benefits into their price since the surrounding area is undeveloped. Moreover, people like to be close to certain man-made amenities (shopping, work, public transportation, etc.) and are willing to pay more for the convenience. Houses around Headwaters would be far from these services, and this valuation technique may actually attribute a negative value to the forest.

- Donations

One could examine how much money people have donated to groups like Headwaters Earth First! that lobbied not to have the forest preserved. We could compare these sums to the amounts donated to other causes to get a measure of the relative value of Headwaters. These sums may not reflect the particular forest in question, however, as people may simply be doing what they think is the “right” thing to do an give money to save the environment. Donations may also be affected by free-riding, misinformation, media attention and the personal zeal of the lobbyists trying to sell their agenda.

- Entry fee/ marketing/ experiment

  We could charge an entry fee and calculate how many people visit. By varying the entry fee a few times we could find a demand curve, as in a marketing experiment. The problem is that people may not have to pay the entry fee if the forest is not excludable. It is not feasible to build a fence around 11 000 acres of land in order to prevent people from using the "park" unless they pay. This entry fee would only be part of the actual cost to the visitors as it does not include travel costs. Under the travel cost method, the fee would be included as a cost of visiting the park. So, the "entry fee: method is not as reliable as the travel cost technique.

- Engineering/restoration

  Claims that the cost of restoring a degraded environment to its natural state can be used as a measure of the value of the restored state. Simply put, this is absurd. As economists, we know that there is no relationship between the total costs of producing a good and the total benefits people get from consuming that good. There is one possible exception: if we observe private citizens voluntarily restoring part of a river, a landscape, etc., then we can conclude that their private valuation is at least as large as the costs they incurred. This could not give a complete values for Headwaters since the primary reasons for preserving it are its uniqueness and unreproducibility (species cannot be brought back from extinction and it would take centuries to grow a comparable forest.)

- Voting

  Like the interview technique, this asks people about their preferences. For the method to be useful, people have to be asked in a referendum to approve or disapprove of a policy that will have predictable costs to them (e.g., a $5 tax increase). The difference is that people are likely to take this question seriously and reveal their true preference. Overstating your preference will only help pass the measure, in which case you will have to deal with the consequence of your lie, i.e., an increase in taxes you aren't really willing to take on. Understating your preference will only help defeat the measure, in which case you will have to live with the consequence of not having something you were actually willing to pay for. The drawback of this method is that you don't actually get the full value to people. You get a lower bound for those people who voted. Moreover, an election is likely to be more costly than a contingent valuation survey.

- Timber

  The logging company's profits from selling the timber derived from Headwaters Grove is not a measure of the benefits from preserving the forest. It is a measure of the benefits from cutting it down. Reciprocally, it is a cost of preserving the forest.