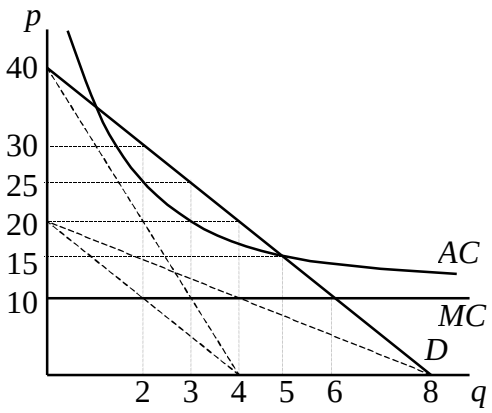
Name:
Student No.:

SPP/Econ 573
Benefit-Cost Analysis
Midterm Exam No. 1 - Answers

March 15, 2000

Answer all questions, on these sheets in the spaces or blanks provided. In questions where it is appropriate, **show your work**, if you want partial credit for an incorrect answer. Point values of the questions are shown; there are a total of 97 points possible.

1. (10 points) The figure at the right shows the demand curve for a product produced by a monopolist, together with the firm's average and marginal cost curves. There are no externalities or other distortions associated with this product, except for the possibility of monopoly pricing. Marginal cost is constant at \$10, while average cost declines with output because of a presence of a fixed cost. The figure also includes several other lines that may or may not be useful in identifying the prices, quantities, or values requested below. In each case find or calculate the amount requested using the numbers on the axes of the diagram, and write your answer in the blanks provided.



The price at which the firm's profit would be zero. \$15

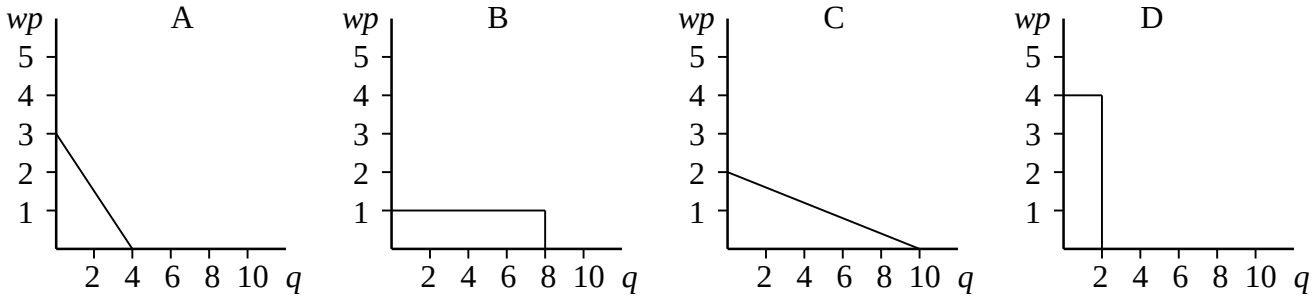
The price the firm would charge as a profit-maximizing monopolist. \$25

The total profit the firm would make as a profit-maximizing monopolist. \$15

The socially optimal level of output 6

The firm's (approximate) total profit or loss at the socially optimal level of output (specify + or –) –\$24 (±6)

2. (10 points) The graphs below show curves representing the marginal willingness to pay (*wp*) for a public good for each of the (only) four people in an economy, A, B, C, and D. (These are conceptually the same demand curves for the public good that we looked at in class, although the shapes of some of them are different.)



a. Which person (or persons, if they are tied), A, B, C, or D, would choose the largest quantity of the public good, if the cost to them would be close to zero? C

b. Which person(s) would be willing to pay the largest ***total*** amount for the provision of exactly 5 units of the public good (the only alternative being none of it at all)? D

c. What is the highest amount that the ***society***, consisting of these four people together, should be willing to pay for a very small amount of the public good? 10

d. What is the largest quantity of the public good that this society should provide if it can be provided almost free – that is, if the marginal cost is a positive constant but very close to zero? 10

e. How much of the public good should this society provide if the marginal cost is constant and equal to 1? 8

Answer Notes:

a) This is the horizontal intercept of the person's *wp* curve.

b) This is the area under the person's *wp* curve from q=0 to q=5: A=6, B=5, C=7.5, D=8

c) This is the sum of the vertical intercepts of all four curves, since society should be willing to pay the (vertical) sum of the individuals' *wp*'s.

d) If the cost is nearly zero, then society should provide the largest amount wanted by any one person, which is C

e) For q>8, only person C has willingness to pay for more, and their *wp*<1. For q<8, society's *wp* includes person B, which is itself 1, so that society's *wp* is greater than 1. So society wants more than any quantity less than 8. (The social *wp* curve, if you were to draw it, is vertical at 8 between approximately 0.5 and 1.5.)

(21 points) The island nation of West Myopia has a population of 3000 persons. Its government pays for the island's national defense by taxing the residents' consumption of bon bons (candies), which are produced competitively at a constant cost of 4 blinks (4 bl) per bon bon (the blink is the national currency). The tax rate is 2 bl per bon bon. The population consists of three groups of 1000 each: Adiposers, Barelybulgers, and Calistas. As individuals, they have the following demand functions for bon bons:

Adiposers: $D_A = 610 - 5\ P$

Barelybulgers: $D_B = 1100 - 150\ P$

Calistas: $D_C = 240 - 20\ P$

Where P is the price of bon bons in blinks and the D's are quantities demanded in bon bons per month.

One member of this population has just returned from two years at the School of Public Policy, in Ann Arbor Michigan, and has argued that the country would be better off financing its defense with a non-distorting lump-sum tax per person instead of the bon bon tax. In order to evaluate this proposal and its likelihood of being adopted, answer the following questions. Be sure to show your work, so that you can get partial credit if appropriate.

a. (6 points) With a 2 bl tax and thus a 6 bl price of bon bons (recall that marginal cost is constant at 4 bl), verify that the government collects 1,800,000 bl per year for its defense budget, and determine how much of that is paid by members of each group. That is, how much of what each person spends on bon bons goes to the government in taxes? (Hint: your three answers should add up to 1800 bl, in order to generate the above total revenue from the 1000 members of each group.)

Adiposers: 1160 bl Tax paid = $T_A = 2\ D_A = 2[610 - 5\ (6)] = 2\ [580] =$ 1160

Barelybulgers: 400 bl $T_B = 2\ D_B = 2[1100 - 150\ (6)] = 2\ [200] = 400$

Calistas: 240 bl $T_C = 2\ D_C = 2[240 - 20\ (6)] = 2\ [120] = 240$

b. (6 points) Calculate the increase in consumer surplus that each type of person gets if the tax is removed.

Adiposers: 1170 bl
New demand = $D_A' = 610 - 5\,(4) = 590$
Change in consumer surplus =
$\Delta CS_A = \Delta P(D_A + D_A')/2$
$= 2\,(580 + 590) / 2 = 1170$

Barelybulgers: 700 bl
$D_B' = 1100 - 150\,(4) = 500$
$\Delta CS_B = 2\,(200 + 500) / 2 = 700$

Calistas: 280 bl
$D_C' = 240 - 20\,(4) = 160$
$\Delta CS_C = 2\,(120 + 160) / 2 = 280$

c. (9 points) With 3000 people sharing the defense budget of 1,800,000 bl, each will have to pay 600 bl if they are to share it equally through a lump-sum tax per person. Based on each of the three criteria listed on the next page, and assuming that Myopians are rational and respond to their true self-interest, determine whether the proposal to replace the bon bon tax with this lump-sum tax should be accepted. That is, for each criterion listed, answer "yes" or "no" whether the policy change meets the criterion, and ***explain why***. Your explanation is necessary, in this case, and it should not just restate the criterion, but should indicate with numbers why the policy change does or does not satisfy it.

Pareto Optimality: No (Yes/No)

Why? Because it is not true that nobody loses from the proposal, as would be required by the Pareto Criterion. One group, the Calistas, lose, paying more in taxes (600 bl) than they gain in consumer surplus (280 bl).

Majority Voting: Yes (Yes/No)

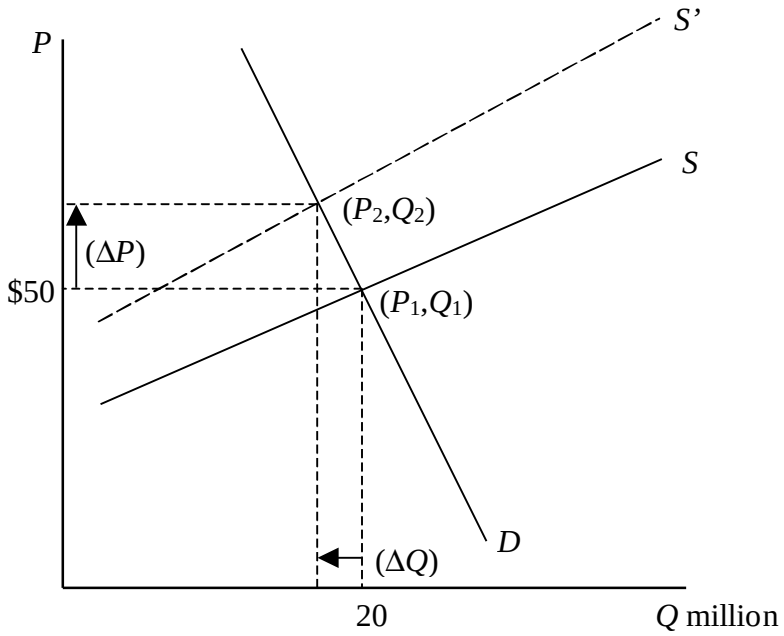
Why? Because two groups, the Adiposers and the Barelybulgers, gain from the proposal, paying less in taxes (600 bl) than they gain in consumer surplus (1170 bl and 700 bl respectively). They therefore vote for it, while the Calistas vote against, generating a majority of 2000 for and 1000 against.

Kaldor-Hicks Criterion Yes (Yes/No)

Why? Because the two groups that gain, the Adiposers and the Barelybulgers, could compensate the losers and still remain better off (or, equivalently, they gain more than the losers lose). That is, for each trio of one from each group, the Adiposer gains 1170–600=570 and the Barelybulger gains 700–600=100, for a total gain of 670, which is more than the 600–280=320 that the Calista loses. In this case, in fact, the Adiposers alone could more than compensate the Calistas, paying them, say, 400 bl each, and still remain better off themselves from the policy change.

3. (22 points) The market for handguns is currently in equilibrium with 20 million being produced and sold each year for a price of $50 per gun. The government is proposing a requirement that all such guns produced in the future be equipped with trigger locks. All agree that this would increase their cost of production by 7%. Part of the motivation for this proposal is the belief that gun ownership causes a negative externality for society. Suppose that this externality is valued at $10 per gun. Suppose also that the elasticity of supply of guns is 3, while the elasticity of demand for guns is 0.5. Your job is to calculate the benefits and costs to society (including gun **producers**, gun **buyers**, and those **bystanders** affected by the externality) of requiring trigger locks, assuming that all of these assumptions are correct. To do this, work through the following steps of analysis, following the instructions given.

   a. (4 points) On the axes below, illustrate the effects of the trigger-lock requirement by drawing initial supply and demand curves for the current equilibrium, then new supply and/or demand curves in the presence of the requirement. Label the diagram to indicate both the old equilibrium (P_1,Q_1), the new equilibrium (P_2,Q_2), and the changes in price and quantity (? P, ? Q) caused by the requirement. You need not try to draw any of this to scale – just get the directions right.



For parts (b) through (k) below, fill in the blanks as indicated, using numbers that you derive from the assumptions that are stated above and that are repeated on the next page for your convenience.

Initial quantity	20 million guns
Initial price	$50 per gun
Elasticity of supply	3
Elasticity of demand	0.5
Increase in cost due to trigger lock	7 percent
Size of negative externality	$10 per gun

b. (1 point) Using the inverse ***supply*** curve, the change in the price of guns, ? *P*, is related to the change in quantity, ? *Q*, and to the percentage increase in cost due to the new regulation (0.07), as follows (complete the equation by putting the appropriate number in the blank):

$$\frac{\Delta P}{P_1} = \underline{\quad 1/3 \quad} \times \frac{\Delta Q}{Q_1} + 0.07$$

c. (1 point) Using the inverse ***demand*** curve, the change in price is also related to the change in quantity by using the elasticity of demand (put another number in the blank):

$$\frac{\Delta P}{P_1} = \underline{\quad -1/0.5 \quad (=-2) \quad} \times \frac{\Delta Q}{Q_1}$$

d. (2 points) Equating the two price changes in (b) and (c), solve for the change in quantity as (another number, and show your work, from here on):

$$\frac{\Delta Q}{Q_1} = \underline{\quad -0.03 \quad}$$

$-2 \; ? \; Q/Q_1 = (1/3) ? \; Q/Q_1 + 0.07$
$-6 \; ? \; Q/Q_1 = ? \; Q/Q_1 + 0.21$
$-7 \; ? \; Q/Q_1 = 0.21$
$? \; Q/Q_1 = -0.21/7$

e. (2 points) The new quantity of guns sold is therefore:

$Q_2 =$ 19.4 million $Q_2 = Q_1 - 0.03\, Q_1 = 20 - 0.6 = 19.4$

f. (2 points) The change in price is:

$\frac{\Delta P}{P_1} =$ +0.06 $\Delta P/P_1 = -2 \Delta Q/Q_1 = -2(-0.03) = +0.06$

g. (2 points) And the new price is therefore:

$P_2 =$ \$53 $P_1 + 0.06\, P_1 = 50 + 3 = 53$

h. (2 points) The change in consumer surplus (**gun users**) is:

$\Delta CS =$ –\$59.1 million $\Delta CS = -\Delta P(Q_1+Q_2)/2 = -\$3\ (20+19.4)/2$

i. (2 points) The change in **producer** surplus is:

ΔPS = –$9.85 million

Their costs rise by 7% = $3.50 at initial output Q_1. Since price rises by only $3, this is equivalent to a drop in price of $0.50.
$\Delta PS = -\Delta P(Q_1+Q_2)/2 = -\$0.50\ (20+19.4)/2 = -.5(19.7)$

j. (2 points) The gain from the reduced externality to the **bystanders** is:

ΔExt = $6 million

$-\$10\ (\Delta Q) = -\$10\ (20 - 19.4)$ million = $6 million

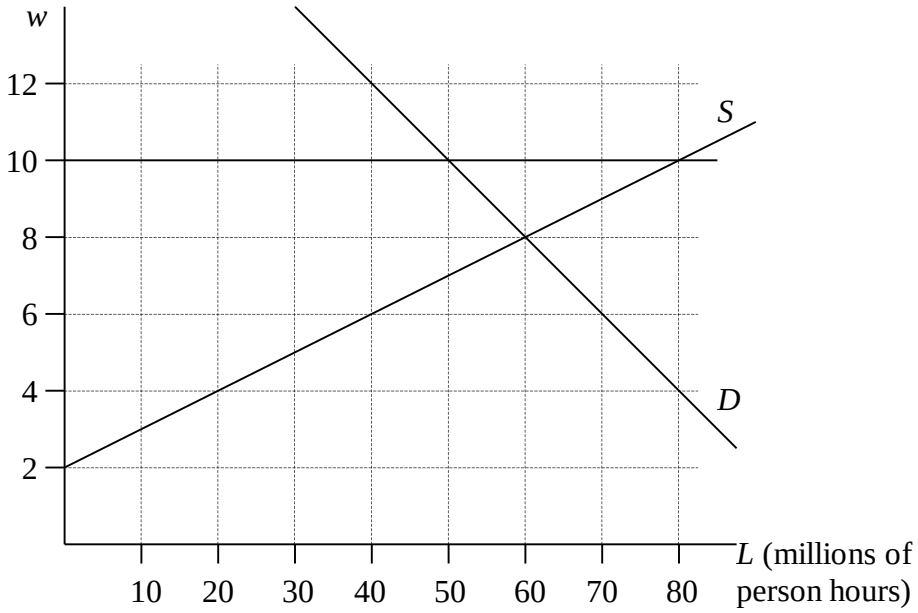
k. (2 points) Based (only) on this analysis, should the trigger lock requirement be instituted? Why?

Do it? NO Why? The gain ($6 million) is much smaller than the combined losses to producers and consumers: $59.1 + 9.85 = 68.95 million.

l. (Extra credit) Are there any assumptions that have been made in this analysis that you think should be changed and that might alter the conclusion?

The most obvious one to me is the implicit assumption that the trigger locks do not make the guns any safer. If they do, then the negative externality will be reduced for all new guns that are sold, and the benefit will not be limited to just selling fewer new guns because they are more costly. In addition, it might be argued that the trigger locks will make guns less convenient to use, causing demand for them to be reduced further. I'm sure, though, that there are many other assumptions you might question, especially if you feel strongly about the gun issue one way of the other.

4. (18 points) In the figure below are drawn a supply curve and a demand curve for labor, in a market where the equilibrium wage would be $8 per hour. However, the government initially enforces a minimum wage that is higher than this, at $10 per hour. (The quantity axis measures labor in millions of person-hours, but you can ignore the "millions" and state your answers in terms of just hours and dollars, with the "millions" assumed where appropriate.)



Assume that whenever demand for labor is less than supply, the rationing of labor is done randomly.

a. (2 points) How much labor is employed at the initial minimum wage of $10, and how much "involuntary unemployment" is there, in the sense of hours that workers want to work in this market at the prevailing wage but cannot?

The demand for labor is 50 (million person-hours), and this is less than the supply of 80, so the level of employment is **50**. The level of involuntary unemployment is the different between supply and demand at this wage, or **30**.

b. (2 points) At the initial minimum wage of $10, what is the average reservation wage (that is, the marginal cost of working in this market) for the workers who are willing to work?

$6 = (2+10)/2 = the average of the lowest reservation wage, $2, and the wage being paid, $10, since with the linear supply curve shown, workers are distributed uniformly over this interval.

c. (2 points) How much total "producer surplus" do the workers who are employed get from being employed in this market?

The average worker who is employed gets a surplus of $10 - $6 = $4. With employment of 50, the total surplus is $4(50) = **$200** (million).

Now suppose that the minimum wage is **increased** from $10 to $12. Assume that employment is reduced only by laying off workers who were already employed, and that no new workers are given jobs who didn't have them before. Assume also that the laid off workers are chosen randomly from those initially employed.

d. (2 points) How much will employment in this market decrease?

Demand for labor and therefore employment falls from 50 to 40, for a decrease of **10**.

e. (2 points) How much total surplus will the workers who remain employed now enjoy?

Their average reservation wage is still $6, so with the rise in their actual wage to $12, their surplus rises to $6 per hour. Since their employment is now 40, their surplus is now $6×40 = **$240**.

f. (2 points) What is the total loss of welfare of the workers who become unemployed due to this increase in the minimum wage?

They lose their average surplus of \$4 per hour on their lost employment of 10, so their loss is \$4×10 = **\$40**.

g. (2 points) Quantify the effect on the welfare of demanders of labor in this market due to the change in the minimum wage. That is, how much do they gain or lose?

They lose "consumer surplus" as measured to the left of the demand curve between the two wages. That is, they lose - (\$12 - \$10)(40 + 50)/2 = **- \$90**.

h. (2 points) What is the effect of the rise in the minimum wage on the workers who initially wanted to work in this market but were unable to find jobs? What about the workers who initially did *not* want to work in this market but now do?

Neither of these groups lose anything at all from the fact that the minimum wage has increased. They are still doing whatever they were doing before.

i. (2 points) What, then, is the net effect (change in benefits minus costs) on all of society due to this increase in the minimum wage?

Still-employed workers	+\$80 (=\$2×40)
Newly-unemployed workers	- 40
Demanders of labor	- 90
Net	**- \$50**

5. (16 points) Determine the present discounted values using the interest rates indicated:

   a. (2 points) The present discounted value, at an interest rate of 4% per year, of $130 two years from now.

   PV(130) = $130/(1.04)^2 = 120.19 ~ **$120**

   b. (2 points) The present discounted value, at an interest rate of 7% per year, of a payment of $21 that is repeated every year forever, starting ***one*** year from now.

   PV = $21/0.07 = **$300**

   c. (2 points) The present discounted value, at an interest rate of 7% per year, of a payment of $21 that is repeated every year forever, starting ***now***.

   PV = $21 + $21/0.07 = **$321**

   d. (2 points) The present discounted value, at an interest rate of 5% per year, of a payment that is $72 one year from now and that grows by 3% a year thereafter, forever.

   PV = $72/(0.05 – 0.03) = **$3600**

e. (4 points) What ***will be***, ***five years from now,*** the value of a stream of costs of $6 starting in year six and continuing forever, discounted to year five at an interest rate of 3%? What is the discounted value of that same stream of costs from the perspective of today, five years earlier?

From the perspective of five years from now, this is simply a constant payment per year, starting a year later, just like part (b). Thus PV = $6/0.03 = **$200 in year 5**. From the perspective of today, this cost must be discounted by another five years: $200/$(1.03)^5$ = **$172.52 today**.

f. (2 points) What is the present discounted value ***today***, again with an interest rate of 3%, of benefits of $6 each year starting one year from now and continuing for only ***five*** years. (You may derive this directly from the formula, if you know it, or you can notice that this is the same as a $6 benefit that continues every year forever, together with a $6 *cost* that starts in year 6, and use your results from part (e).)

From the formula in class, PV = $(\$6/0.03)(1 - 1/(1+0.03)^5) = \$27.48$. Or using part (e), this is $200 – 172.52 = **$27.48**.

g. (2 points) The City of Ann Arbor has been offered a tree that will produce a fixed number of apples every year forever, starting one year from now. At next year's prices, those apples are expected to be worth $480. The price of apples is expected to rise at the same rate as overall inflation, which is 2% a year. The nominal interest rate is 8% a year. What is the present discounted value of this apple tree today to Ann Arbor?

It is simplest just to discount the constant real benefit, $480, with the real interest rate of 8% – 2% = 6%. Therefore, PV = $480/0.06 = **$8000**. Alternatively, you can define the nominal value of the apples as $A_t = \$480 (1.02)^{(t-1)}$ and use the formula for an appreciating benefit, but this is the same thing.