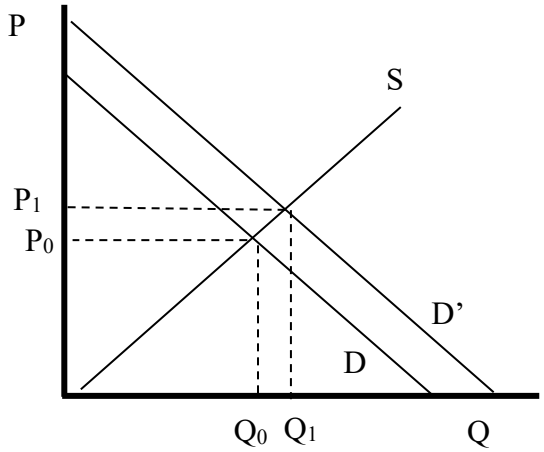
Practice Problem Solutions PAI 723 Professor David Popp Fall 2024

1. The following questions ask you to consider the domestic market for gasoline. Use a supply and demand diagram to analyze each of the following scenarios. Explain briefly. ***Be sure to show how both the equilibrium price and quantity change in each case.***

a) As the economy becomes better, both business and holiday travel increases.
b) Geopolitical instability in major oil producing countries in the Middle East reduces the amount of oil available to import from these countries.
c) In response to increasing minimum fuel economy requirements from the government, the automobile industry has continuously made technological progress improving the average fuel economy of vehicles sold in the U.S. market.

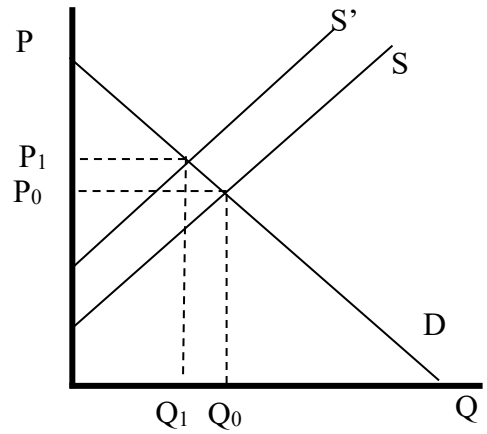
The purpose of this problem is to get you thinking about how demand and supply curves are affected by outside influences, and to help you distinguish between shifts of a curve versus a movement along a curve.

a)

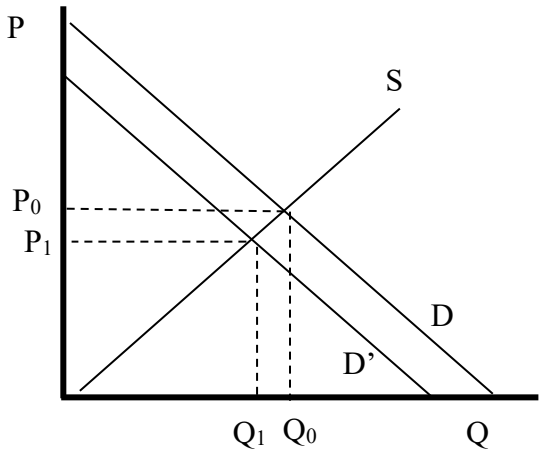


As travel increases, more drivers will need gasoline. As a result, demand shifts up and to the right. The equilibrium quantity and price both increase.

b) The reduction in oil from the Middle East means less oil is available to refine into gasoline. As a result, supply shifts up and to the left. The price of gasoline increases and the equilibrium quantity falls.



c) Improved fuel efficiency means that people now need less gasoline to drive the same distance that they did before. This will reduce the demand for gasoline, causing the demand curve to shift down to the left. Both the equilibrium price and quantity fall.



Note that while the question asks about a technological improvement, it is a technological improvement to a compliment for gasoline – that is, for a product that uses gasoline. Thus, the improvement in fuel efficiency of vehicles does not affect the supply of gasoline, but rather the demand for gasoline.

2. Suppose the market for AquaDoodles (once a popular toy) has a supply curve of P = 10 + Q, and a demand curve of P = 150 – 6Q. Assume that the market is perfectly competitive.

a) What will the equilibrium price and quantity of AquaDoodles be?
b) Calculate the producer and consumer surplus associated with the equilibrium found in part (a). Illustrate on a graph.
c) Now, suppose the government levies a tax of $7 per Aquadoodle sold, to be paid by consumers. What is the quantity of Aquadoodles sold? What price do consumers pay? What price do producers receive? Illustrate on a graph.
d) What do the new prices tell you about the price elasticities of supply and demand for Aquadoodles? Which is more elastic? How do you know this?
e) Find the new producer and consumer surplus associated with your answer to part (c).
f) How much revenue does the government raise from the tax?
g) How does the sum of consumer surplus, producer surplus, and revenue after the tax (your answers to (d) and (e)) compare to the sum of producer and consumer surplus found before the tax (your answer to (b))? What does the difference between the two represent?

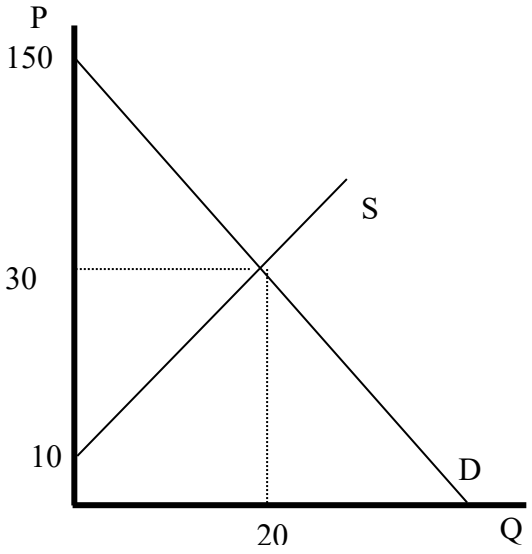
a) The equilibrium price and quantity are:

$$10 + Q = 150 - 6Q$$
$$7Q = 140$$
$$Q = 140/7$$
$$\mathbf{Q = 20}$$

Substitute this into either supply or demand to get:

$$\mathbf{P = 30}$$

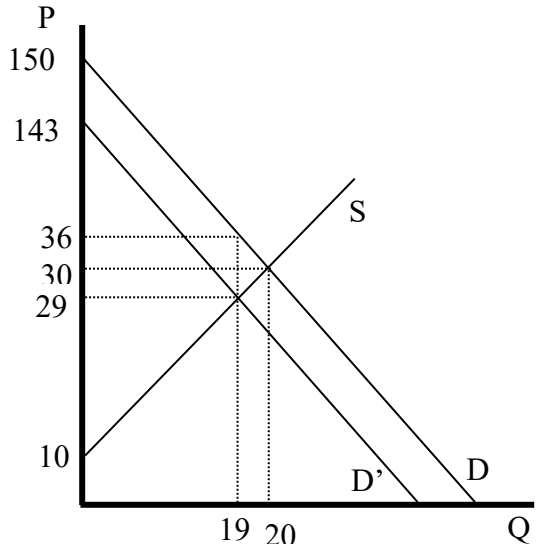
b)



Consumer surplus is the triangle above the price and below demand. It has a height of 120 (= 150 – 30) and a base of 20. Its area = 0.5(120)(20) = **$1200**.

Producer surplus is the triangle below price and above supply. It has a height of 20 (= 30 – 10) and a base of 20. Its area = 0.5(20)(20) = **$200**.

c) The result of the tax is to shift either the supply curve or demand curve in. Note that while your results will be the same no matter which one you choose, the question says that the tax is imposed on consumers, so I shift the demand curve below. The demand curve shifts down by the amount of the tax. The new demand curve represents the demand curve faced by suppliers. If P is the price consumers pay, suppliers get P - 7, with $7 going to the government. Algebraically, P = 150 – 6Q becomes P = 143 – 6Q. Graphically, note that the y-intercept of the graph has shifted down by the amount of the tax.



We begin by finding the new equilibrium. Equate the new supply curve with the old demand curve.

$$10 + Q = 143 - 6Q$$
$$133 = 7Q$$
$$Q = 133/7$$
$$\mathbf{Q = 19}$$

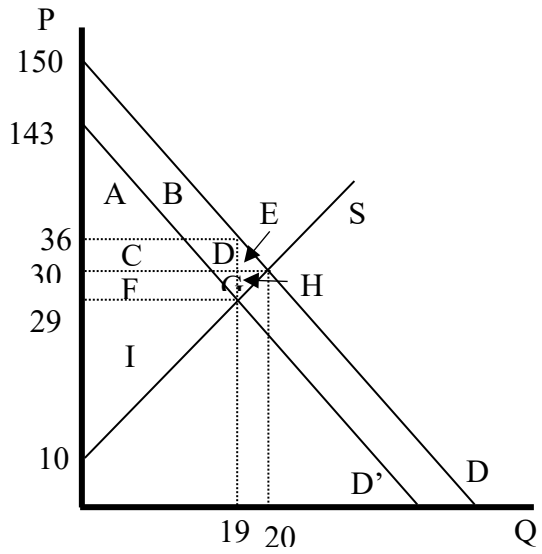
We plug this quantity into the *original* supply and demand curves to get the post-tax prices. With a quantity of 19, suppliers receive:

$P_S = 10 + 19 =$ **$29** (from the original supply curve)

Consumers must pay $7 more than this, or **$36**. Note that we can verify this using the *original* demand curve, where we get $P_C = 150 – 6(19) = 150 – 114 = \$36$.

d) Most of the tax is paid by consumers – their price increases by $6, while producers only receive $1 less. Since inelastic parties bear the larger burden of a tax, this tells us that demand is more inelastic than supply.

e) Note that we use the original supply and demand, at the new prices and quantities, to find consumer and producer surplus.



Areas A & B in the above graph represents consumer surplus. This is a triangle with a height of 114 (= 150-36) and a base of 19. Its area = 0.5(114)(19) = **$1083**.

Area I in the above graph represents producer surplus. This is a triangle with a height of 19 (= 29-10) and a base of 19. Its area = 0.5(19)(19) = **$180.5**.

f) Revenue is simply the tax times the quantity sold.

$7 x 19 = $133.

On the above graph, revenue is the rectangle represented by areas CDFG.

g) Before the tax, the sum of consumer and producer surplus was $1400. Afterwards, the sum of consumer surplus, producer surplus, and revenue is $1396.5. The difference is $3.5. Graphically, this is the area of triangles E & H.

This difference is the deadweight loss. It is the value of lost opportunities, because some potentially beneficial transactions do not occur after the tax. For the quantities between 19 and 20, demand is above supply. This tells us that consumers are willing to pay more than the marginal cost of producing the good. However, because of the tax, these units are not sold. The potential producer or consumer lost because of this is the deadweight loss.

3. To encourage increased growth of grasslands in the Animal Kingdom, their leader, Simba, is considering a subsidy for production of grasslands. Suppose that the market for grasslands can be represented by the following equations:

Demand: $P = 200 – 1.5Q$
Supply: $P = 50 + Q$

where P is the price per acre, and Q represents quantity of grasslands, represented in acres consumed per week.

a) Calculate the equilibrium price and quantity of grasslands before the subsidy.
b) To encourage grassland production, Simba announces a price floor of $140 per acre. With this new price floor, what will be the new quantity of grassland consumed in the Animal Kingdom?
c) Illustrate your answers to (a) and (b) on a graph. Using this graph, calculate the consumer surplus and producer surplus at the initial equilibrium price and quantity from part (a).
d) Calculate the new consumer surplus and producer surplus with the price floor of $140 per acre (part b).
e) How does the total consumer and producer surplus in part (c) compare to the total consumer and producer surplus in part (d)? What explains the difference in these two figures?
f) Suppose that the government supports the $140 per acre price by purchasing any excess grassland that producers make available but are unable to sell to other animals. How many acres of grassland must the government buy?

a) The equilibrium occurs where supply equals demand:

$$200 – 1.5Q = 50 + Q$$
$$150 = 2.5Q$$
$$Q = 150/2.5$$
$$\mathbf{Q = 60 \text{ acres}}$$

To find the price, we substitute the equilibrium quantity into either the demand or supply equation:

Either:

$$P = 200 – 1.5(60) = \mathbf{\$110}$$

Or:

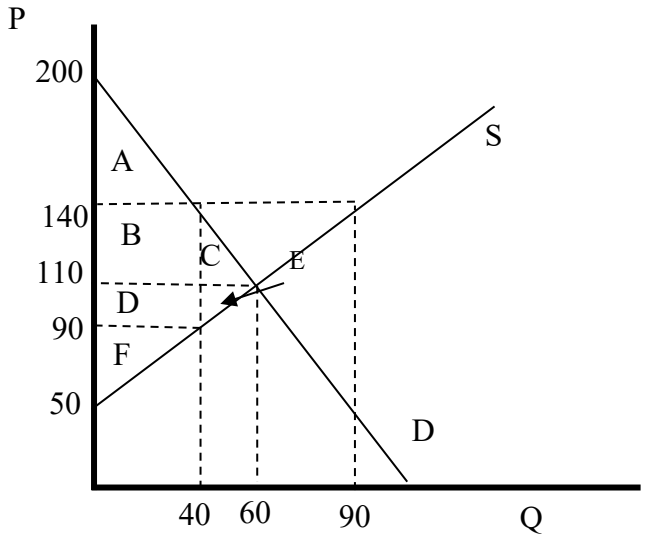
$$P = 50 +(60) = \mathbf{\$110}$$

b) The minimum price is above the equilibrium price. Thus, there will be an excess supply of grasslands – more animals will want to sell grasslands than will be willing to buy grasslands. The new quantity sold will be limited by the number of animals willing to purchase grasslands at this higher price. We find this by substituting \$140 for P in the demand equation, and then solving for Q:

$$140 = 200 - 1.5Q$$
$$60 = 1.5Q$$
$$Q = 60/1.5$$
$$\mathbf{Q = 40 \text{ acres}}$$

c) To draw the graph, we begin by drawing the supply and demand curves. Note that the equations are already solved for P. Thus, we know that the y-intercept (on the price axis) for demand is \$200. Similarly, by setting P = 0, we find that Q = 133.33 when P = 0 (because 200 – 1.5(133.33) = 0).

For supply, we know that the y-intercept is 50, and intersects demand at a quantity of 60 and a price of \$110.



With a price floor of \$140, note that there will be excess supply, so the quantity demanded at \$140 determines the quantity sold. As we found in part (b), this is 40 acres of grasslands.

Consumer surplus is everything above the price and below the demand curve. Before the price floor, this is areas **A, B and C** above. This is a triangle with a height of 90 (= 200-110) and a base of 60. Its area = 0.5(90)(60) = **\$2700**.

Producer surplus is everything below the price and above the supply curve. Without the price floor, this is areas **D, E, and F**. This is a triangle with a height of 60 (= 110-50) and a base of 60. Its area = 0.5(60)(60) = **\$1800**.

d) With the price floor, consumer surplus is everything below demand and above the price of $140. This is area **A** above. This is a triangle with a height of 60 (=200-140) and a base of 40. Its area = 0.5(60)(40) = **$1200**.

The new producer surplus is everything below the price of $140 and above supply. This consists of the rectangle **B and D**, as well as the triangle **F**. To find the area of the rectangle, we need to know the value of the bottom line. This is the price that suppliers are willing to make available for 40 acres of grasslands. Plugging 40 into supply gives us 50 + 40 = 90. Thus, this rectangle has a height of 50 (=140-90) and a width of 40. Its area = (50)(40) = $2000. The triangle F has a height of 40 (=90 – 40) and a base of 40. Its area = 0.5(40)(40) = $800. The total producer surplus is the sum of these two areas, or **$2800**.

e) The total consumer and producer surplus in part (c) is $4500. The total surplus in part (d) is $4000. The difference of $500 is the deadweight loss. This is lost surplus because some of the grassland sales that took place before the introduction of price supports no longer occur. Note that it is equal to areas **C and E** on the graph. This is a triangle with a height of 50 (= 140-90) and a base of 20 (= 60-40), for an area = 0.5(50)(20) = $500.

f) With the price support, there will be an excess supply of grassland. One way for the government to support prices is to purchase this extra supply. To find this, we need to know (a) how much suppliers make available at $140 per acre, and (b) how much consumers purchase at this price. We know from part (b) that consumers purchase 40 acres. To find out how much suppliers make available, plug in the price of $140 to the supply equation:

$$140 = 50 + Q$$
$$Q = 90$$

Since suppliers make 90 acres available, and consumers only purchase 40 acres, the government will need to purchase 50 acres of grasslands at a price of $140 per acre.

4. Due to concerns about the health of young children, the state of Minnesota proposes a subsidy for vitamins. You are given the following information:

- Production of vitamins is very competitive and the price is set in a global market. Thus, the price of vitamins in Minnesota can be considered perfectly elastic. Currently, a bottle of vitamins sells for $5 in the state.
- 400,000 bottles of vitamins are sold in Minnesota each year.
- The price elasticity of demand for vitamins is -0.15.
- The subsidy would lower the price of vitamins to $3 per bottle.

a) How many more bottles of vitamins would be sold in Minnesota if the proposed subsidy was approved?
b) Illustrate on a graph. Calculate the change in consumer surplus that would result from this policy
c) How well does the proposal meet the state's goal of increasing vitamin consumption among children? Would you recommend approval of the subsidy? Please be sure to explain both why the policy does or does not meet the state's goal *and* your recommendation.

a) We can use elasticity here. The formula for elasticity is:

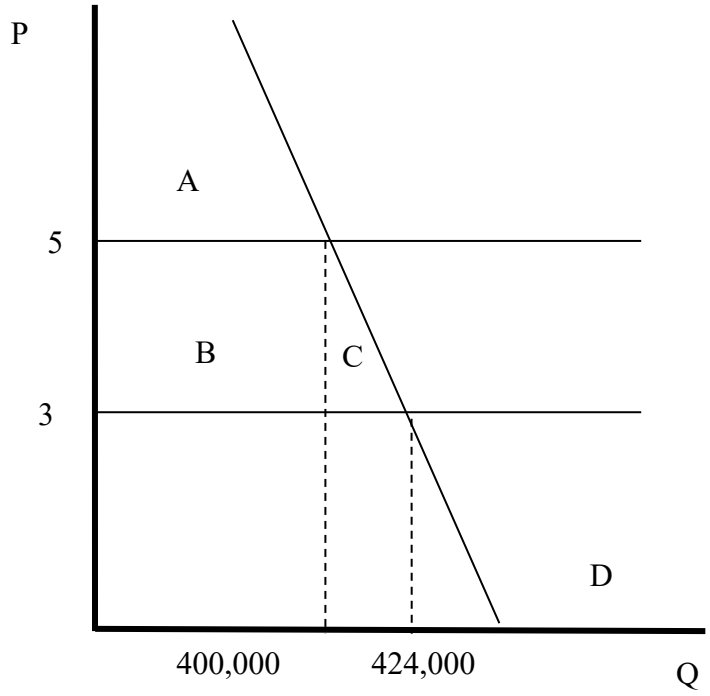
$$\varepsilon = \frac{\%\Delta Q}{\%\Delta P}$$

Recall that $\%\Delta P = \Delta P/P_0$. Thus, the proposed percentage change in price is = -2/5 = -0.4. Plugging this into our equation along with the elasticity gives us:

$$-0.15 = \frac{\%\Delta Q}{-0.4}$$
$$\%\Delta Q = (-0.4)(-0.15) = -0.06$$

Thus, the quantity demanded increases by 6%. Multiplying by the original quantity of 400,000, we find that just **24,000** additional bottles of vitamins are sold.

b) Note that you do not need to know the end points of the demand curve to find the change in consumer surplus. Also note that supply is perfectly elastic, so that the supply curve is a flat line. The illustration below shows all that you need to find the change in consumer surplus:



With the original price of \$5 per bottle, consumer surplus is just area A. When the price falls to \$3 per bottle, consumer surplus increases to areas A, B, & C. Thus, we can find the increased consumer surplus by calculating areas B & C. Even though we don't know the *y*-intercept of the demand curve, we do know enough to calculate this area.

B is a rectangle with a height of 2 and a length of 400,000. Thus, its area is \$800,000.

C is a triangle with a height of 2 and a base of 24,000 (= 424,000 – 400,000). Its area is 0.5(2)(24,000) = \$24,000

Thus, the increased consumer surplus = 800,000 + 24,000 = **\$824,000**.

c) While there is no right or wrong recommendation, the key point to notice here is that the subsidy does not do much to meet the state's goal of increasing vitamin consumption. Despite a 40% decrease in price, vitamin consumption increases by just 6%. That is because demand is inelastic. Consumers are not responsive to changes in the price of vitamins. Thus, the subsidy does not encourage them to purchase more vitamins.

Although it wasn't necessary to answer this question, one way to illustrate this point is to note how much the government spends to increase vitamin consumption. The subsidy costs the government $848,000 (= $2 x 424,000). Vitamin consumption goes up by 24,000 bottles. That comes to $35.33 per additional bottle!

The policy does have a large consumer surplus. However, note that most of the additional surplus goes to people who would have purchased vitamins anyway (area B on the graph for part (b)). The subsidy helps people who want vitamins anyway, but does little to encourage additional people to buy vitamins. Whatever you recommended, it should take these points into consideration.

5. Prince Edward Island is considering raising the fare for the ferry connecting the island to the mainland of Canada by 20%. You have been asked to project whether the fare increase will lead to an increase or decrease in revenues. You have been given the following data pertaining to the last time that fares were increased:

	before increase	**after increase**
riders per day:	3,000	2,650
fare:	$10	$12.50

a) Based on the figures provided, calculate the price elasticity of demand for trips on Prince Edward Island's ferry.
b) Based on your calculation above, would you expect revenues to increase or decrease if the fare rose by another 20 percent? Why?

a) The formula for elasticity is:

$$\varepsilon = \frac{\%\Delta Q}{\%\Delta P}$$

Recall that $\%\Delta Q = \Delta Q/Q$ and $\%\Delta P = \Delta P/P$. Thus, the percentage change in quantity = -350/3000 = -0.11666, and the percentage change in price is 2.5/10 = 0.25. From this, we calculate the elasticity to be -0.467:

$$-0.467 = \frac{-0.11666}{0.25}$$

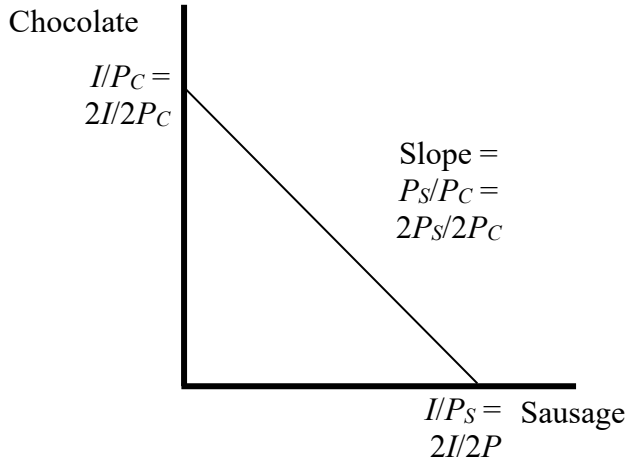
Two common errors here were:

1. Using the new quantity and price, rather than the original quantity and price, to calculate the percentage change, and
2. Using 20% for the change in price. While the proposed price increase is 20%, you must use the previously observed data to calculate the elasticity. The change in quantity that occurred previously was the result of a 25% price increase. Thus, you must use 25%, not 20%, as the change in price.

b) Revenue will increase. Demand is inelastic. Thus, the decrease in quantity demanded will be small relative to the increase in revenues from the higher fare.

Note that simply calculating the new and old revenues only received partial credit. Simply calculating these revenues shows that revenues increase, but does not explain why they increased.

6. Reggie consumes only two goods, chocolate and sausage. Suppose that the price of both chocolate and sausage doubles. At the same time, Reggie is given a raise at work, so that his income also doubles. What affect do all of these changes have on Reggie's budget constraint? What does this problem tell you about the effect of inflation that doubles all prices, but in which income also doubles?



The key to this question is thinking about the interpretation of the x and y intercepts of the budget constraint. In each case, the intercept is the amount of that good that you could consume if you only bought that good. It is found by dividing total income, *I*, by the price of the good, *P*. If both the price and income are doubled, you can still purchase the same amount of the good that you did before. Thus, the budget constraint *does not change* at all. The intercepts are the same because you can purchase the same amount of the good as before, and the slopes have not changed because relative prices (P_S/P_C) have not changed. This problem tells us that if prices increase because of inflation, but income rises at the same rate, the inflation has no real effect, since purchasing power remains the same.

7. To encourage communities to spend more on recycling programs, Representative C. Robin has proposed providing federal aid to communities to help pay for these programs. There are two proposals:

Proposal A – block grants: This proposal would give each community a block grant of $250,000. The money could only be spent on recycling programs.

Proposal B – matching grants: This proposal would subsidize spending on recycling programs. For each dollar spend on recycling programs by local communities, the federal government would provide $0.50 of aid.

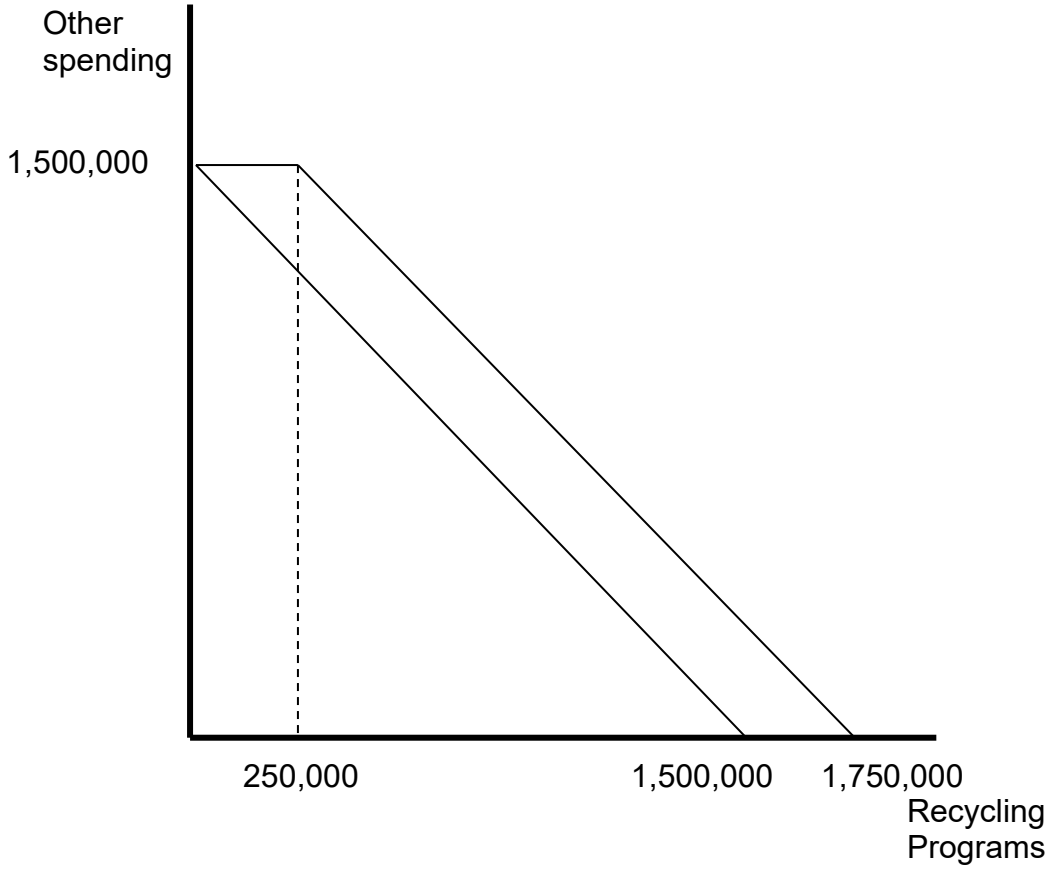
a) Suppose that a typical community has a budget of $1,500,000. Draw a budget constraint for such a community showing their current choices (pre-policy). Then, add a second budget constraint depicting the community's options under proposal A. Be sure to clearly label all endpoints of each budget constraint.

b) Please reproduce your figure from part (a). Then, add a third budget constraint depicting the community's options under proposal B. Once again, please clearly label all endpoints.

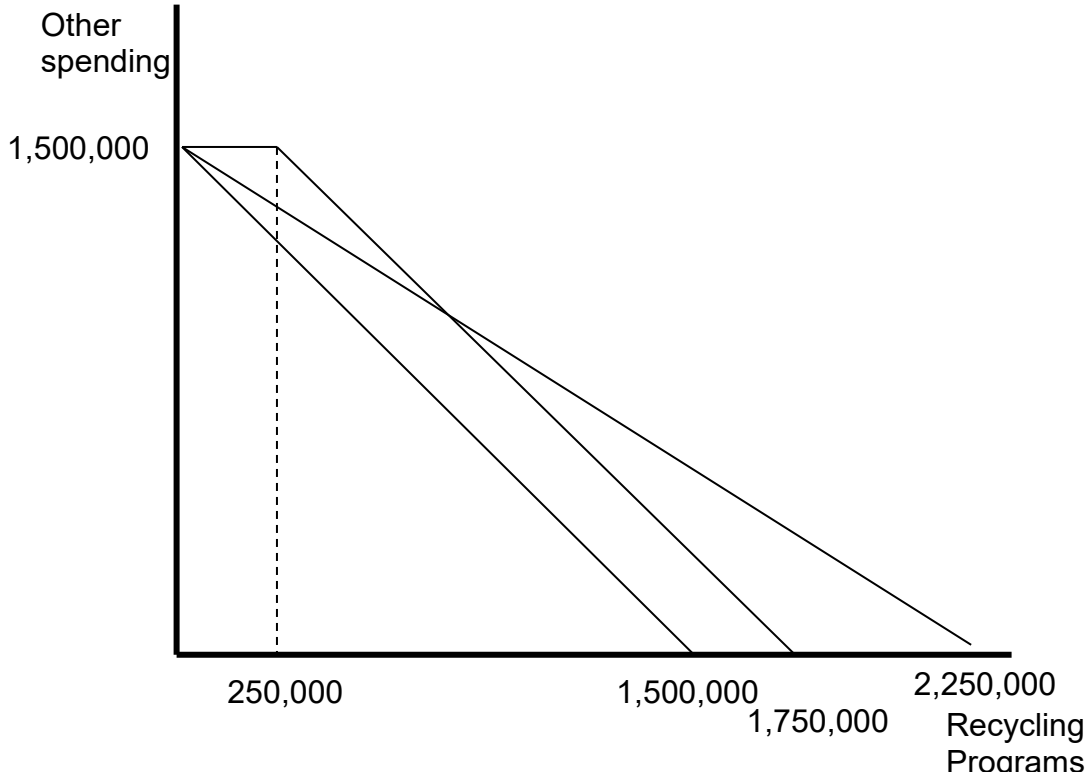
c) Representative Robin is concerned about communities that currently spend little on recycling programs. Which of the proposals above will these communities prefer? Please explain the intuition of your answer in a way that Representative Robin, who has little formal training in economics, would understand.

d) Representative W. Pooh represents a community that spends more than $750,000 on recycling programs devices. Which proposal makes Representative Pooh's community better off? Why? Again, please explain your answer in a way that would be clear to a non-economist. (*Hint:* Calculate how much money is left for other spending under each proposal when a community spends a total of $750,000 on recycling programs.)

a) The initial budget constraint allows the community to spend $1,500,000 on recycling or other goods. With the new policy, if this community spends all of its own money on other spending, it still has $250,000 to spend on recycling. Similarly, if it spends all of its money on recycling, it now has $1,7500,000 to spend.



b) The subsidy lowers the price of recycling. For every dollar spent by the community, the federal government contributes 50 cents. Thus, the price of recycling services under this program is $0.67, since the community pays 2/3 of the cost for every unit of recycling services (= $1/$1.50). Under this policy, the community can afford $2.25 million worth of recycling services (= 1,500,000/0.66666).



c) Communities that prefer little recycling will prefer the block grant. For these communities, the $250,000 of income given with the block grant is more valuable than the subsidy. A community would need to spend at least $500,000 on recycling to get back $250,000 from the government under the subsidy in proposal B.

While I was looking for an intuitive answer, we can see this on the graph above. If the level of spending on recycling is low, the community will be to the left of the intersection of the two budget constraints. In this area, the block grant budget constraint is highest.

d) If a community purchases more than $750,000 on recycling programs, it will get back more than $250,000 from the government. To see this, note that to get $750,000 worth of recycling services, the community spends $500,000 under each proposal. Under proposal A, the $250,000 block grant makes up the difference to get to $750,000, and under proposal B, the 50 cent subsidy provides the additional $250,000. Thus, Representative Pooh's community gets more from the government under the matching grant (proposal B). Again, while it wasn't what I was looking for in this answer, you can also see this on the graph, as Representative Pooh's community is to the right of the intersection of the two budget constraints. In this area, the matching grant budget constraint is highest.

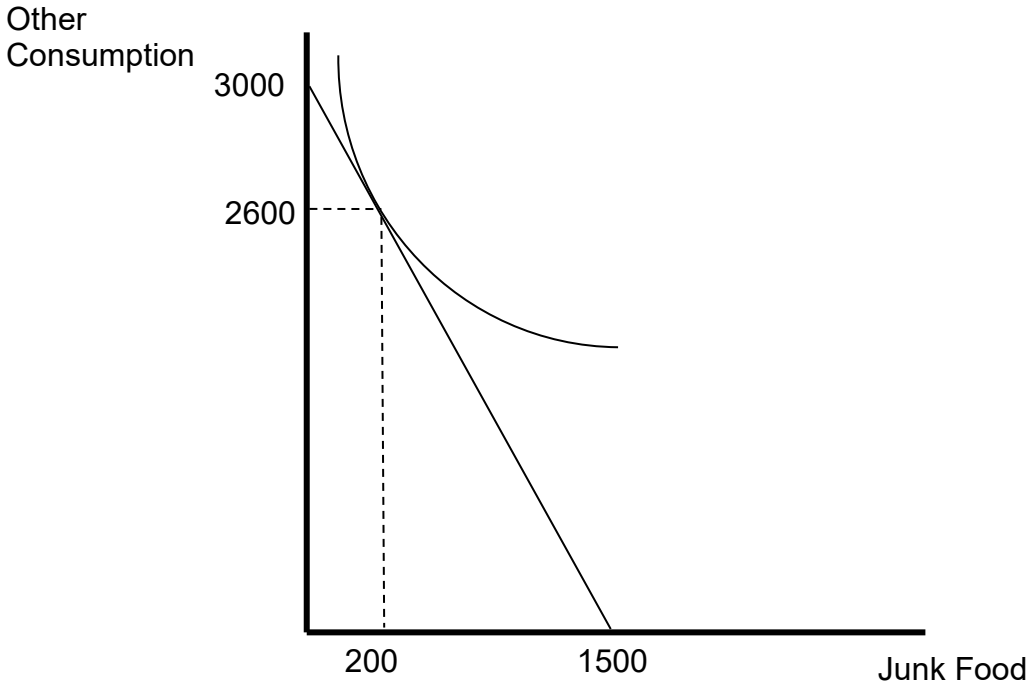
8. Concerned about the unhealthy diet of many American youth, United for Skinny Adolescents (USA), a health advocacy group, proposes a junk food tax. Unhealthy foods such as soda, salty snacks, and high-fat baked goods would be taxed. Because new taxes are unpopular, USA proposes that the policy be revenue neutral. That is, all of the revenue raised from the tax will be given back to taxpayers. For simplicity, in this question we'll assume that all revenues are returned as a lump-sum income tax rebate. That is, each household's income will rise by the amount of revenue raised per household by the new junk food tax.

This question asks you to analyze the effect of this policy on a typical American household. Suppose that, without the policy, the typical American household has $3000 to spend for month. They can spend this money on junk food and other goods. Suppose that, before the tax, a unit of junk food costs $2.[1] At that price, the typical household purchases 200 units of junk food per month.

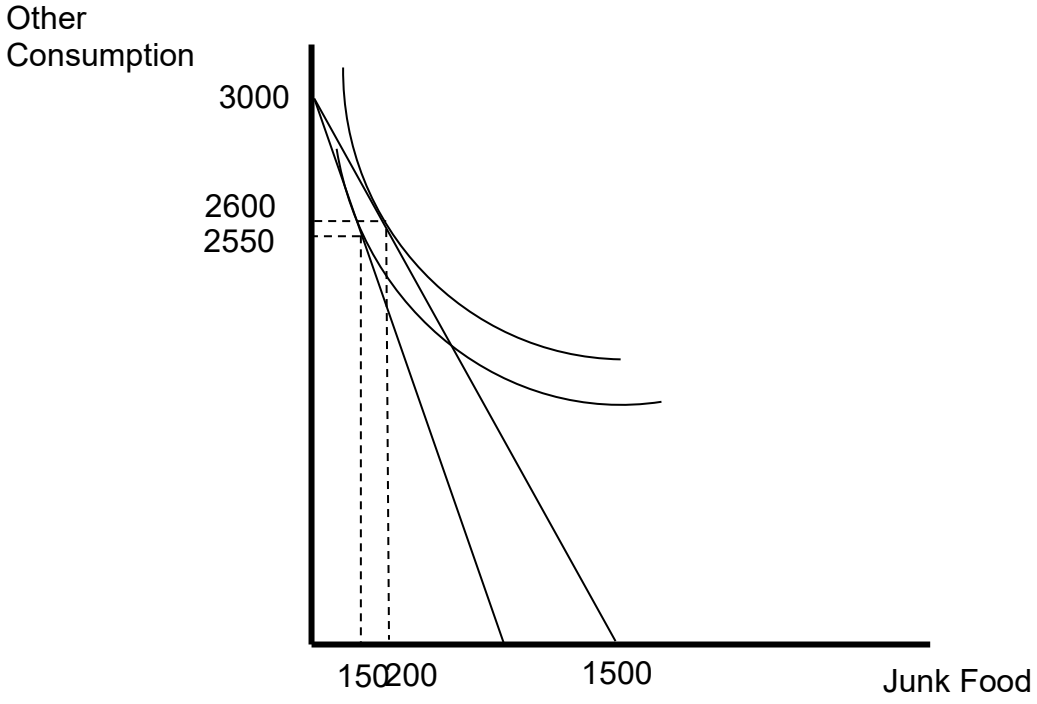
a) Using an indifference curve and budget constraint, sketch this initial condition below, with other consumption on the y-axis, and *units* of junk food on the x-axis.
b) As a result of the proposed tax, the price of junk food will rise to $3/unit. At this new price, the typical household is expected to consume 150 units of junk food per month. Redraw the above graph, and illustrate the effect of the price change on the graph. Be sure to show how much the household spends on other consumption when it chooses 150 units of junk food at the new prices. (Note: for this part of the question, *do not consider the effect of the tax rebate*. That will come in the next part of the question.)
c) Recognizing that new taxes are unpopular, USA proposes returning the income raised by the tax to consumers. Suppose that this is done through a lump-sum income tax rebate. Redraw your graph from part (b). Add a new budget constraint for the typical household after receiving the rebate. For simplicity, assume that consumers bear the burden of the tax, so that the government collects $1 per unit of junk food sold. (*Hint*: Think about how much other consumption a household could afford if they purchased 150 units of junk food, as in part (b), but prices hadn't risen as a result of the tax.)
    - How will the amount of junk food consumed now compared to what households chose before the tax (part a)? How do you know this?
    - How will the utility of consumers after the rebate compare to the utility they had in part (a), before the junk food tax was put in place. Explain intuitively why these are different.

[1] You could think of a "unit" of junk food as representing a bag of chips or bottle of soda, for example.

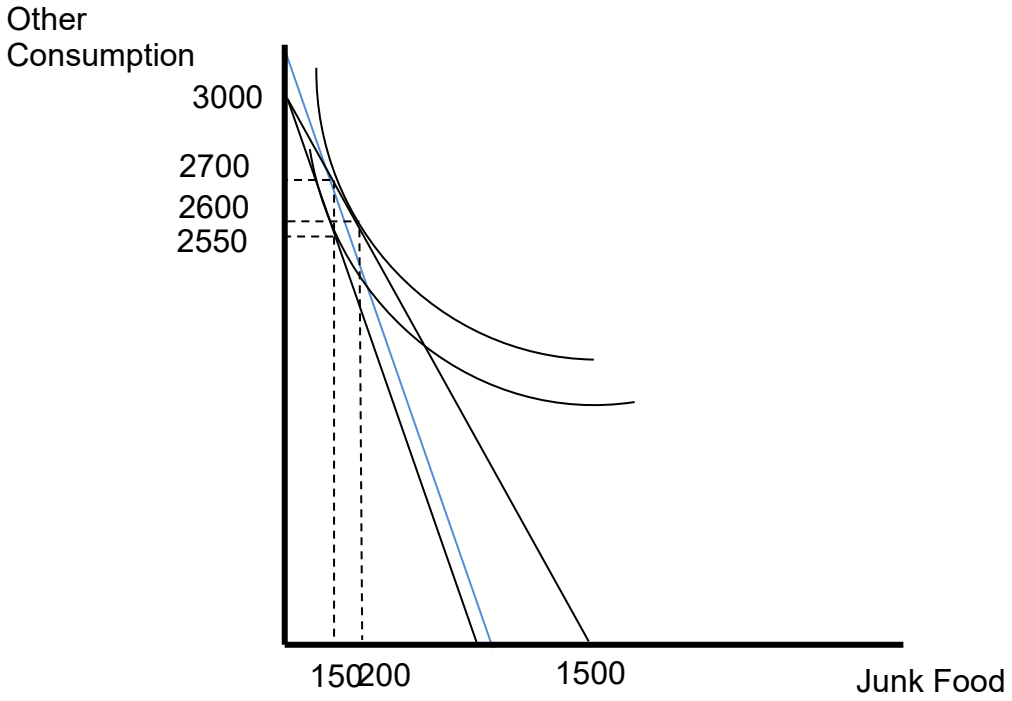
a) To draw the budget constraint, note that consumers can buy up to 1500 units of junk food (= \$3,000/\$2), or \$3,000 worth of other goods. Note that these endpoints are what we need for the budget constraint – we want to show *what is possible*, not just what the consumers actually do. Consumers actually choose 200 units of junk food per month. Since each unit costs \$2, this leaves them \$2600 to spend on other consumption. This is shown by drawing an indifference curve tangent to the budget constraint at 200 units of junk food. This is the highest possible indifference curve given the budget constraint.



b) The price increase rotates the budget constraint in. Now, the most junk food that consumers can afford is 1000 units. Given that the household chooses 150 units of junk food, the family can afford to purchase $2550 worth of other goods (= $3000 – 3(150)). The new indifference curve, tangent to the new budget constraint, is lower than the original indifference curve. Utility has fallen.



c) The key to this problem is the hint. The difference between the two budget constraints is due to the tax. Thus, for any quantity, the difference between the two constraints is the amount of money paid to the government. In this case, the family consumes 150 units of junk food after the tax. They have 2550 left to spend. If they had purchased 150 before the tax, they would have had 2700 to spend. The difference (2700-2550) is the tax revenue (which, it should be noted, equals $150, since the tax is $1 per unit of junk food). Thus, the new budget constraint has a steep slope, parallel to the one drawn in part (b), and goes through the original budget constraint at a quantity of 150 units of junk food. I have made this new line blue to highlight its position.



Note that the blue budget constraint is below the original budget constraint. It is also steeper than the original budget constraint. As a result, households will choose less junk food, even after the rebate. That is because of the *substitution effect*. Higher prices make junk food less appealing. Even if we had given households enough income to get them back to their original utility curve, they would choose less junk food.

As I've drawn the curves above, consumers are worse off with the tax and rebate plan. Although the rebate helps compensate them, it is not enough to get them back to their original indifference curve. Note that the original indifference curve is infeasible with the blue budget constraint. The reason is that the compensation is only equal to the amount of revenue raised by the tax. As junk food prices rise, consumers substitute away from junk food and purchase more of other goods. Because of this substitution effect, the revenue that is raised is not sufficient to get consumers back to their original indifference curve.

The key here is that the new indifference curve goes through the original budget constraint. The old indifference curve only touches that constraint in one place. Thus, it is unlikely for the new line to go through the old budget constraint. However, depending on the scale of your graph, it is possible. If you drew the curves so that there was little change in junk food consumption, the revenue raised may be sufficient to compensate consumers for their lost welfare. As long as your answer to this question was consistent with your drawing in part (c), either answer is acceptable.

The intuition here is that there is a *substitution effect* – people consume less junk food after the tax, which reduces government revenue – and an *income effect* – using the revenue to lower income taxes allows consumers to increase their welfare. One makes consumers better off, and the other makes consumers worse off. For consumers to be better off, the income effect has to dominate the substitution effect.

9. You manage one department in a large corporation. Two years ago, you had 20 workers and produced 40,000 units. The company allocated 10 more workers to your department last year, and output increased to 45,000. You just received a memo from your boss indicating that he is very concerned about the 500-unit fall in the average productivity of your workers. How can you defend yourself?

Defend yourself by noting that you were only given additional labor. Because of *diminishing returns to inputs*, the marginal productivity of the additional labor was less than before. Since marginal product was falling, average product must fall.

The problem is likely one of capacity constraints. If you were also given more capital to work with, the productivity of the labor could be maintained.

10. Suppose that the state of California is debating proposals to increase access to affordable housing. Among the proposed options is offering tax credits to developers of new apartment buildings that reserve 25% of the apartments in new building to be rented at below market rates. A supporter of this proposal argues that this is the best option for California because it will not cost the state government any money. Is this argument correct? Please use arguments from this section of the course to support your answer.

This supporter is ignoring opportunity costs. While it is true that the government will not be spending public money on housing under this proposal, the tax credit will reduce the taxes paid by developers. As a result, the government will bring in less revenue from taxes. The net effect on the budget is no different than if the government kept taxes at their original rates and spent the value of the tax credit to build public housing.

Policy analysts refer to support programs provided through the tax code as tax expenditures. While the government does not spend its own money through such programs, it costs the government money through lost revenue. Common examples in the U.S. include the mortgage interest deduction and the deduction for charitable donations.

One common mistake was to argue that the policy would reduce the supply of other types of housing. Note that the policy only applies to new buildings. It does not apply to existing buildings, so supply will not decrease.

11. CSI, Community Services, Inc., uses a combination of high school students and professional staff to provide services to low-income families in the community. High school students are able to serve 4 families per day, whereas professional staff can serve 20 families per day. Students are paid $40 per day, whereas professionals are paid $100 per day. Their accountant argues that CSI could lower costs by using more students and fewer professionals, while still serving the same number of families. Given the data above, do you agree with this assessment? Why or why not?

The accountant's assessment is incorrect. To minimize costs, CSI should consider how much it costs per family served – the marginal product per dollar spent on each type of worker. We are given information on the marginal product for each type of worker, as well as the cost per day for each. Comparing the two, we see:

$$\frac{MP_{Professional}}{w_{Professional}} \; ? \; \frac{MP_{Student}}{w_{Student}}$$

$$\frac{20}{100} \; ? \; \frac{4}{40}$$

$$0.2 > 0.1$$

Thus, we see that, given the current allocation, professionals serve more families per dollar spent than high school students. Thus, CSI could actually lower costs by using *more* professionals and fewer students.

Alternatively, some of you did the inverse:

$$\frac{w_{Professional}}{MP_{Professional}} \; ? \; \frac{w_{Student}}{MP_{Student}}$$

$$\frac{100}{20} \; ? \; \frac{40}{4}$$

$$5 < 10$$

As long as you interpret this result correctly, your answer will be the same. In this case, rather than calculating the number of families served per dollar spent, you are calculating the cost per family served. The cost per family served is lower for professionals, so more professional staff should be used.

12. Tom's Terrific Turkeys is getting ready for the Thanksgiving rush. Turkeys sell for $30 each, and the market is perfectly competitive. Tom has prepared the following data for his firm:

Q	TC	MC	ATC	AVC
0	$10	--	--	--
1	$20	$10	$20	$10
2	$35	$15	$17.5	$12.5
3	$55	$20	$18.33	$15
4	$80	$25	$20	$17.5
5	$110	$30	$22	$20
6	$145	$35	$24.17	$22.5

a) What are the fixed costs for Tom's firm? How do you know this?

Tom's fixed costs are $10. We know this because he has to pay $10 even if he does not produce any turkeys.

b) Given the current market price of $30, at what quantity would Tom maximize profits? Explain the economic intuition behind your answer.

Since the turkey market is perfect competition, Tom is a price taker, and can sell as many turkeys as he can at $30. Thus, Tom's marginal revenue is $30. To maximize profit, Tom should equate marginal revenue to marginal cost. This occurs when Tom sells 5 turkeys. At this quantity, the amount of extra money he makes by selling a turkey is the same as the additional cost of producing another turkey.

c) Is a price of $30 a long-run equilibrium for the turkey industry? Why or why not?

No. Tom makes a profit of $40 when he sells 5 turkeys at $30 each. (Total revenue = 5 x $30 = $150, and total cost = $110). In long-run equilibrium, firms must make 0 profits. Because there are profits available, firms will enter the turkey industry until the price falls enough so that no more profits are available.

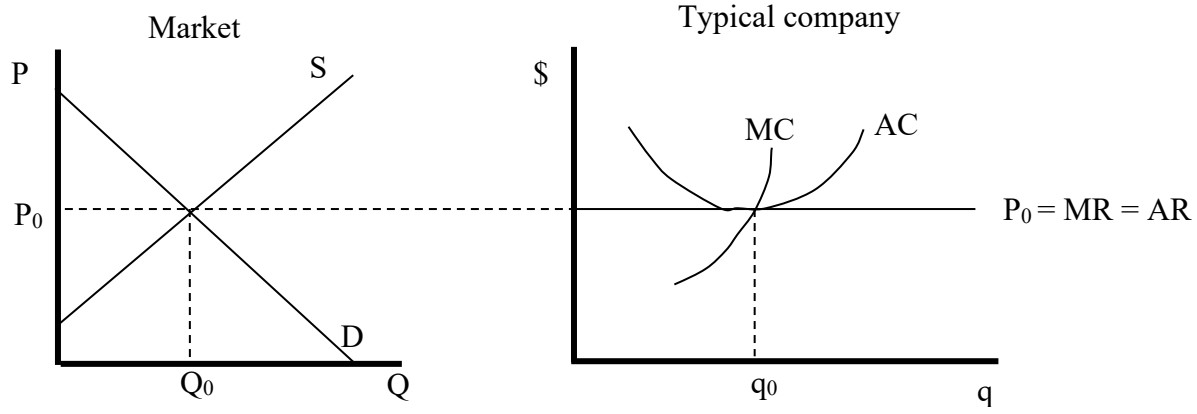
d) Suppose the price fell to $15? How many turkeys would Tom sell now? Would he make a profit? Should Tom continue to operate in the short run? Why or why not?

Tom would sell 2 turkeys. He would lose $5. He should continue to operate, however, since he is at least covering his variable costs, and has some money left to pay some of his fixed costs. If he decided to shut down, he would lose $10 (his fixed costs). Obviously, this is worse than losing $5.

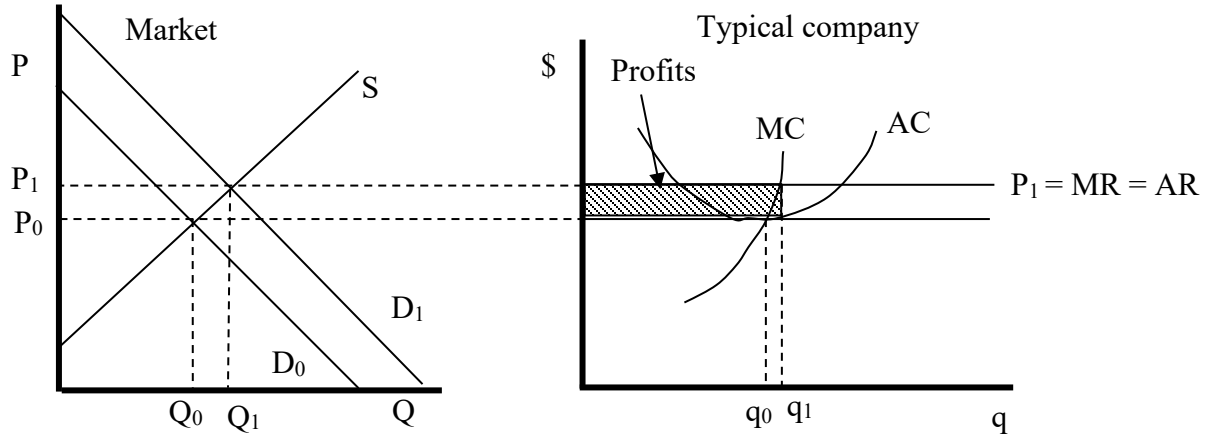
13. This question asks you to consider the market for cab rides in Metropolis. The city is currently served by several cab companies, each who own multiple cabs and hire drivers to operate them. The number of cab companies is sufficiently high to consider the market perfectly competitive.

a) The industry is currently in long-run equilibrium. Using two diagrams, one to represent the market for cab rides, and a second to represent the costs of a typical cab company, illustrate the current price, quantity and profits of a typical cab company. Explain why you have drawn the curves as you did.
b) To reduce traffic in Metropolis, city managers have reduced the number of parking spaces in the city. This has reduced the number of people who bring their own cars into the city, and increased demand for cab rides. Show how this affects the market equilibrium, price, and profits immediately after the policy takes affect. Using one diagram for the cab ride market and a second for a typical cab company, illustrate below.
c) Will the scenario you have described in part (b) be a stable long-run equilibrium? Why or why not? Once again using separate diagrams for both the industry and a typical cab company, illustrate the long run equilibrium for cab rides in Metropolis.
d) To avoid the possibility you discuss in (c), cab companies lobby for licensing rules that prohibit new entry. They argue that, to avoid new congestion problems, only drivers approved by the city should be allowed to operate cabs. Moreover, they argue that the number of approved drivers should equal to the number of drivers operating before the number of parking spaces was reduced. How would that change your answer to part (c)? Why?
e) Economists often call such lobbying efforts "rent seeking" behavior. Why do you think this is? What is the most that the industry would be willing to spend on such lobbying?

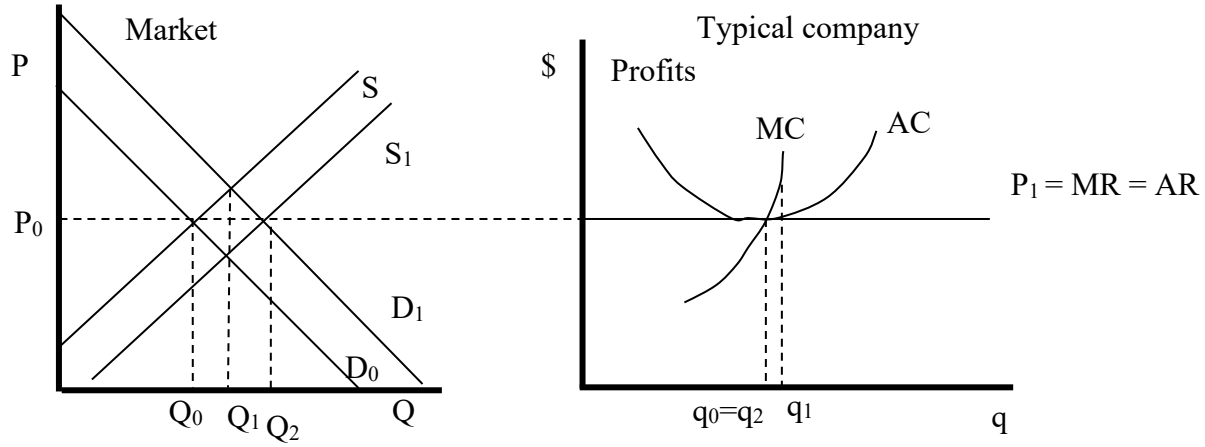
a) In long-run equilibrium, firms are making zero economic profits. The price must be equal to the marginal cost at the point where MC intersects the AC curve.



b) The new policy increases demand for cab rides, so demand shifts to the right. In the short run, increased demand leads to a higher equilibrium price and quantity. Each cab company provides more rides than it did before, and earns positive economic profits.



c) No, it will not be a stable long-run equilibrium. Since cab companies are making positive economic profits, more companies will enter the market, shifting supply out. As a result, the price of cab rides will fall. This will occur until the price returns to its original level, with cab companies making zero economic profit.



d) By restricting the number of drivers, supply would not be able to shift out. The result of part (b) would remain in place, and current cab companies would earn positive economic profits.

e) The positive profits earned in part (d) are an example of economic rent. Intuitively, the extra value from the restriction is now capitalized into the "price" of a cab company. If the owner of a cab company making long-run economic profits decided to sell the company, she would be able to sell for a higher price than for a cab company making zero economic profits.

Since the policies that result from this lobbying result in economic rent, economists often refer to such behavior as "rent seeking." The most an industry would be willing to spend on rent seeking is the total value of the profits to the industry.

14. To reduce reliance on their local electric utility, the city of Mount Washington has decided to build their own municipal power plant. They must now decide what price to charge consumers. After some careful research, you estimate the following demand curve for electricity:

$$P = 400 - 3Q$$

where Q represents the quantity of electricity used per month, measured in megawatt hours (MWh). The marginal costs of electricity generation are $40 per MWh. The fixed costs of running the power plant come to $5,000 per month.

a) Because the municipal power plant is the only source of electricity for local residents, the city can act like a monopolist provider of electricity. Councilman Alexander argues that acting as a monopolist and maximizing profits from the power plant will bring in needed revenue to the city. Find the amount of electricity purchased per month, along with the price per month, if the city maximizes profits as a monopolist. Illustrate on a graph.
b) How much profit does the city make if it acts as a monopoly?
d) Councilwoman Eliza believes that the city is providing a vital public service, and so should provide electricity without any deadweight loss. To completely eliminate the deadweight loss, what should the price of electricity be? How much electricity will citizens purchase at that price? Will the city make money, break even, or lose money at that price? Explain.
d) Redraw your graph from part (a). On it, please show the consumer surplus that consumers receive and the deadweight loss from this pricing strategy. Compare this result to the consumer and producer surplus associated with Councilwoman Eliza's pricing strategy. What does the difference represent?
e) Councilman Aaron is not happy with either plan. He does not like the deadweight loss and large profit from monopoly pricing, but is also not happy with the outcome of part (d). Can you suggest a compromise pricing strategy that could reconcile these concerns? (Note: you do not need to calculate any numbers here. Just give a general explanation of an alternative pricing strategy that could work.)

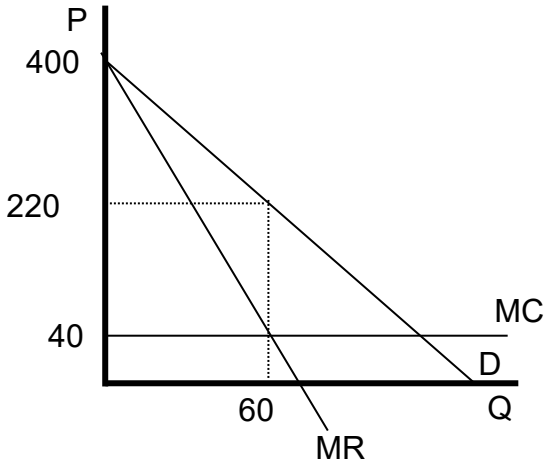
a) Profits are maximized where MR=MC. If the city acts as a monopolist, the marginal revenue curve will bisect the demand curve. Thus, MR = 400 – 6Q.

$$MR = 400 - 6Q = 40 = MC$$
$$360 = 6Q$$
$$Q = 360/6 = \mathbf{60}$$

To get the price, we need to look at the demand curve, to see how much citizens are willing to pay for 60 MWh of electricity. We get:

$$P = 400 - 3(60)$$
$$\mathbf{P = \$220}$$

The graph for this market is shown below. Note that the equilibrium quantity is found where MC=MR, and the price is found from the demand curve. The price charged is how much consumers are willing to pay for 60 MWh of electricity.



b) To calculate the profit, note that we need to consider the fixed cost. Thus, profit is not just the producer surplus from the graph. Rather, we must calculate profit as total revenue minus total cost. Total costs include the per unit costs (= 60 MWh at \$40/per MWh) plus the fixed costs:

$$profit = TR - TC$$
$$profit = PxQ - TC$$
$$profit = (220)(60) - 40(60) - 5000$$
$$profit = \mathbf{\$5{,}800}$$

c) To completely eliminate this deadweight loss, the city should set the price equal to marginal cost. We find the new quantity by equating marginal cost and demand:

$$400 - 3Q = 40$$
$$360 = 3Q$$
$$\mathbf{Q = 120}$$
$$\mathbf{P = 40}$$

Unfortunately, at this price, the city will lose money, because of the fixed costs:

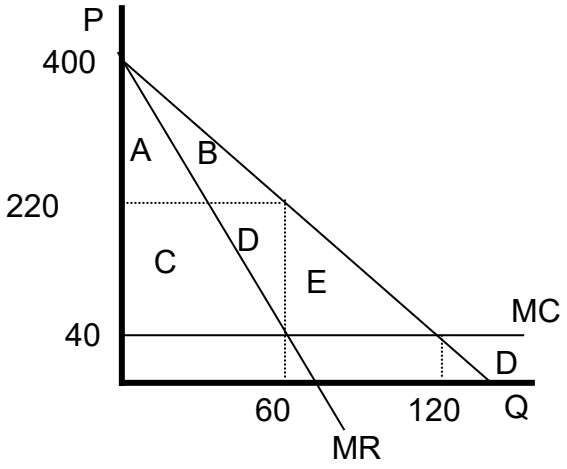
$$\text{profit} = TR - TC$$
$$\text{profit} = PxQ - TC$$
$$\text{profit} = (40)(120) - 40(120) - 5000$$
$$\text{profit} = \mathbf{-\$5{,}000}$$

d) Consumer surplus is the area above the price and below demand. With monopoly pricing it is equal to areas A and B. This is a triangle with base of 60, and a height of 180 (= 400-220). Thus, consumer surplus = 0.5(60)(180) = **$5,400**.

The producer surplus under a monopoly is areas C and D. This is a rectangle with a length of 60 and a width of 180 (= 220-40). It's area = (60)(180) = **$10,800**. Note that this is equivalent to the profits made relative to variable cots (e.g. ignoring the fixed costs).

There is no producer surplus in the case of marginal cost pricing. The consumer surplus with marginal cost pricing includes areas A, B, C, D, and E. This triangle has a base of 120 and a height of 360 (= 400 - 40). Its area = 0.5(120)(360) = **$21,600**.

The sum of consumer and producer surplus with monopoly pricing is $16,200. The difference between the consumer surplus with marginal cost pricing and this sum is **$5,400**. This represents the deadweight loss, which is area E on the graph. This area is a triangle with base of 60 (= 120-60) and a height of 180 (= 220-40). Thus, the deadweight loss = 0.5(60)(180) = **$5,400**.



e) The problem with marginal cost pricing is that it does not cover the fixed costs of providing electricity in Mount Washington. One solution would be average cost pricing, where the price equals the average cost of each MWh of electricity provided. This way, the price covers both the marginal cost of $40 per MWh and each person's share of the fixed costs, allowing the city to break even. While there is some deadweight loss associated with average cost pricing, the deadweight loss will be less than with monopoly pricing.

   Another possibility is to consider price discrimination. For example, low income users could be charged the marginal cost of electricity generation, and higher income users could be charged a higher price. This second price simply needs to be high enough so that it covers the fixed costs as well as the marginal costs of the municipal power plant. Another price discrimination idea suggested by several students is to vary the price by time of day. Users could be charged more to use electricity during peak demand periods, such as hot summer days. Not only does this pricing scheme bring in more money when demand is high, it also discourages households from using electricity when the power plant is under stress from heavy demand.

   Finally, tiered pricing is another option. Each MWh could be priced at marginal cost, but users could also be charged an annual connection fee. The connection fee could be set based on the number of households to cover the fixed costs of the municipal power plant.

15. The Department of Transportation in Boston has been asked to evaluate the price that it charges riders on its subway system. Because of your background in economics, you have been asked by the city to advise their deliberations.

The fixed costs of operating the system are $26,000. In addition, the marginal costs of operation are $1 per rider. Having researched the demand for public transportation in Boston, the city has come up with the following table with price, quantity, marginal revenue, and various costs filled in:[2]

P	Q (riders per day)	MR	AC	MC
15	0	--	--	--
14	2,000	13	14.00	1
13	4,000	11	7.50	1
12	6,000	9	5.33	1
11	8,000	7	4.25	1
10	10,000	5	3.60	1
9	12,000	3	3.17	1
8	14,000	1	2.86	1
7	16,000	-1	2.63	1
6	18,000	-3	2.44	1
5	20,000	-5	2.30	1
4	22,000	-7	2.18	1
3	24,000	-9	2.08	1
2	26,000	-11	2.00	1
1	28,000	-13	1.93	1
0	30,000	-15	1.87	1

[2] For those that are interested, the table was derived using a demand curve of $P = 15 - 0.5Q$ where Q represents 1,000 riders per day. Note that you do not need to know this to solve the problem.

a) Josh, a member of the city council, has taken some economics, and recalls that setting prices equal to marginal cost is efficient. Thus, he asks you to consider what the effects of setting the price equal to marginal cost will be. How many riders will use the subway at this price? How much revenue will these riders generate? What will be the total costs of serving these riders? Will the subway make money, lose money, or break even?

Since the marginal cost is $1, this requires setting the price at $1. From the table, we see that at this price there will be **28,000** riders.[3]

These riders will generate **$28,000** of revenue (= $1 x 28,000).

The total cost of providing this service is **$54,000**. You could find this in one of two ways. First, you could multiply the marginal cost per rider of $1 by the quantity, and then add the $26,000 fixed cost (= $1 x 28,000 + $26,000). Second, you could simply multiply average costs by quantity (=$1.93 x 28,000). The second method will not be exact, since the average cost figures presented have been rounded off.

Since the total costs are greater than the total revenues, the city will lose money. Boston loses **$26,000** operating its subway using marginal cost pricing. Intuitively, since the marginal cost is constant, marginal cost pricing covers all of the variable costs, but does not provide any money to cover fixed costs.

b) Manny, a second council member, suggests that Boston should take advantage of its market power. He asks you to determine the price at which the city, which has a monopoly as the only subway operator, would maximize its profit from the subway. What price would that be? How many riders would use the subway? Please calculate the total revenue and total costs, as well as the profit generated by these riders.

To maximize profits, we must find the point where marginal revenue equals marginal costs. Since the marginal cost is $1, we find the quantity where marginal revenue equals $1, which occurs with **14,000** subway riders. The price for this quantity is **$8**.[4]

These riders will provide **$112,000** of revenue (= $8 x 14,000).

The total cost of providing this service is **$40,000**. Again, you could find this in one of two ways. First, you could multiply the marginal cost per rider of $1 by the quantity, and then add the $26,000 fixed cost (= $1 x 14,000 + $26,000). Second,

[3] Note that you could also get this answer by setting the demand curve equal to marginal cost: $15 - 0.5Q = 1$ implies that $Q = 28$. However, since I gave you the information in the tables, such calculations were not necessary.

[4] Again, you could use the bisection rule and then find this algebraically. Given the demand curve of $15 - 0.5Q$, we know that $MR = 15 - Q$. Setting this equal to 1 gives us $15 - Q = 1$, which simplifies to $Q = 14$. We get the price by plugging this quantity into the original demand curve.

you could simply multiply average costs by quantity (=$2.86 x 14,000). Because of rounding, this second method will not be exact.

Finally, we find the profit by subtracting total costs from total revenue. The city makes **$72,000** of profit at this price.

c) A third member of the council, Jonathan, is concerned about consumers, and does not want the city to maximize its profits. However, it is important to Jonathan that the city covers its costs, so that Boston does not lose money operating the subway. Based on the numbers above, what price should the city set to meet Jonathan's goal? How do you know this?

At this price, how many riders will use the subway? How much revenue will they generate? What will be the total costs of serving these riders? What profit, if any, does the city make from these riders?

For the city of Boston to just cover its costs, the profits should equal zero. The trick here is to remember what holds when the profits are equal to zero. When profits equal zero, total costs and total revenue are equal. Thus, *average revenue* and *average cost* are also equal. Since average revenue is just the price, we need to find the price and quantity sold when average costs and price are equal. This is the intuition of average cost pricing that we discussed as a potential policy solution for natural monopolies.

Referring to the table, we see that average costs and price are equal two places: at a price of $14 or a price of $2. While I gave students that chose a price of $14 partial credit for recognizing the P=AC relationship, given Jonathan's goals, the better choice is a price of **$2**. At this price, **26,000** people ride the subway. Because Jonathan is concerned about consumers, it makes more sense to choose the lower price, and thus the higher number of riders. Moreover, choosing a price of $14 would results in a higher price, lower ridership (2,000 riders), and lower profits than the profit maximizing strategy in part (b). Thus, neither the city nor consumers are better off choosing $14 instead of the profit-maximizing price of $8.

These riders generate **$52,000** of revenue (= $2 x 26,000).

The total cost of providing this service is also **$52,000**. You could find this in one of two ways. First, you could multiply the marginal cost per rider of $1 by the quantity, and then add the $26,000 fixed cost (= $1 x 26,000 + $26,000). Second, you could simply multiply average costs by quantity (=$2 x 26,000).

As expected, Boston makes no profit in this case. It just breaks even. Thus, it satisfies the goal of serving as many people as possible without losing money.

16. Evaluate the following statement:

"The First Theorem of Welfare Economics states that as long as producers and consumers act as perfect competitors, and there are no other market failures, a Pareto efficient allocation of resources emerges. Thus, if market failure is not evident, there is no justification for government intervention in the economy."

This statement assumes that the only justification for government intervention is market failure. However, the First Theorem of Welfare Economics only states that, in the absence of market failure, an efficient solution results. It does not say anything about the desirability of efficiency. Recall from class that an efficient solution could nonetheless involve a very inequitable distribution of income. Some people may find this objectionable, and argue that government intervention is needed to promote more equality.

17. For each of the policy proposals below, identify who the potential beneficiaries and losers (if any) are. Then, state whether the change is likely to be:

1) a Pareto improvement
2) an improvement in social welfare using a Rawlsian social welfare criterion.

Explain briefly.

a) Providing free health care to low-income families, financed by increasing income taxes

The potential beneficiaries are those receiving free health services. These will all be low income families.

The losers are those who are pay higher income taxes but do not receive additional health services. Since low-income families pay little or no income tax, most taxpayers will be losers in this scenario.

Because one group benefits at the expense of another, this policy is not a Pareto improvement.

However, because it benefits the least well-off members of society, it is an improvement in social welfare using a Rawlsian social welfare criterion.

b) Providing free public wi-fi, financed by an increase in sales taxes

The potential beneficiaries are those who would use the free public wi-fi. Presumably, one will need to use a cell phone or laptop to access these services.

Losers in this scenario are those who pay higher sales taxes but receive little or no benefit from free public wi-fi. For instance, those who don't use a cell phone would not benefit.

Since not everyone owns a cell phone, there will be some consumers who pay more in sales taxes but do not enjoy the benefits of free public wi-fi. Thus, the policy is not a Pareto improvement.

To be an improvement in welfare under a Rawlsian social welfare criterion, the policy must improve the welfare of the least well-off people in the community. Since the poorest people in the community are unlikely to own a cellphone, this policy is likely not a welfare improvement under a Rawlsian social welfare function.

c) Providing free public wi-fi, financed by a tax on cell phone users.

The potential beneficiaries are those who would use the free public wi-fi. Presumably, one will need to use a cell phone or laptop to access these services. Thus, the beneficiaries are also the ones paying the cost of free public wi-fi. Thus, there are not clearly identified losers in this scenario. (A possibility is someone who only uses their phone to make phone calls, and thus doesn't care about free public wi-fi.)

While it is not necessarily the case, it is possible that this policy could be a Pareto improvement. If cell phone users value free public wi-fi service at least as much as the cost of the tax increase, it is a Pareto improvement.

However, the policy is not an improvement in welfare under a Rawlsian social welfare criterion, since it does nothing to improve the welfare of those who are so poor that they do not use a cell phone.

In answering these questions, note that a Rawlsian social welfare criterion does not necessarily imply competition among different classes – it is just that if focuses on the well-being of those who are the worst off. For example, some students said that the tax on cell phone users is an improvement with a Rawslain social welfare criterion, because it makes laptop users better off at the expense of cell phone users. That is incorrect. The key question is whether the policy makes the *worst off* people in society better off.

18. *Using theories discussed in this class*, what rationale can you provide (if any) for government intervention in the following areas? Your answer should both clearly state whether or not you think the proposed service makes sense, and should use economic logic to defend your answer.

a) Prohibiting smoking in public buildings

Because of the dangers of second-hand smoke, smoking creates negative externalities to those nearby. Thus, prohibiting smoking in public buildings can be justified by reducing the harm from second-hand smoke, and thus reducing a negative externality.

b) Food stamps

Providing food stamps cannot be justified as correcting a market failure. Rather, support for food stamps depends on concerns about equity and redistribution. For example, if market forces leave some families with insufficient food for sustenance, we may support food stamp programs as a way to provide a minimum level of food consumption for everyone.

c) Public transportation

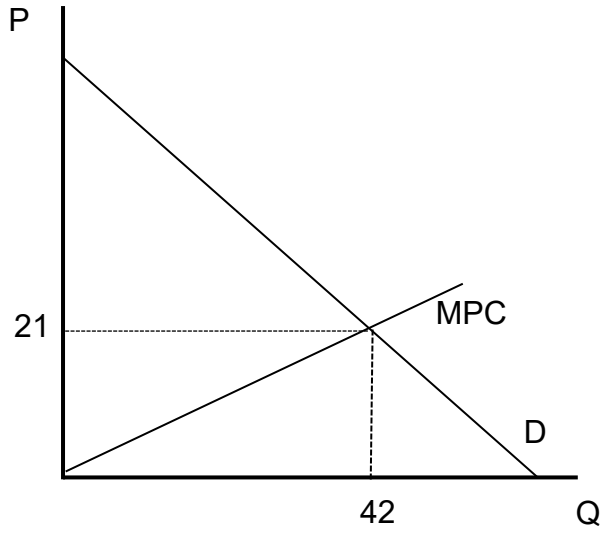
There are several possible justifications that could be offered for public transportation. First, public transportation reduces traffic congestion and the pollution that comes from traffic. Thus, the use of public transportation helps reduce negative externalities. One could also support public transportation for equity reasons. For example, public transportation can be used by low-income citizens that cannot afford their own vehicle. Government provision of a natural monopoly is another possible answer. It would not be sensible to duplicate the infrastructure (particularly for things such as subway tunnels) to allow multiple companies to compete on public transit routes. Thus, a single operator makes sense. Having the government as this operator prevents a for-profit firm from abusing monopoly power over public transport.

One justification that does not work here is public transportation as a public good. Public transportation has neither of the features of a public good. It is excludable – you cannot use the service without paying. Moreover, as anyone who has rode public transportation in a large city at rush hour can attest, it is also rival.

19. Golf balls are hand crafted by artisans in Scotland. Demand for golf balls can be represented by the curve P = 105-2*Q*, where *Q* represents boxes of golf balls. The marginal cost per box of golf balls equals 0.5*Q*. However, to produce dimples on golf balls, the artisans must chip away at the surface of the balls, creating small waste particles that pollute the local environment. The damage done to the local environmental is given by the following marginal damage curve: MD = *Q*.

a) Assume that the market for golf balls is perfectly competitive. How many boxes of golf balls will be produced if nothing is done to regulate the pollution? At what price will they be sold? Use a graph to illustrate your answer.
b) What is the socially efficient level of golf ball production? What should the price be? Use a graph to illustrate your answer.
c) To bring about the level of production you found in part (b), the government proposes using a Pigouvian tax. At what level should they set the tax? How do you know this?

a) In a competitive market, we use marginal cost to get the supply curve. Thus, we set demand equal to the marginal private costs to find the quantity sold. Note that, since nothing is done about pollution in this question, we ignore the damages caused by pollution. In this case, marginal private costs equal 0.5*Q*.

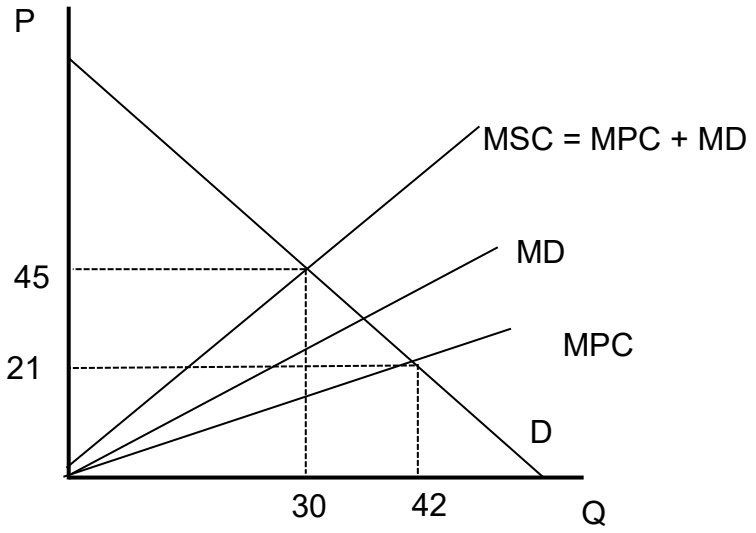


$$105 - 2Q = 0.5Q$$
$$105 = 2.5Q$$
$$Q = 105/2.5$$
$$\boldsymbol{Q = 42}$$

To find the price, plug this quantity into either supply or demand to get ***P* = $21:**

$$P = 105 - 2(42) = \$21$$
or
$$P = 0.5(42) = \$21$$

b) To find the efficient level of production, we equate the social marginal cost and demand. Social marginal cost is the sum of private marginal costs (0.5*Q*) and marginal damages (*Q*). Thus, social marginal costs equal 1.5*Q*.



We get:

$$SMC = 1.5Q = 105 - 2Q = \text{demand}$$
$$3.5Q = 105$$
$$Q = 105/3.5$$
$$\boldsymbol{Q = 30}$$

To get the price, plug the quantity of 30 into demand:

$$P = 105 - 2(30) = \$\mathbf{45}.$$

c) The tax should make producers to incorporate the cost of pollution into their decisions. Thus, the tax should equal to the marginal damage at a quantity of 30. Since MD = *Q*, the tax equals **$30**.

Note that the price does not increase by the full $30. That is because the producer price falls – both consumers and producers bear the burden of the tax. At a quantity of 30, the marginal private cost equals $15. As marginal private cost represents the original supply curve in a competitive market, this is the price that suppliers will receive after the tax. When the price received by producers falls from $21 to $15, the difference between the consumer price ($45) and producer price ($15) equals the Pigouvian tax of $30.

A common mistake was to use the difference between $45 and $21 as the tax. This equals $24. However, this tax will not be sufficient to reduce the equilibrium quantity to 30, as shown below, here I add the tax to the marginal private cost curve:

$$105 - 2Q = 0.5Q + 24$$
$$81 = 2.5Q$$
$$Q = 32.4$$

20. Lake Poisson is being poisoned by two chemical firms on its shores. The wastewater released into the lake by these firms, Acme Acids and Barry's Bases, are killing the fish in Lake Poisson. Each firm is currently emitting 10 gallons of pollution into the lake. Scientists estimate that to neutralize the effect of this pollution, 12 gallons of waste from these plants will need to be eliminated. The marginal costs of reduction for each firm are as follows:

Abatement	Acme Acids	Barry's Bases
1	$5	$10
2	$10	$20
3	$15	$30
4	$20	$40
5	$25	$50
6	$30	$60
7	$35	$70
8	$40	$80
9	$45	$90
10	$50	$100

a) The government's goal is to reduce 12 gallons of emissions. To do this, they require each firm to abate 6 gallons. What is the total cost of abatement for Acme Acids? For Barry's Bases? What is the combined total for both firms?
b) Is this the cheapest way to reduce 12 gallons of total emissions? If not, can you suggest a better strategy? How many tons should Acme Acids clean up to minimize clean up costs? How many gallons should Barry's Bases clean up to minimize clean up costs? Please explain how you found your answer.
c) Can you suggest a policy that will lead the firms to clean up the amounts you propose in part (b)? Explain how the policy works to bring about the efficient solution.

a) To find the total costs of abatement for each firm, we add up the marginal abatement costs for each gallon.

For Acme Acids, the total cost of abatement = $5 + $10 + $15 + $20 + $25 + $30 = **$105**.
For Barry's Bases, the total cost of abatement = $10 + $20 + $30 + $40 + $50 + $60 = **$210**.

The combined total is **$315**.

b) This is not the cheapest way to reduce 12 gallons of pollution. To see this, note that marginal abatement costs of the last gallon reduced are not equal. Eliminating the 6th gallon of pollution only costs Acme Acids $30. In contrast, eliminating the 6th gallon costs Barry's Bases $60. If Barry's Bases did not have to eliminate this 6th gallon, they would save $60. At the same time, suppose we ask Acme Acids to remove one additional gallon (so that total abatement remains at 12 gallons). This would only cost Acme $35. Thus, we could still reduce 12 gallons of pollution, but save $25 (= 60-35).

   Such savings are possible any time the two marginal abatement costs aren't equal. Thus, we can continue making such trades until the marginal abatement costs are equal. This occurs when Acme Acids removes **8** gallons of pollution, and Barry's Bases removes **4** gallons of pollution. Here, the marginal abatement cost of each firm equals $40.

   Note that the total abatement costs have now fallen. Acme Acid's cleanup costs rise slightly, to $180. However, Barry's Bases now spends only $100 on pollution abatement. The total abatement cost of $280 is $35 lower than in part (a).

c) There are a couple of policy options that could achieve an efficient allocation of abatement responsibility. One is an *emissions fee*. Consider an emissions fee set just above $40 (e.g. $40.01). For Acme Acids, they will not choose to pollute and pay the fee until they have removed 8 gallons of pollution, since the marginal abatement cost for the first 8 gallons is less than the fee. In contrast, Barry's Bases will only remove 4 gallons of pollution. After that, it is cheaper to pay the fee than to pollute less.

   An alternative policy with the same effect would be to give each firm tradable pollution permits. We could begin by giving each firm enough permits to cover one-half of their pollution. Thus, the starting point is similar to the current policy. However, if firms are allowed to buy and sell permits, Barry's Bases will buy permits from Acme Acids until their two marginal abatement costs are equal. At that point, no more beneficial trades are possible. For example, beginning with the initial allocation, Acme and Barry could negotiate a permit price anywhere between $35 and $60. At this price, Acme could sell one permit to Barry. Since Acme's marginal abatement cost for the 7th gallon is $35, any price above $35 allows them to cover the clean-up costs and save the remainder as profit. Similarly, by reducing one less gallon of pollution, Barry's Bases saves $60. Thus, they are willing to pay any price up to $60 to avoid the clean-up cost.

21. Canterbury and Midland are remote regions in the country of Amazonia separated by a large mountain range. To travel from one region to the other, drivers must either take a series of narrow, windy roads over the mountains or drive around the mountain range. Either route takes 3 hours to complete.

The leader of Amazonia proposes building a tunnel through the mountains. This tunnel will provide a direct route connecting Canterbury and Midland, and reduce the travel time between these regions to just 45 minutes. Because the tunnel will reduce travel times, reduce congestion on narrow mountain roads, and stimulate economic development in these regions, he argues that the tunnel is a public good.

Do you agree? Using theories discussed in class, should the tunnel be considered a public good?

A public good has two features: it is *non-rival*, meaning that many people can use the good at the same time, and it is *non-excludable*, meaning that we cannot prevent people from using the good, making it difficult to collect a fee for usage. Neither applies here. Thus, while the tunnel may be beneficial to Amazonia, the tunnel is not a public good.

As the tunnel becomes more crowded, travel times will fall. Thus, congestion is a possibility. While it may be non-rival for low levels of traffic, at some point it will become rival. A few people pointed out that, since congestion is only a problem for high traffic levels, the tunnel has characteristics of a club good.

Similarly, although Amazonia may choose to not charge a toll for using the tunnel, the decision to finance the tunnel by other means is a choice. It is not a feature of the tunnel. Since there are limited entry points, it would be possible to charge a toll to drivers using the tunnel. Thus, excluding people who don't pay would be feasible.

22. Some national parks do not charge entrance fees during the winter, except on weekends. Is this an efficient pricing policy?

This is an efficient pricing solution. In the winter, national parks are rarely crowded during the week. As a result, the parks are non-rival. The marginal cost of additional visitors is zero, and so it is inefficient to charge an admission fee.

Some students argued that the pricing solution is efficient because it is a use of peak-pricing. That is also an acceptable answer. I was looking to connect this question with our discussion of public goods, but the logic is the same – the park is only rival during periods of peak use.

23. Three neighbors – Tyrone, Tasha, and Pablo – will be voting on expansion of a neighborhood park. The expansion will cost $6,000. All three will share the cost of the expansion – that is, each person will contribute $2,000 to the installation. The expansion is worth $2,500 to Tyrone, $2,250 to Tasha, and $1,000 to Pablo.

a) Explain why the park expansion is a public good.
b) Is the proposed park expansion efficient? Why or why not?
c) Suppose a majority rule vote is held to determine whether the expansion should take place. What will the result of the vote be? Explain any differences between this result and your answer in part (b).

a) The park expansion is both *non-rival* and *non-excludable*. It is usually impossible to keep anyone from enjoying the benefits of a neighborhood park, as unlimited access is usually desired. In addition, it is non-rival. Unless the park becomes very crowded (again, unlikely in a small neighborhood park), more people using the park will not reduce its benefits.

b) It is not efficient to proceed with the park expansion. Since this is a public good, we need to compare the social marginal benefit – that is, the sum of individual marginal benefits – to the marginal cost. The sum of marginal benefits equals $5,750. This does not justify the cost of $6,000 to expand the park.

c) If the expansion is approved, each voter will pay $2,000. To determine whether an individual will vote yes or no, compare the voter's *individual* benefit to their share of the cost:

Tyrone = 2,500 – 2,000 = $500
Tasha = 2,250 – 2,000 = $250
Pablo = 1,000 –2,000 = -$1,000.

Since two of the three voters have positive net benefits, the park expansion will be approved. Both Tyrone and Tasha will vote for the expansion. The problem here is that the yes/no referendum does not reflect the intensity of an individual's preferences. The two who vote for the expansion have only a small positive net benefit. Pablo, the only one who opposes the expansion, has large negative net benefits. However, his no vote has only as much weight as one of the two yes votes.

24. Consider the price of an automobile insurance policy that replaces the car in case it is destroyed in an accident. For simplicity, assume all cars are worth exactly $20,000 and all accidents require that the car be replaced. Also, assume there are just two types of drivers:

- Safe drivers, who have a have a 1% chance of being in an accident
- Speedsters, who have a have a 5% chance of being in an accident

a) If a driver is in an accident, the insurance policy will replace the vehicle with a new one of equal value. Given this, what is the actuarially fair price for an insurance policy that only covers safe drivers? That is, what is the expected value of the damages that safe drivers have?
b) What is the actuarially fair price for an insurance policy that only covers speedsters? That is, what is the expected value of the damages that speedsters have?
c) Suppose that one-half of all drivers are safe drivers, and the other half are speedsters. If the insurance company must offer a policy with the same price to all drivers, what would that price be? That is, what price covers the expected value of payouts to all drivers?
d) At this price, will safe drivers wish to buy insurance? Why or why not? What type of market failure does this illustrate?

a) Actuarially fair insurance is when the premium equals the expected payout. Here, there is a 1% chance of an accident that will lead to a $20,000 payout. Thus, the expected payout is 0.01 X $20,000 = **$200**.

While the calculation above is all you needed to answer this question, note how this relates to the example we did in class. Either with or without insurance, this driver would have the same expected income:

- EV(with insurance) = 100%($20,000 - $200) = $19,800
- EV(no insurance) = 0.99($20,000) + 0.01($0) = $19,800

b) Here, there is a 5% chance of an accident that will lead to a $20,000 payout. Thus, the expected payout is 0.05 X $20,000 = **$1,000**.

While the calculation above is all you needed to answer this question, note again how this relates to the example we did in class. Either with or without insurance, this driver would have the same expected income:

- EV(with insurance) = 100%($20,000 - $1,000) = $19,000
- EV(no insurance) = 0.95($20,000) + 0.05($0) = $19,000

c) The insurance company needs the price to cover its expected payouts. If one-half of drivers have a 1% chance of an accident, and one-half have a 5% risk, the average risk is 3%. Thus, the expected payout is 0.03 X $20,000 = **$600**.

d) At a price of $600, safe drivers will choose not to buy insurance. Their expected income is higher without it:

- EV(with insurance) = 100%($20,000 - $600) = $19,400
- EV(no insurance) = 0.99($20,000) + 0.01($0) = $19,800

This is an example of **adverse selection**. Adverse selection occurs because insurance is more attractive to people with a high probability of suffering a loss. If the insurance company is unable to identify which drivers are safe, or if government regulations do not allow them to charge higher prices to riskier drivers, the resulting price will be based on average risk. Such a price discourages low-risk drivers from buying insurance.

A common error here was to say this is an example of moral hazard. While moral hazard is relevant for insurance, that is not what this example shows. Moral hazard is when a person takes unnecessary risks because they are not responsible for the full cost of their actions. Even if the insurance company could charge a higher price to Speedsters, those drivers could still take greater risks because insurance will pay the costs if an accident occurs.

25. Characterize each of the following as an example of (i) adverse selection, (ii) moral hazard, or (iii) principal-agent problem. Explain briefly.

a) A savings and loan association, with federally insured funds, makes risky investments.
b) A physician prescribes tests that are relatively expensive and ineffective for treating a patient's illness.
c) An employee signs up for disability insurance, aware of having an illness that is likely to be disabling.

a) This is an example of moral hazard. Because the bank is insured, it can take greater risks, because it will not pay the full cost of a negative outcome.

b) This is an example of a principal-agent problem. The doctor is compensated for the tests provided, whether or not the patient gets better. Prescribing more tests rewards the doctor, but does not help the patient.

c) This is an example of adverse selection. Those most likely to benefit from insurance are more likely to purchase it.

26. Concerned about trash in neighborhood parks, the city of Urbana has decided to undertake a beautification project. As a result of cleaner, more attractive parks, they expect that park attendance will increase by 10%. They also project that property values of homes near the park will increase by $5,000 per home. There are 1,000 homes that are considered "near" local parks.

a) What are the benefits of the beautification project?
b) How would you measure these benefits?

a) The benefits of the beautification project are the increased recreation opportunities due to a cleaner, more attractive park. The city estimates that these opportunities will increase by 10%, and that residents of 1,000 homes will take advantage of these opportunities.

b) We can use the increase in property values to place a dollar value on the increased recreation opportunities. Homes near the park will be worth $5,000 more after the beautification project. That is, people are willing to pay an extra $5,000 to be in a location where they can enjoy the cleaner park. 1,000 homes are near the parks. Thus, the total value is $5,000,000 (=$5,000 x 1000).

Note that, in doing a cost-benefit analysis, you could simply list the benefits as the 10% increase in recreational opportunities, or you could value these benefits at $5,000,000. However, including a $5,000,000 benefit plus 10% additional recreational opportunities would be double counting, as it is increased opportunities from cleaner parks that cause the property values to rise.

27. We Like Sports (WLS) is a group of citizens lobbying for a new sports stadium for the local baseball team. They argue that the new stadium would have several benefits:

- Currently, the team attracts 1 million spectators a year. WLS projects that with the new stadium, 1.5 million fans will attend games. Each fan spends $30 at the game, which generates $3 in taxes. This will create additional revenue for the city.
- In addition to spending money on the games, WLS argues that these fans will bring more revenue to the city. They project that one-half of these fans will eat at restaurants near the stadium, either before or after the game, providing a needed boost to the struggling neighborhood around the stadium.
- Finally, WLS projects that 10% of these fans will travel from a town more than two hours away, and will choose to stay in a local hotel after the game.

You have been hired by the city to provide an impartial analysis of the proposed stadium. As part of this analysis, you have been asked to critique the claims of WLS. Do you agree with the potential benefits? In preparing a cost-benefit analysis, should these benefits be considered? Please explain your answer.

We Like Sports (WLS) is being overly generous by attributing all these benefits to the stadium. First, consider the claim that additional tax revenues will be raised from increased attendance. Here, WLS has ignored the distinction between benefits and transfers. For these revenues to truly be a benefit, they must be new resources coming into the city (assuming that the analysis is being done at the scale of the city). For any new fans that are from the city, this is simply a transfer of money from their pockets to the city's revenues. Moreover, for fans coming from outside the city, this tax revenue is only a benefit if these people would not have visited the city anyway. If increased attendance at baseball games means lower attendance at local theaters, museums, etc., then this is also a transfer. In this case, the baseball team benefits at the expense of other local attractions, and revenues for the city as a whole do not increase (here, I'm assuming that fewer visitors at other attractions means less tax revenue from those places). Similar logic holds for the other claims. While there may be more business at restaurants near the stadium, at least some of this business will come at the expense of other restaurants in the city.

The most likely benefit is the 10 percent that come from more than two hours away. Again, what matters here is whether these people would have visited the city anyway, or whether it is the baseball game that makes them want to come. If they would not come without the new stadium, the revenues brought in by these new fans, both through taxes and through their purchases at local businesses, are a legitimate benefit in the eyes of the city.

28. Emerald City is connected to its suburbs by two highways, one privately owned and one public. Because the public highway has no toll, it has much traffic, so that it takes 75 minutes to complete a journey to Emerald City. The Yellow Brick Highway is a privately run toll road. A journey on the Yellow Brick Highway costs $5. Because of the tolls, the highway is less congested, so that commuters using the Yellow Brick Highway can reach Emerald City in 60 minutes.

After careful study, you have determined that the demand curve for the Yellow Brick Highway is:

$$P = 10 - 0.05Q$$

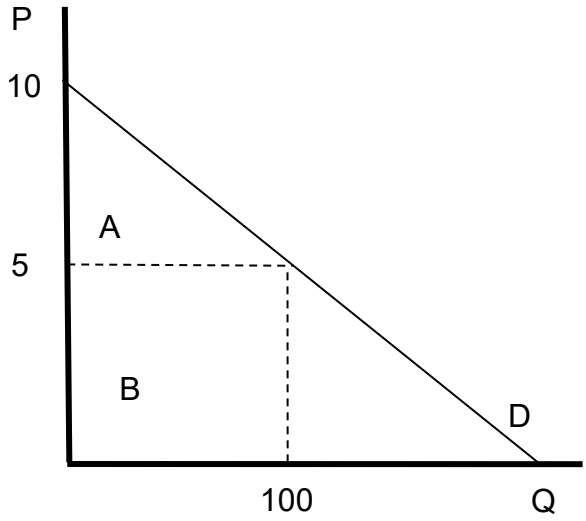
where Q represents the number of drivers on the toll road per hour.

a) At the current toll of $5, how many drivers will use the Yellow Brick Highway each hour? Illustrate on a graph.
b) What is the total willingness to pay for the number of journeys on the Yellow Brick Highway that you found in part (a)?
c) How much time does a driver save by using the Yellow Brick Highway rather than the public highway? Using this information and the total willingness to pay found in part (b), calculate the value of one hour of time to a typical user of the Yellow Brick Highway (*Hint*: First use the number of drivers found in part (a) and your answer in part (b) to find the willingness to pay per person for the amount of time saved).

a) To find the number of drivers using the Yellow Brick Highway each hour, simply replace P with $5 and solve for Q:

$$5 = 10 - 0.05Q$$
$$5 = 0.05Q$$
$$Q = 5/0.05$$
$$\boldsymbol{Q = 100}$$

The graph is shown on the next page, along with the areas necessary to find willingness to pay in part (b).



b) The willingness to pay for 100 trips on the highway equals the total expenditure on tolls (area B) plus consumer surplus (area A). The value of each is:

area A = consumer surplus = 0.5(10 - 5)(100) = $250
area B = expenditure = (5)(100) = $500
Willingness to Pay = A + B = **$750**

c) Since it takes 60 minutes to get to Emerald City using the Yellow Brick Highway, rather than 75 minutes using the public highway, each driver on the Yellow Brick Highway saves 15 minutes. Since there are 100 drivers, this is a total of 1,500 minutes saved.

The community as a whole is willing to pay $750 to save 1,500 minutes. This comes to $0.50 per minute (= 750/1500). Multiplying this by 60 minutes gives us a value of **$30 per hour**.

Alternatively, you could solve this by saying each of the 100 drivers using the Yellow Brick Highway places a value of $7.50 on their time saved (= $750/100). Each driver saves 15 minutes, which is ¼ of an hour. Thus, multiplying $7.50 by 4 gives the total value of $30 per hour.

29. Consider two projects. The first has a large setup costs, but provides larger benefits afterwards. The second involves no set up, but provides only minimal net befits each year. The net benefits of each project in each year are listed below:

Project	Year 0	Year 1	Year 2	Year 3
A	-$200	$100	$100	$100
B	$100	$100	$100	-$250

You may assume that all values are presented as real dollars.

a) Suppose that the real discount rate is 3%. Which project is preferable? Why?
b) Suppose that the real discount rate is 7%? Which project is preferable? Why?
c) Explain intuitively why the results differ in parts (a) and (b).

a) In each case, we need to calculate the net present value of each project. For each discount rate, we will select the project with the highest net present value. We use the following formula to calculate the net present value. Note that costs or benefits that occur in year 0 are not discounted. Future benefits and costs are discounted as appropriate. In each case, we are given net benefits for a given year, and discount that value as appropriate. Thus:

$$NPV = FV_0 + \frac{FV_1}{(1+r)} + \frac{FV_2}{(1+r)^2} + \frac{FV_3}{(1+r)^3}$$

where FV_t is the future value of the net benefit in year t.

We begin by using the above formulas with a discount rate of 3%:

$$PV_A = -200 + \frac{100}{(1.03)} + \frac{100}{(1.03)^2} + \frac{100}{(1.03)^3} = -200 + 97.09 + 94.26 + 91.51 = \$82.86$$

$$PV_B = 100 + \frac{100}{(1.03)} + \frac{100}{(1.03)^2} - \frac{250}{(1.03)^3} = 100 + 97.09 + 94.26 - 228.79 = \$62.56$$

The net present value is higher for option A than for option B. Given this **option A** is preferable.

b) We repeat the calculations with a discount rate of 7%:

$$PV_A = -200 + \frac{100}{(1.07)} + \frac{100}{(1.07)^2} + \frac{100}{(1.07)^3} = -200 + 93.46 + 87.34 + 81.63 = \$62.43$$

$$PV_B = 100 + \frac{100}{(1.07)} + \frac{100}{(1.07)^2} - \frac{250}{(1.07)^3} = 100 + 93.46 + 87.34 - 204.07 = \$76.73$$

The net present value is higher for option B than for option A. Given this **option B** is preferable.

c) A higher discount rate means that people place less importance on future outcomes. In option A, the costs are paid up-front, but the benefits come later. With a high discount rate (part b), these benefits are less important. In contrast, the future benefits receive more weight in part a.

Recall that the discount rate relates to interest rates. In part a, with a lower discount rate, the opportunity cost of having money now, rather than in the future, is lower. Thus, paying the up-front cost is not costly. In contrast, if alternative investments could earn a 7% return, paying the costs up-front, rather than investing them elsewhere, is costly.

30. Bill rides the subway at a cost of 75 cents per trip, but currently would switch if the price were any higher. His only alternative is a bus that takes five minutes longer, but costs only 50 cents. He makes 10 trips per year.

The city is considering renovations of the subway system that would reduce the trip by 10 minutes. Fares would rise by 40 cents per trip to cover the costs of the renovation.

The fare increase and benefits of reduced travel time are both projected to be in effect forever. Alternative investments made by the city currently earn a 7% nominal rate of return. Inflation is 2%.

a) Use the information on Bill's travel decisions to calculate the value he places on a minute of his time.
b) Based on this information, what is the present value of the project's benefits and costs to Bill?
c) The city's population consists of 55,000 middle-class people, all of whom are identical to Bill, and 5,000 poor people. The poor people are either unemployed or work close to home, so they do not use any form of public transportation. What are the total benefits and costs of the project for the city as a whole? What is the net present value of the project? Is the project worth doing?
d) Suppose that, instead of raising fares, the city decided to pay for the renovations by increasing taxes to cover the cost. This leads to a tax increase of $3.67 per person. All families, whether or not they ride the subway, must pay the higher taxes. How, if at all, does this change your answer to part (c)?

a) Bill is willing to pay no more than 75 cents to ride the subway. By riding the subway, rather than the bus, he saves 5 minutes per trip. The bus costs 50 cents. Thus, he spends 25 cents to save 5 minutes per trip. Each minute saved is worth **5 cents** to Bill.

b) To calculate the present value of costs and benefits, we first need to find the appropriate discount rate. The nominal rate of return on alternative investments is 7%. This is the opportunity cost of investing in this project, rather than another project. The rate of inflation is 2%. To find the real discount rate, we subtract inflation from the nominal rate of return, to get a real discount rate of 5%.

Let's first calculate the present value of benefits. The renovations would reduce travel time by ten minutes. Since each minute is worth 5 cents to Bill, this has a value of 50 cents per trip. He makes 10 trips per year, so receives $5 of benefit per year. The present value of $5 per year forever is:

$$PV = \$5/r = \$5/0.05 = \$100$$

The cost of renovations to Bill is the increased fare. Each trip would cost 40 cents more. Since he takes 10 trips per year, his total costs increase by $4. The present value of $4 per year forever is:

$$PV = \$4/r = \$4/0.05 = \$80$$

c) Since the poor families work close to home, we only consider the benefits and costs to the middle class residents who will be riding the subway. We get the total present values of benefits and costs by multiplying the answers to part (b) by 55,000:

$$\text{total PV benefits} = \$5{,}500{,}000$$
$$\text{total PV costs} = \$4{,}400{,}000$$

The total net benefit of this project is the difference of the total benefits and total costs. This is **$1.1 million**. Based on the cost-benefit test, this project is worthwhile.

d) Using taxes, rather than a fare increase, to fund the project does not change the net present vale, as costs and benefits are the same. However, this does change the distribution of benefits and costs. Subway riders save $0.33. Their total costs are just the $3.67 tax increase, rather than the $4 fare increase. The PV of this cost is $73.40 per person (= 3.67/0.05), for a total cost to riders of $4,037,000. Thus, riders are better off using taxes to fund the renovations. The net benefit *to riders* is $1,463,000.

However, the renovations now affect poor families, as their taxes increase. Since they receive no benefits, only their costs matter. The present value of costs to these families is $367,000 (= ($3.67/0.05) x 5,000).

Thus, the net benefits are still positive. Whether or not the project is desirable, however, depends on a value judgment. Is it worthwhile to impose a cost of $367,000 on poor families in the city in order to provide $1,463,000 of benefits to middle-class subway riders?