Practice Problem Solutions for Quiz 1

1. 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.

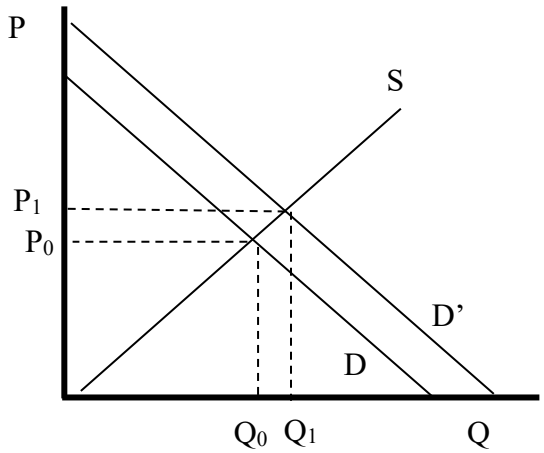
a) The economic downturn has led to more people staying home to watch movies, rather than go to a movie theater. Show how this change in behavior affects the market for microwave popcorn.

b) Suppose that drought conditions in agricultural regions increase the costs of irrigation. How would this affect the market for fruits and vegetables?

c) The *New York Times* recently reported on technological advances leading to an increase in the number of female cows. Female cows are valuable to farmers because they can be used to produce milk. However, while farmers now have more female cows available to produce milk, they are not happy. Use a supply and demand diagram for the milk market to explain why.

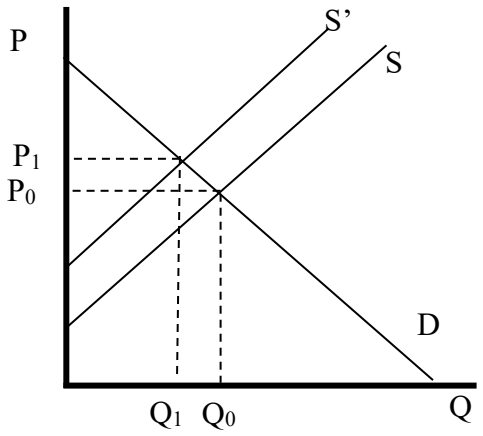
The purpose of this problem is to get you thinking about how demand and supply curves are affected by outside influences, and to help you distinguish between shifts of a curve versus a movement along a curve.

a)



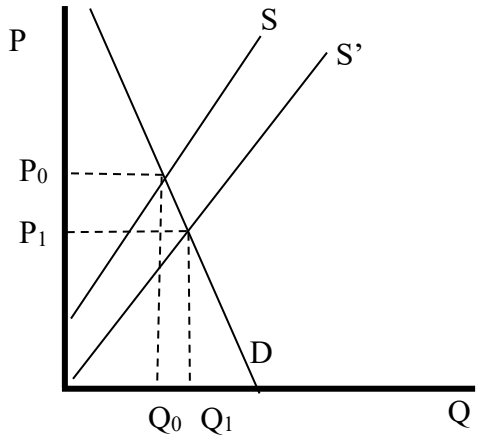
Microwave popcorn is a *compliment* to watching movies at home. Thus, demand for microwave popcorn increases, shifting up and to the right. The equilibrium quantity and price both increase.

b)



Drought conditions reduce the supply of fruits and vegetables, shifting the curve up and to the left. The equilibrium price rises, and the equilibrium quantity falls.

c)



This technological advance increases milk production. As a result, supply increases, shifting down and to the right. Although the equilibrium quantity rises, the equilibrium price falls, explaining why farmers are not happy. Note, in particular, that the demand for milk is usually inelastic. Thus, the drop in price is likely to be larger than the increase in quantity demanded, so that the farmers' revenue likely falls.

2. Suppose that the market for milk can be represented by the following equations:

$$\text{Demand: } P = 12 - 0.5Q_D$$
$$\text{Supply: } P = 0.1Q_S$$

where P is the price per gallon, and Q represents quantity of milk, represented in millions of gallons of milk consumed per day.

a) Calculate the equilibrium price and quantity of milk.
b) To help dairy farmers, the government sets a minimum price of $2.50 per gallon of milk. What is the new quantity of milk sold in the marketplace?
c) Illustrate your answers to (a) and (b) on a graph. Using this graph, calculate how the consumer surplus and producer surplus change after the price supports are enacted. Also calculate any deadweight loss that results.
d) Suppose that the government supports the $2.50 per gallon price by purchasing any excess milk suppliers make available but are unable to sell to consumers. How much milk must the government buy?

a) The equilibrium occurs where supply equals demand:

$$12 - 0.5Q = 0.1Q$$
$$0.6Q = 12$$
$$Q = 12/0.6$$
$$\mathbf{Q = 20 \text{ million gallons}}$$

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

Either:

$$P = 0.1(20) = \mathbf{\$2}$$

Or:

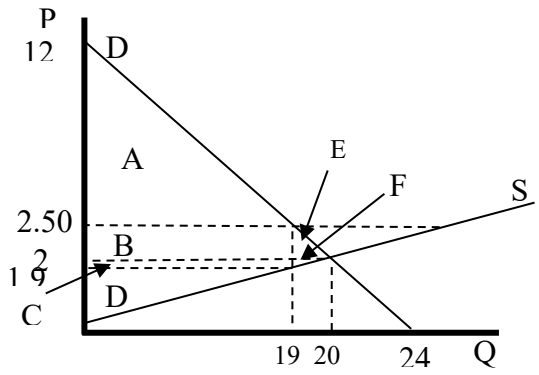
$$P = 12 - 0.5(20) = \mathbf{\$2}$$

b) The minimum price is above the equilibrium price. Thus, there will be an excess supply of milk – more people will want to sell milk than will be willing to buy milk. The new quantity sold will be limited by the number of people willing to purchase milk at this higher price. We find this by substituting \$2.50 for P in the demand equation, and then solving for Q:

$$2.50 = 12 - 0.5Q$$
$$9.50 = 0.5Q$$
$$Q = 9.50/0.5$$
$$\mathbf{Q = 19 \text{ million gallons}}$$

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 \$12. Similarly, by setting P = 0, we find that Q = 24 when P = 0 (because 12 – 0.5(24) = 0).

For supply, we know the line goes through the origin (y-intercept = 0), and intersects demand at a quantity of 20 and a price of \$2.



With a price floor of \$2.50, note that there will be excess supply, so the quantity demanded at \$2.50 determines the quantity sold. As we found in part (b), this is 19 million gallons of milk.

Consumer surplus is everything above the price and below the demand curve. Before the price supports are enacted, this is areas **A, B and E** above. This is a triangle with a base of 20 and a height of 10 (=12-2). Thus, the area of this triangle, and thus the consumer surplus, equals 0.5(20)(10) = **\$100**.

After the price supports are in place, consumer surplus falls to just area **A**. This is a triangle with a base of 19 and a height of 9.5 (=12-2.5). Thus, the area of this triangle = 0.5(19)(9.5) = **\$90.25**.

Producer surplus is everything below the price and above the supply curve. Without price supports, this is areas **C, D, and F**. The area of this triangle = 0.5(20)(2) = **\$20**.

With price supports, producer surplus is areas **B, C, and D**. Thus, producers lose F, but gain B. Area B is a rectangle with a height of 0.5 (=2.50 – 2) and a base of 19. Its area = (0.5)(19) = 9.5. To find the areas for C and D, we need to know where the line between these areas hits the supply curve at the quantity of 19. We get this by substituting 19 for Q in the supply equation: P = 0.1(19) = 1.9. Given this, we can now calculate that rectangle C has an area of 1.9 (=0.1x19), and triangle D has an area of 18.05 (=0.5x19x1.9). Thus, the total producer surplus = 9.5 + 1.9 + 18.05 = **$29.45**. As expected, producer surplus increases, and consumer surplus decreases, after price supports are enacted.

There is a deadweight loss with the price supports, because some milk that was sold before is now not sold. This is areas **E and F**. Note that these two areas are part of consumer or producer surplus before the price supports are in place, but not afterwards. These areas represent lost opportunities because less milk is sold. To calculate the value, note that this is a triangle with a height of 0.6 (= 2.5 – 1.9) and base of 1 (= 20 – 19). The area is (0.5)(0.6)(1) = **$0.30**.

Finally, to see the intuition of deadweight loss, compare the sum of consumer and producer surplus before and after the policy. Before the policy, the total surplus is $120. After the policy, the total of consumer and producer surplus is $119.70. The difference between these is $0.30. That is, $0.30 of potential surplus is lost because of the minimum price.

d) The excess supply is the difference between the quantity supplied at a price of $2.50 and quantity demanded at a price of $2.50. We know from part (b) that 19 million gallons are demanded at this price. Thus, we just need to find the quantity supplied at this price:

$$2.50 = 0.1Q_S$$
$$Q_S = 2.50/0.1$$
$$Q_S = 25 \text{ million gallons}$$

Since 25 million gallons of milk are available for sale, but consumers only purchase 19 million gallons, the government must purchase the **6 million gallons** that are not purchased by consumers.

3. Suppose that the market for gasoline can be represented by the following equations:

$$\text{Demand:} \quad P = 10 - 2Q_D$$
$$\text{Supply:} \quad P = 1 + 0.5Q_S$$

where P is the price per gallon, and Q represents quantity of gasoline, represented in millions of gallons of gasoline consumed per year.

a) Calculate the equilibrium price and quantity of gasoline.
b) Concerned over high prices, the government sets a price ceiling of $2.25 per gallon of gasoline. What is the new quantity of gasoline sold in the marketplace? Use a supply and demand diagram to illustrate your answer, showing both the original equilibrium from part (a) and the new quantity sold with the price ceiling.
c) 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 ceiling of $2.25 per gallon (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?

a) The equilibrium occurs where supply equals demand:

$$10 - 2Q = 1 + 0.5Q$$
$$2.5Q = 9$$
$$Q = 9/2.5$$
Q = 3.6 million gallons

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

Either:

$$P = 1 + 0.5(3.6) = \textbf{\$2.80}$$

Or:

$$P = 10 - 2(3.6) = \textbf{\$2.80}$$

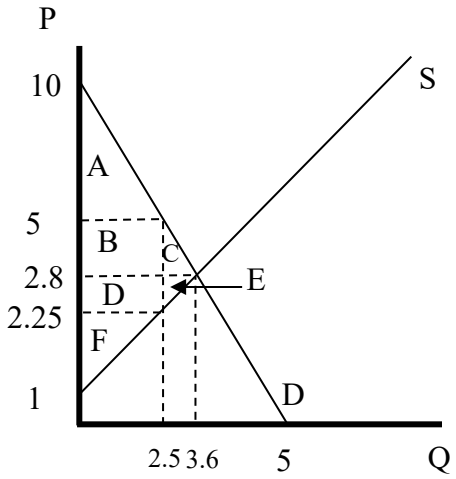
b) The price ceiling is below the equilibrium price of gasoline. Thus, there will be excess demand for gasoline. Consumers will want to purchase more gasoline than suppliers will make available at the price of $2.25 per gallon. Thus, we need to find out how much supply is available. We do this by plugging in $2.25 in the supply curve and solving for Q:

$$2.25 = 1 + 0.5Q$$
$$1.25 = 0.5Q$$
$$\mathbf{Q = 2.5}$$
2.5 million gallons of gasoline are sold

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 $10. Similarly, by setting P = 0, we find that Q = 5 when P = 0 (because 10 – 2(5) = 0).

For supply, we know the y-intercept is at $1, and intersects demand at a quantity of 3.6 and a price of $2.80. Note also that the line for a price of $2.25 is below equilibrium, so that we get the new quantity of 32.5om the supply curve.

Finally, the graph below also includes labeled areas for consumer and producer surplus. We will use this to answer the questions below.



Note from the graph that it is supply, rather than demand, that determines what the new quantity will be. Because the price ceiling is lower than the equilibrium price, the quantity is constrained by how much suppliers are willing to make available at $2.25. There will be excess demand.

c) Consumer surplus is the area under the demand curve and above the price. In the initial equilibrium, this includes areas A, B, & C. This is a triangle with a height of 7.2 (= 10-2.8) and a base of 3.6. Its area is 0.5(7.2)(3.6) = **$12.96**.

Producer surplus is the area above the supply curve and below the price producers receive. It is areas D, E, & F. This is a triangle with a height of 1.8 (= 2.8 - 1) and a base of 3.6. Its area is 0.5(1.8)(3.6) = **$3.24.**

d) Again, consumer surplus is everything above the new price ($2.25) and below the demand curve. This is areas A, B, & D. To find the area of A, we need to know the value at the bottom of the triangle. This is the amount that consumers are willing to pay for 2.5 million gallons of gasoline. We find this by plugging 2.5 into demand:

$$P = 10 - 2(2.5) = \$5.$$

Thus, triangle A has a height of 5 (= 10 – 5) and a base of 2.5. Its area equals 0.5(5)(2.5) = $6.25. The area of the rectangle comprised of B & D has a height of 2.75 (= 5- 2.25) and a length of 2.5. Its area equals (2.75)(2.5) = $6.875. Thus, the total consumer surplus is **$13.125**.

Producer surplus is just area F. This is a triangle with a height of 1.25 (= 2.25 – 1) and a base of 2.5. Its area is 0.5(1.25)(2.5) = **$1.5625**.

e) The total consumer and producer surplus in part (c) is $16.20.
The total consumer and producer surplus in part (d) is $14.6875.

The difference between these two is **$1.5125**. This difference is the **deadweight loss**. Deadweight loss is the lost welfare resulting from potentially beneficial transactions that took place before but do not occur after rent control is in place. Note that we can check our work by referring back to the graph. The deadweight loss is the triangle comprised of areas C & E. It has a base of 1.1 (= 3.6 – 2.5) and a height of 2.75 (= 5 – 2.25). The area is thus 0.5(1.1)(2.75) = **$1.5125**.

4. You are the manager of a store that carries generic soft drinks. Due to a local economic boom, your customers' incomes are forecasted to rise by five percent during the next month. The income elasticity of demand for these products is estimated to be –2.0. Estimate the change in the quantity of your soft drink orders required to accommodate the new demand without a surplus or shortage of inventory (that is, how much will demand for the generic soft drinks change due to the increased income?).

Income elasticity is the percentage change in quantity demanded due to a one percent change in income. In this case, a one percent increase in income leads to a two percent decrease in quantity demanded. Since income is rising by 5 percent, quantity demanded will decrease by 10 percent (5% X –2%).

To see this, begin with the formula for income elasticity:

$$\frac{\%\Delta Q}{\%\Delta I} = -2$$

Now, plug in the income elasticity from above and solve for the percentage change in quantity:

$$\frac{\%\Delta Q}{5} = -2$$
$$\%\Delta Q = -10$$

5. Muse, the local art museum, is considering raising its admission fee by 10 percent. Muse last raised their fee three years ago. You have been asked to project whether the new admission fee increase will lead to an increase or decrease in revenues. For the analysis, you have been given data pertaining to the previous fee increase:

	before increase	**after increase**
visitors per day:	2,000	1,400
average price paid:	$8.00	$10.00

a) Based on the figures provided, calculate the price elasticity of demand for visits to Muse.
b) Based on your calculation above, would you expect revenues to increase or decrease if tolls increase by another 10 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 = -600/2000 = -0.3, and the percentage change in price is 2/8 = 0.25. From this, we calculate the elasticity to be -1.2:

$$\epsilon = \frac{-0.3}{0.25} = -1.2$$

b) Revenue will decrease. Demand is elastic. Thus, the resulting decrease in quantity will more than offset the revenues gained from those who still come to the museum.

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 10% for the change in price. While the proposed price increase is 10%, 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 10%, as the change in price.

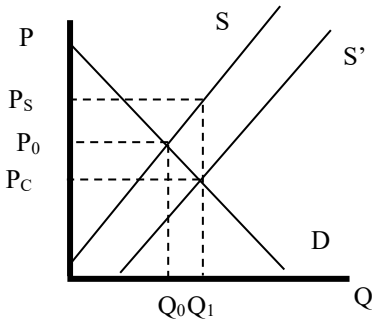
Note that simply calculating the new and old revenues only received partial credit. Simply calculating these revenues shows that revenues increase, but does not explain why they increased.

6. From an analytic standpoint, a subsidy is simply a negative excise tax that confers a benefit to certain groups rather than imposing a burden on them. For decades, the federal government has given fairly large subsidies to farmers for producing everything from grain to honey.

a) Under what conditions of supply and demand would farmers enjoy all the benefits of these subsidies?

b) Under what conditions of supply and demand would farmers enjoy none of the benefits of these subsidies? Who does benefit from the subsidy in this case?

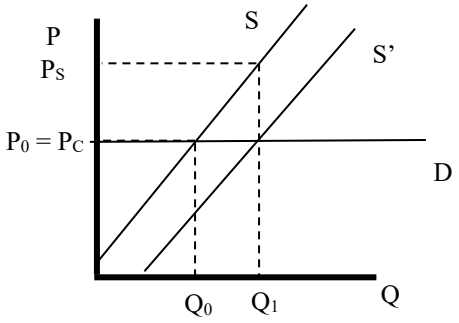
a) This problem is simply a tax incidence problem in reverse. Consider how the subsidy affects the agricultural market:



Just like a tax on farmers would shift the supply curve in, a subsidy for farmers shifts the supply curve out. The equilibrium quantity increases from Q_0 to Q_1.

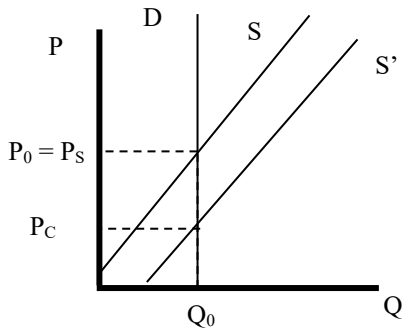
To see what happens to prices, remember that we get the price consumers pay off of the demand curve. This is P_C. Consumers pay less as a result of the subsidy, since there is more food available. However, farmers earn more money, since they get both the price consumers pay and the subsidy. The total amount received by farmers is P_S.

Now, consider what must be true for farmers to enjoy all the benefits. That can only be true if the price consumers pay does not change. When might that occur? There are two possibilities. One is when demand is perfectly elastic, consumers will continue to pay the same price. Thus, suppliers receive the entire benefit of the subsidy. This is illustrated below:



Alternatively, if supply was perfectly inelastic, the quantity sold would not change, so consumers would continue to pay the original price. Again, in this case, suppliers would receive the entire benefit of the subsidy.

b) Farmers enjoy none of the benefits when the price paid by consumers falls by the entire amount of the tax. An example of when this would occur is when demand is perfectly inelastic. In this case, there is no demand for extra agricultural products, so the price falls to discourage additional production. This is illustrated below:



Alternatively, this could occur if supply were perfectly elastic. In that case, the subsidy would simply induce more and more farmers to grow crops, so that the price farmers receive always remains the same.

7. Suppose the market for cameras has a supply curve of P = 30 + Q, and a demand curve of P = 240 – 2Q. Assume that the market is perfectly competitive.

a) What will the equilibrium price and quantity of cameras be?
b) Calculate the producer and consumer surplus associated with the equilibrium found in part (a). Illustrate on a graph.
c) Suppose the government levies a tax of $18 per camera sold. What is the new quantity of cameras sold? What price do consumers pay? What price do producers receive? Illustrate on a graph.
d) Find the new producer and consumer surplus associated with your answer to part (c).
e) How much revenue does the government raise from the tax?
f) 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?

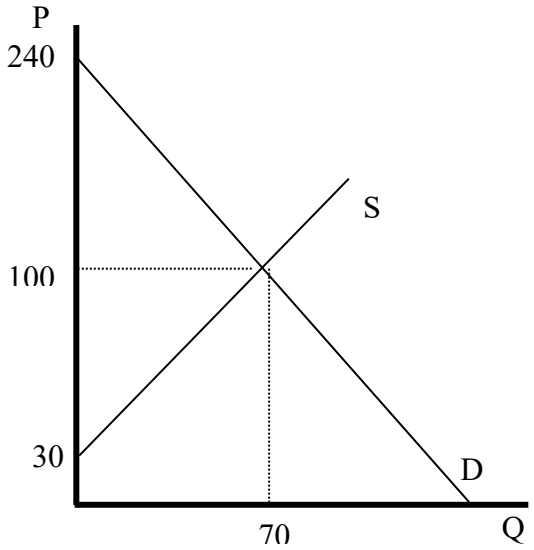
a) The equilibrium price and quantity are:

$$30 + Q = 240 - 2Q$$
$$3Q = 210$$
$$Q = 210/3$$
$$\mathbf{Q = 70}$$

Substitute this into either supply or demand to get:

$$\mathbf{P = 100}$$

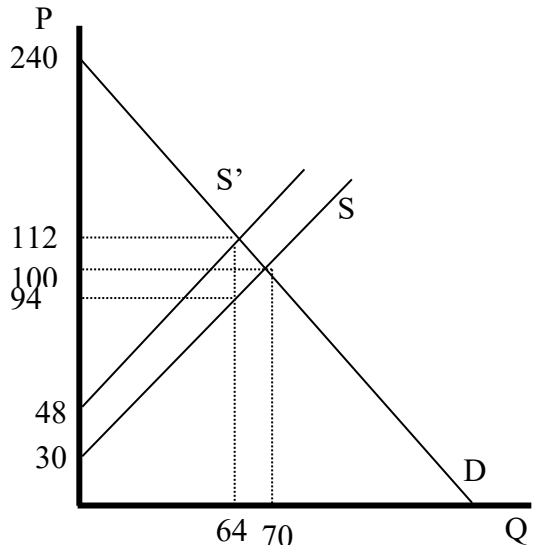
b)



Consumer surplus is the triangle above the price and below demand. It has a height of 140 (= 240 – 100) and a base of 70. Its area = 0.5(140)(70) = **$4,900**.

Producer surplus is the triangle below price and above supply. It has a height of 70 (= 100 – 30) and a base of 70. Its area = 0.5(70)(70) = **$2,450**.

c) The result of the tax is to shift either the supply curve or demand curve in. Note that your results will be the same no matter which one you choose. In this example, I'll shift the supply curve. The supply curve shifts up by the amount of the tax. The new supply curve represents the supply curve faced by consumers. If P is the price consumers pay, suppliers get P - 18, with $18 going to the government. Algebraically, P = 30 + Q becomes P = 48 + Q. Graphically, note that the y-intercept of the graph has shifted up by the amount of the tax.



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

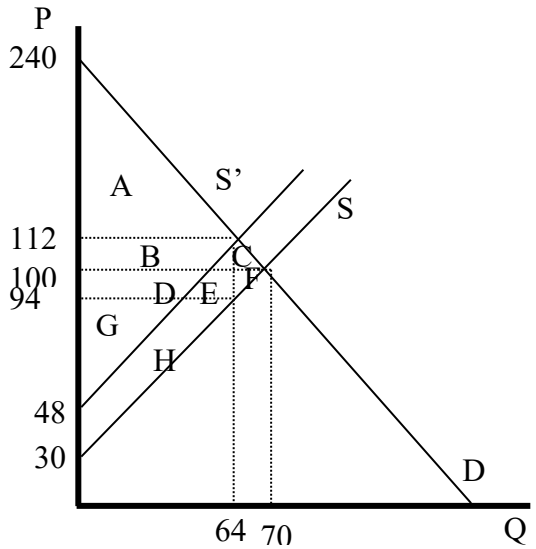
$$48 + Q = 240 - 2Q$$
$$192 = 3Q$$
$$Q = 192/3$$
$$\mathbf{Q = 64}$$

We plug this quantity into the *original* supply and demand curves to get the post-tax prices. With a quantity of 64, suppliers receive:

$P_S = 30 + 64 =$ **$94** (from the original supply curve)

Consumers must pay $18 more than this, or **$112**. Note that we can verify this using the demand curve, where we get $P_C = 240 - 2(64) = 240 - 128 = \$112$.

d)



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

Area A in the above graph represents consumer surplus. This is a triangle with a height of 128 (= 240-112) and a base of 64. Its area = 0.5(128)(64) = **$4,096**.

Areas G and H in the above graph represents producer surplus. This is a triangle with a height of 64 (= 94 - 30) and a base of 64. Its area = 0.5(64)(64) = **$2,048**.

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

$$\$18 \times 64 = \$1152.$$

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

f) Before the tax, the sum of consumer and producer surplus was $7,350. Afterwards, the sum of consumer surplus, producer surplus, and revenue is $7,296. The difference is $54. Graphically, this is the area of triangles C & F.

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 64 and 70, 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.

8. Suppose the market for cell phones has a supply curve of P = 13 + 2Q, and a demand curve of P = 85 – 4Q. Assume that the market is perfectly competitive.

a) What will the equilibrium price and quantity of cell phones 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 $6 per cell phone sold, to be levied on consumers. What is the quantity of cell phones sold? What price do consumers pay? What price do producers receive? Illustrate on a graph.
d) Find the new producer and consumer surplus associated with your answer to part (c).
e) How much revenue does the government raise from the tax?
f) 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?

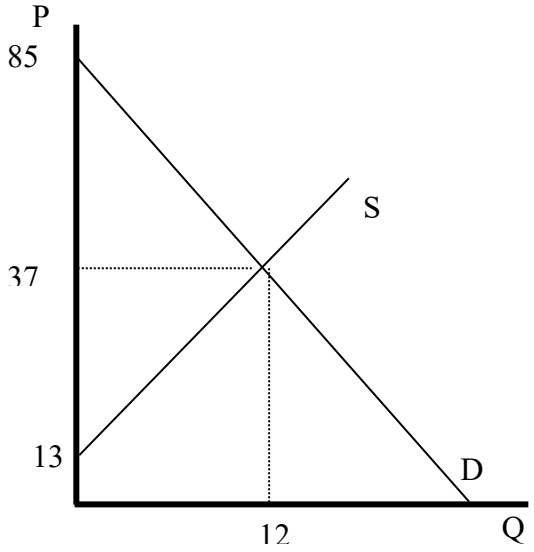
a) The equilibrium price and quantity are:

$$13 + 2Q = 85 - 4Q$$
$$6Q = 72$$
$$Q = 72/6$$
$$\mathbf{Q = 12}$$

Substitute this into either supply or demand to get:

$$\mathbf{P = 37}$$

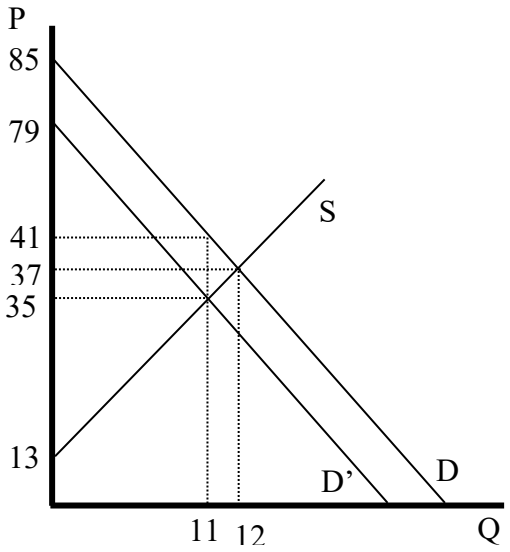
b)



Consumer surplus is the triangle above the price and below demand. It has a height of 48 (= 85 – 37) and a base of 12. Its area = 0.5(48)(12) = **$288**.

Producer surplus is the triangle below price and above supply. It has a height of 24 (= 37 – 13) and a base of 12. Its area = 0.5(24)(12) = **$144**.

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 - 6, with $6 going to the government. Algebraically, P = 85 – 4Q becomes P = 79 – 4Q. 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.

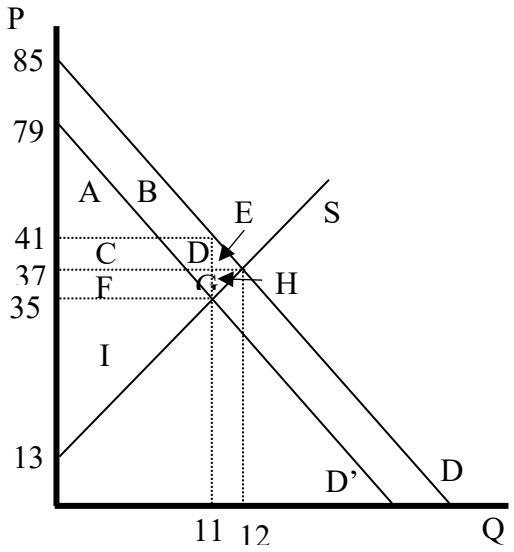
$$13 + 2Q = 79 - 4Q$$
$$6Q = 66$$
$$Q = 66/6$$
$$\mathbf{Q = 11}$$

We plug this quantity into the *original* supply and demand curves to get the post-tax prices. With a quantity of 11, suppliers receive:

$P_S = 13 + 2(11) =$ **$35** (from the original supply curve)

Consumers must pay $6 more than this, or **$41**. Note that we can verify this using the *original* demand curve, where we get $P_C = 85 – 4(11) = 85 – 44 = \$41$.

d)



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 44 (= 85-41) and a base of 11. Its area = 0.5(44)(11) = **$242**.

Area I in the above graph represents producer surplus. This is a triangle with a height of 22 (= 35-13) and a base of 11. Its area = 0.5(22)(11) = **$121**.

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

$$\$6 \times 11 = \$66.$$

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

f) Before the tax, the sum of consumer and producer surplus was $432. Afterwards, the sum of consumer surplus, producer surplus, and revenue is $429. The difference is $3. Graphically, this is the area of triangles E & H.

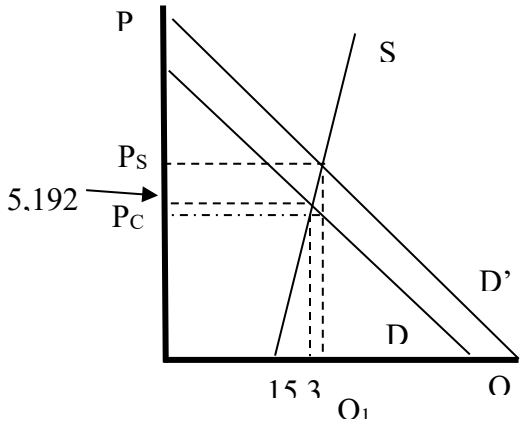
This difference is the deadweight loss. It is the value of lost opportunities, because some potentially beneficial transactions do not occur after the tax. For the quantities between 11 and 12, demand is above supply. This tells us that consumers are willing to pay more than the marginal cost of producing 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.

9. Suppose that after graduation you take a position in the Department of Health, Education, and Welfare. You are asked to show what will happen in the market for college education after the enactment of a new $1,000 tax credit for college tuition. You are given the following information:

- 15.3 million students are enrolled in college, either at private or public institutions. (This does not include enrollments in graduate programs).
- The average tuition paid by these students is $5,192 per year.
- Assume that, overall, colleges are operating near capacity, so the possibility of expanding enrollments is minimal.

Use a supply and demand diagram to show the initial equilibrium ***and*** the effect of the tax credit. Who is the major beneficiary of the tax credit – students or colleges? Explain intuitively why this is the case. How would your answer change if we did not assume that colleges are operating near capacity?

Colleges, not students, will be the main beneficiaries. The assumption that colleges are operating near capacity means that supply is nearly fixed – it is inelastic. Just as inelastic parties bear the burden of taxation, they reap the benefits of tax credits, as shown in the graph below.



The tax credit shifts the demand for college up. However, since quantity cannot increase by much, tuitions received by colleges increase (P_S). Students pay P_C, which equals P_S minus the tax credit. Note that although the price students pay does fall somewhat, the drop is not nearly as large as the gain received by colleges. Most of the $1,000 from the tax credit goes to colleges. If colleges were not at full capacity, students would benefit more, as enrollments could increase without tuition increasing as much.