Name: ___________________________________

Quiz # 2
November 20, 2024

PAI 897
Professor David Popp

You have the entire class period (80 minutes) in which to take the quiz. The questions are worth a total of 100 points. The number of points for each question should serve as a guide to the amount of time to spend on each question. Each question is designed to be answered in the space provided. *A short, direct answer is preferable to a long-winded explanation that includes unnecessary information.* Also, please keep in mind that partial credit is available for each question. It is in your best interest to attempt each problem on the quiz. If you do not have time to finish the math, at least include an illustration to show that you know how to proceed.

This is a closed book quiz. No notes, texts, or other reference materials may be used. The use of calculators is permitted.

Be sure to show all your work for each question. Providing a correct answer without showing how you got it will not get you full credit. You may use the back of the page for scratch work. I will not look on the back for answers or work unless you specifically tell me to do so. *Thus, if there is anything on the back of the page that you want graded, be sure to note this on the front of the page*.

Helpful formulas:

$$elasticity = \frac{\%change\ Q}{\%\ change\ P} = \frac{\frac{\Delta Q}{Q_0}}{\frac{\Delta P}{P_0}} = \frac{\Delta Q}{\Delta P}\frac{P_0}{Q_0}$$

area of a triangle = 1/2 (base) x (height); area of a rectangle = (length)x (width)

Bisection Rule:
If demand is given as P = a – bQ, then MR = a – 2bQ

NOTE: PLEASE READ THE FOLLOWING AND SIGN BELOW TO ACKNOWLEDGE READING THE HONOR CODE BEFORE BEGINNING. ALSO NOTE THAT BY HANDING IN THE QUIZ, YOU IMPLICITLY AGREE TO THE FOLLOWING, WHETHER OR NOT A SIGNATURE FOLLOWS:

Providing or receiving help on this quiz is a violation of both class rules and Syracuse University's policy and academic honesty. I will not (or have not) discuss the contents of the quiz with other students until all classes have had an opportunity to complete the quiz.

Signed by: ____

Good luck!

1. (20 points) The city of Springfield is evaluating the costs and ridership of its subway system and has hired you as a consultant. You have been presented with the following data.

Each subway can carry 200 people. It costs $400 per trip to run a train, regardless of the number of passengers riding the train.

At rush hour, the city runs four trains per half-hour, and each is filled to capacity. Thus, the average cost per passenger is $2. However, during off-peak hours, the city runs just two trains per half-hour. Nonetheless, each train carries just 100 people, so that average costs during the off-peak time are $4.

Based on these figures, Mayor Quimby argues that the city should encourage more people to ride the subway during rush hour, when costs are lowest, and discourage off-peak ridership. How would you respond to his suggestion? Is the Mayor's logic correct? Why or why not?

The Mayor's logic is incorrect. The Mayor is confusing average cost and marginal cost. While the *average cost* per rider is lower during rush hour, the trains are running at full capacity. If more people take the subway during rush hour, Springfield will need to run more trains. Each additional train run during rush hour will cost $400 per trip.

In contrast, during off-peak times trains run at half capacity. Since the cost per trip is the same regardless of the number of passengers on the train, the subway can handle more riders during off-peak times without increasing costs. Until capacity on a train is reached, the marginal cost is zero.

While the above intuition is all that was needed to answer this question, consider the following calculations. In each half-hour, currently 800 people take the subway during rush hour (200 x 4 trains) and 200 take the subway during off-peak hours (= 100 x 2 trains). Suppose we convince 200 people to switch from rush hour to subway. That fills the two trains during off-peak time, so no additional trains are needed. Springfield can then run one less train during rush hour, saving $400.

Some students noted that the trains are a fixed cost. I accepted such an answer, as long as you noticed that there would be an additional cost to adding more riders during rush hour, since you would need to add another train. It is not correct to say that there is no cost to adding additional riders during rush hour.

2. (30 points) The city of Atlantis has just built a new municipal water system, and needs to determine the price to charge city residents for water. Because of your background in economics, you have been asked by the city to help set the price for water in the community.

The fixed costs of operating the system are $1000. In addition, the marginal costs of operation are $5 for each cubic foot of water supplied. Having researched the demand for water in Atlantis, the city has come up with the following demand curve:

$$P = 75 - Q$$

For your convenience, the city has provided the following table with price, quantity, marginal revenue, and various costs filled in:

P	Q	MR	AC	MC
75	0	--	--	--
70	5	65	205	5
65	10	55	105	5
60	15	45	71.66667	5
55	20	35	55	5
50	25	25	45	5
45	30	15	38.33333	5
40	35	5	33.57143	5
35	40	-5	30	5
30	45	-15	27.22222	5
25	50	-25	25	5
20	55	-35	23.18182	5
15	60	-45	21.66667	5
10	65	-55	20.38462	5
5	70	-65	19.28571	5
0	75	-75	18.33333	5

a) Ariel, a member of the city council, has taken some economics, and wants to ensure that there is no inefficiency, and thus no deadweight loss, from the pricing scheme. What price will achieve this goal? How many cubic feet of water will consumers purchase? How much revenue will the sale of this water produce? What will be the total costs of supplying this water? Will the community make money, lose money, or break even on water sales?

To have no deadweight loss, the price should equal marginal cost. This is where the demand curve intersects marginal cost. At this point, all transactions worth at least as much as the cost of providing another ride take place.

Since the marginal cost is $5, this requires setting the price at $5. From the table, we see that at this price, consumers will purchase **70** cubic feet of water.[1]

The sale of this water will produce **$350** of revenue (= $5 x 70).

The total cost of providing this water is **$1350**. You could find this in one of two ways. First, you could multiply the marginal cost per unit of $5 by the quantity, and then add the $1000 fixed cost (= $5 x 70 + $1000). Second, you could simply multiply average costs by quantity (=$19.28571 x 70).

A common mistake here was to use AC X Q *and* subtract fixed costs. Fixed costs are included in average costs. Because marginal costs are constant, average variable costs are simply $5. Average cost is falling because fixed costs are falling.

Since the total costs are greater than the total revenues, the community loses money. Atlantis loses **$1000** on the sale of water if it uses marginal cost pricing.

[1] Note that you could also get this answer by setting the demand curve equal to marginal cost: $75 – Q = 5$ implies that $Q = 70$. However, since I gave you the information in the tables, such calculations were not necessary.

b) Triton, a second council member, suggests that the city 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 water supplier, would maximize its profit from water sales. What price would that be? How much water would be sold? Please calculate the total revenue and total costs, as well as the profit for these sales.

To maximize profits, we must find the point where marginal revenue equals marginal costs. Since the marginal cost is $5, we find the quantity where marginal revenue equals $5, which occurs when consumers purchase **35** cubic feet of water. The price for this quantity is **$40**.[2]

The sale of this water will produce **$1400** of revenue (= $40 x 35).

The total cost of providing this water is **$1175**. You could find this in one of two ways. First, you could multiply the marginal cost per unit of $5 by the quantity, and then add the $1000 fixed cost (= $5 x 35 + $1000). Second, you could simply multiply average costs by quantity (=$33.57143 x 35).

Finally, we find the profit by subtracting total costs from total revenue. The city makes **$225** of profit at this price.

[2] Again, you could use the bisection rule and then find this algebraically. Given the demand curve of 75 – Q, we know that MR = 75 – 2Q. Setting this equal to 5 gives us 75 – 2Q = 5, which simplifies to 2Q = 70, or Q = 35. We get the price by plugging this quantity into the original demand curve.

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

At this price, how many cubic feet of water will consumers purchase? How much revenue will the sale of this water produce? What will be the total costs of supplying this water? What profit, if any, does the city make from these sales?

Since Eric wants Atlantis to cover its costs, the profits should equal zero. The key 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 $55 or a price of $25. While I gave students that chose a price of $55 partial credit for recognizing the P=AC relationship, given Eric's goals, the better choice is a price of **$25**. At this price, **50** cubic feet of water are sold. Because Eric is concerned about consumers, it makes more sense to choose the lower price, and thus the higher quantity of water sold. Choosing a price of $55 would results in a higher price, lower water quantity (20 cubic feet), and lower profits than the profit maximizing strategy in part (b). Thus, neither the city nor consumers are better off choosing that price.

The sale of this water will produce **$1250** of revenue (= $25 x 50).

The total cost of providing this water is also **$1250**. You could find this in one of two ways. First, you could multiply the marginal cost per unit of $5 by the quantity, and then add the $1000 fixed cost (= $5 x 50 + $1000). Second, you could simply multiply average costs by quantity (=$25 x 50).

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

3. (30 points) After graduation, you are hired by a local advocacy group that supports low-income families. The group is considering two proposals to promote consumption of healthy food in these families. You have been asked to provide analysis of the two proposals.

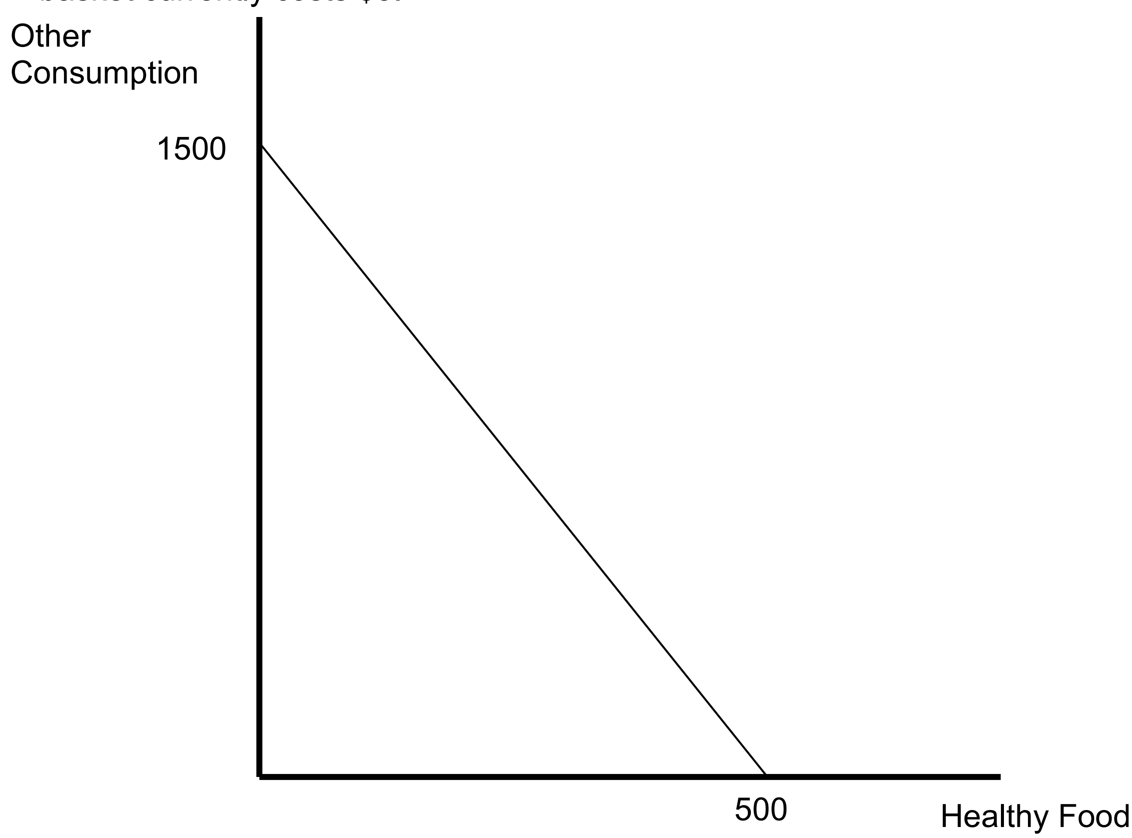
In the analysis below, healthy food is measured in "baskets." Each basket of healthy food currently costs $3.

Proposal 1 would provide each family with a voucher allowing the family to buy 50 baskets of healthy food each month. These vouchers could only be used to purchase healthy food.

Proposal 2 would subsidize the purchase of healthy food by these families, lowering the price of a basket of healthy food to $2 per basket.

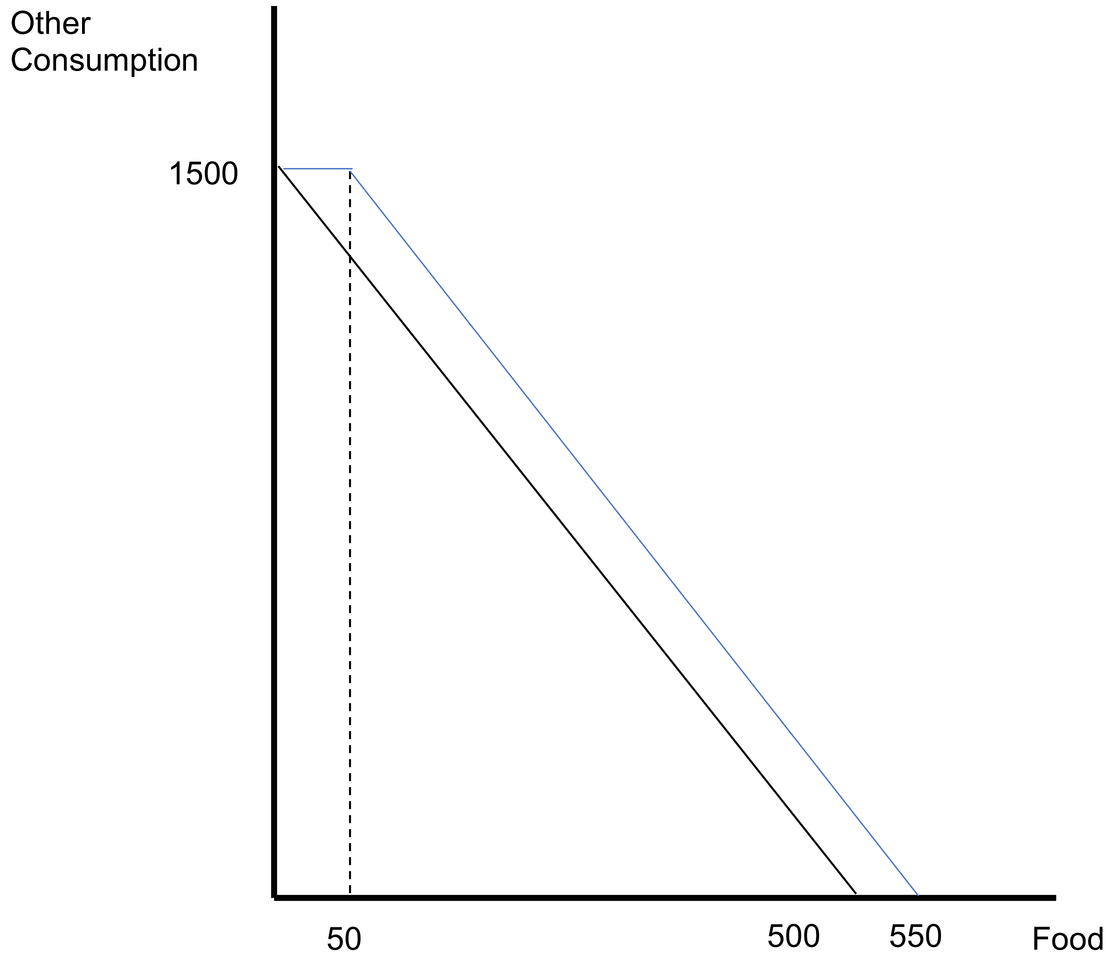
You have been asked to analyze the effect of this proposal on a typical low-income family with an income of $1500 per month.

a) On the axes below, draw a budget constraint for the typical family before aid is provided. For the x-axis, the units are baskets of healthy food, where each basket currently costs $3.



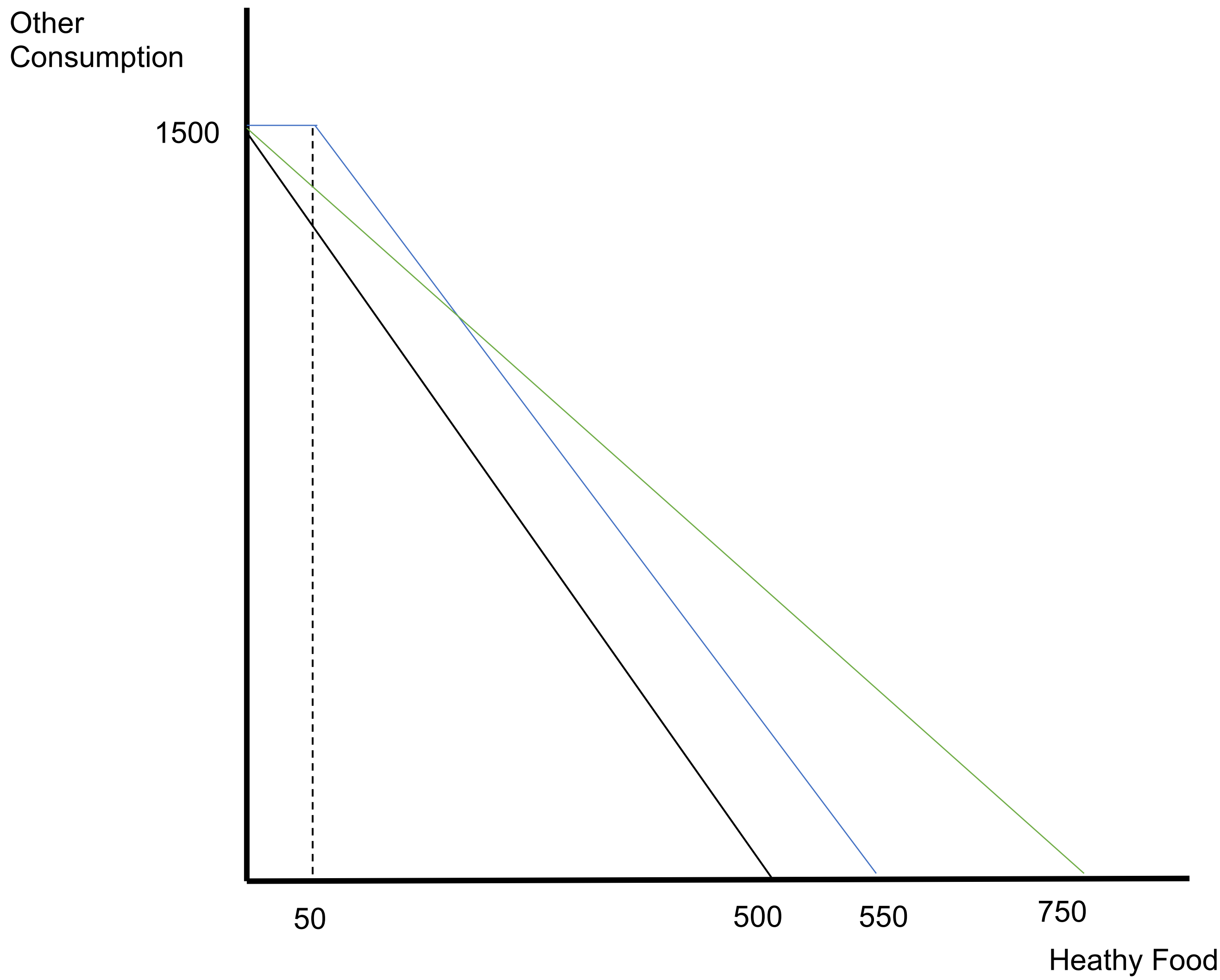
Without any aid, a typical low-income family can spend $1500 on other consumption, purchase 500 baskets of healthy food (= $1500/3), or end up somewhere in between.

b) Reproduce your diagram from part (a) below. Now, add a budget constraint for proposal 1 (the voucher).



The new budget constraint is shown in blue. With the voucher, a family can now buy up to 550 baskets of healthy food. If a family spends all their income on other consumption, they will still be able to get 50 baskets of healthy food by using the voucher. But they cannot spend more than 1500 on other consumption, thus, the budget constraint is cutoff at 50 baskets of healthy food.

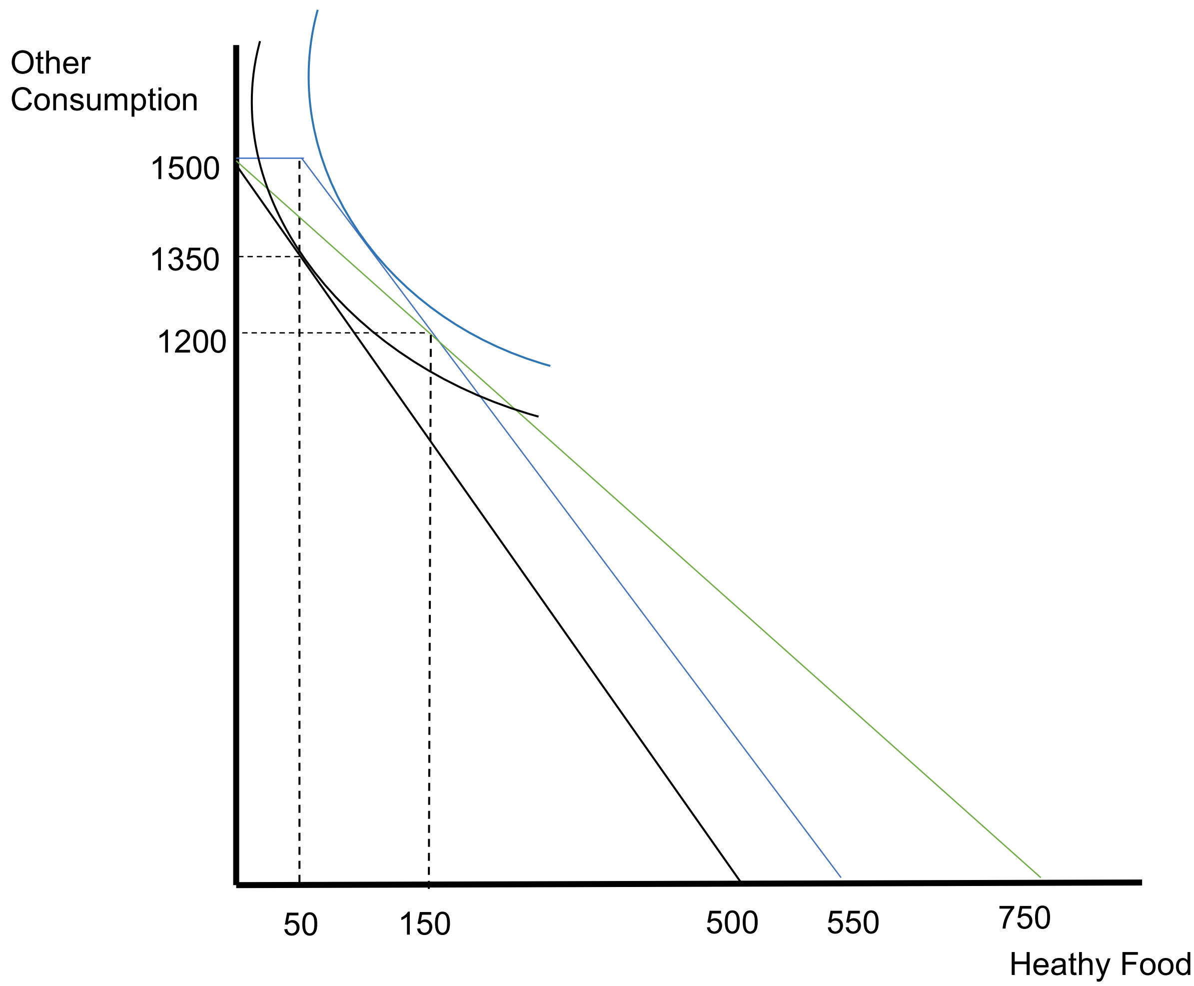
c) Reproduce your answer to (b) on the diagram below. Then, add a budget constraint representing proposal 2 (the subsidy).



The new budget constraint is shown in green. The subsidy lowers the price of healthy food to $2. Thus, the budget constraint rotates. If a family spends all their income on health food, they can now afford 750 baskets of healthy food (= $1,500/2).

d) A typical family currently buys just 50 baskets of healthy food per month. Given this, under which proposal is the family better off? Explain. Draw indifference curves consistent with your answer, either below or on your diagram on part (c). (*Hint*: (1) Before receiving aid, how much money will this family have left after buying **50** baskets of food? (2) Now calculate how much of their own money must the family spend to get **150** baskets of healthy food under each of the two plans? How much will they have left to spend on other goods? How does their current consumption compare to this figure?)

The key to this question is that the typical family currently does not purchase much healthy food. <u>From the first hint</u>, before receiving aid, the family purchases just 50 baskets of healthy food. These cost \$150 (= \$3 X 50). That leaves \$1,350 left to spend on other goods, as shown with the black indifference curve below.



To see which policy benefits a typical family more, we need to compare where they are now to where the two policy budget constraints intersect. That is the purpose of the second hint. With the voucher, consumers get 50 baskets of healthy food free. Purchasing an additional 100 baskets costs $300. That leaves them $1,200 to spend on other consumption.

Similarly, under the subsidy, the family can also purchase 150 baskets of healthy food for $300, since each basket now costs the family $2. That also leaves $1,200 to spend on other consumption. **Thus, the new budget constraints intersect at 150 baskets and $1,200 of other consumption.**

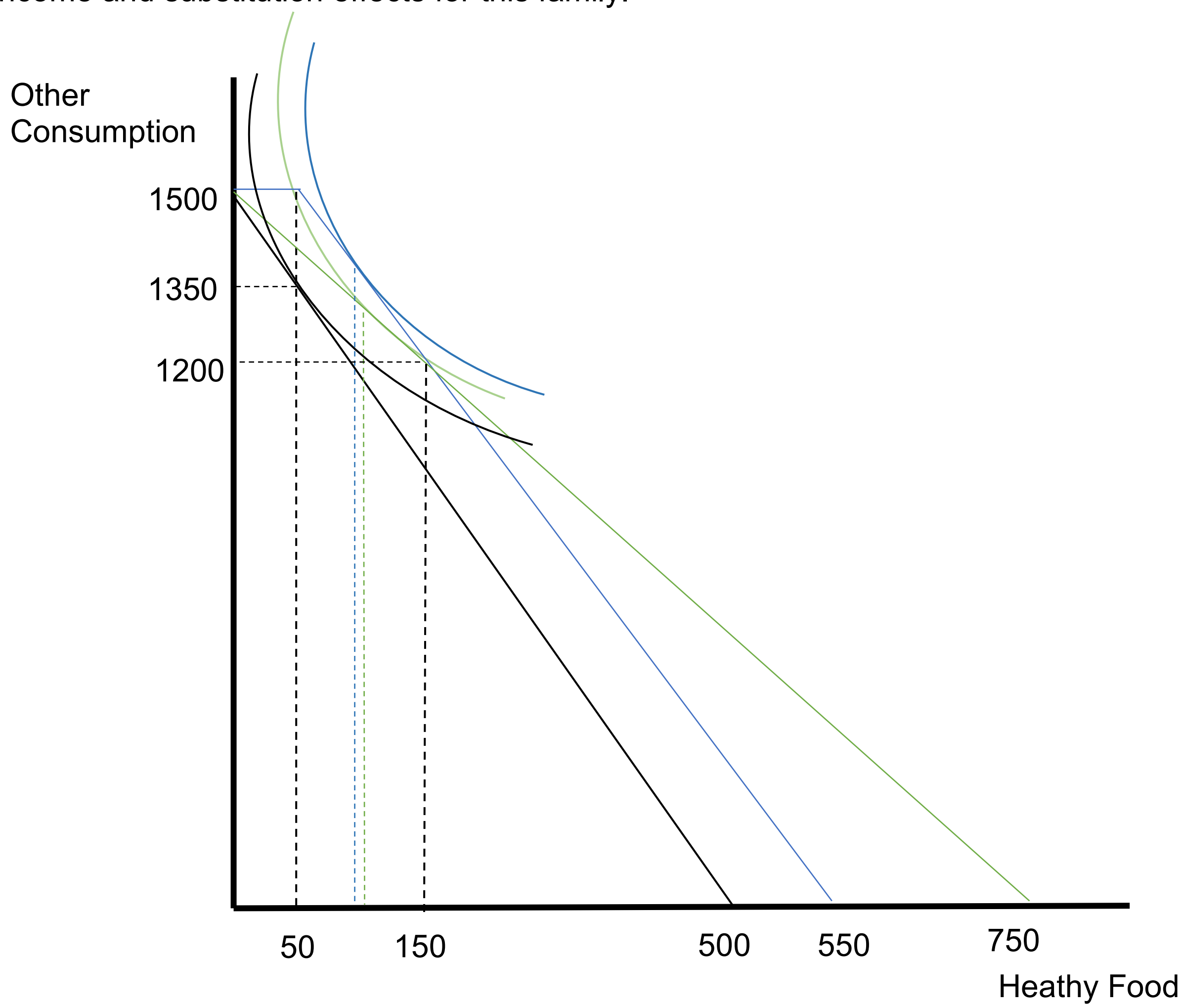
Before either policy, a typical family purchases just 50 baskets of healthy food, and spends $1,350 on other consumption. This puts them well to the left of the intersection of the two budget constraints. They are *already spending more than $1,200 on other consumption.* Given this, they will prefer the vouchers. Note on the graph that, to the left of the intersection, the budget constraint for the vouchers is higher. I've included an indifference curve consistent with this outcome on the diagram.

The intuition is that, since the typical family doesn't purchase a lot of healthy food, the income it saves under the subsidy is not as valuable as the $150 worth of food the family receives with the voucher. A family needs to purchase at least 150 baskets of healthy food worth of healthy food for the subsidy to provide at least $150 worth of savings. But that would be inconsistent with their initial preferences.

A couple of comments on common answers. First, several students drew a corner solution, where food consumption remained at 50 baskets with the vouchers. That is possible, so I didn't take off points for that answer. However, it does not need to be the case. They start at 50 baskets before any policy. Since the vouchers give them extra income, it is possible that they will spend some of that extra income on food. They don't need to stay at exactly 50 baskets after receiving vouchers. What we know from above simply is that they will consume less than 150 baskets with the voucher policy.

Common errors on this question include drawing indifference curves that cross or putting the indifference curves at the intersection of the two budget constraints. In this example, food consumption is to the left of the intersection, and your indifference curves need to show that.

Note that I did not ask which policy promotes more healthy food consumption. That is because the answer for that question is ambiguous. Because the subsidy lowers the price of food, it is possible that families could decide to purchase more healthy food with the subsidy than with the voucher. The graph below illustrates such an outcome. The green indifference curve is below the blue indifference curve, but tangent to the green budget constraint at a point slightly to the right of where the blue indifference curve touches the blue budget constraint. Which policy encourages more food consumption depends on the relative strength of the income and substitution effects for this family.



4. (20 points) It's time to get ready for winter! As a newly hired public administrator for the North Pole, Buddy the Elf must allocate snowplows after each snowfall. Snowplows can be sent to one of three neighborhoods: Reindeer Hollow, Santa's Station, and Elf Village. The North Pole has seven snowplows that may be dispatched. The goal is to plow as many miles of roads as possible.

Buddy is given the following data on the total productivity of plows in each neighborhood.

Reindeer Hollow		**Santa's Station**		**Elf Village**	
# of plows used	Total miles plowed	# of plows used	Total miles plowed	# of plows used	Total miles plowed
1	40	1	30	1	35
2	70	2	55	2	65
3	90	3	75	3	90
4	100	4	90	4	110
5	105	5	100	5	125
6	108	6	107	6	135
7	110	7	110	7	140

To maximize the total miles plowed, how many of the seven snowplows should be sent to each neighborhood? Explain how you know this (without simply saying that you added up all the combinations and found the largest value – I'm looking for some economic intuition here!)

While the question provides information on total output, to choose where to put each plow we must consider the **marginal product** of each – that is, how many more streets are plowed by one additional plow. The table below adds marginal product for each plow, which is simply the change in total miles plowed as each plow is added. For example, the first plow in Reindeer Hollow plows 40 miles. The second plows an additional 30 miles (= 70 – 40).

Reindeer Hollow			**Santa's Station**			**Elf Village**		
# of plows used	Total miles plowed	MP	# of plows used	Total miles plowed	MP	# of plows used	Total miles plowed	MP
1	40	**40**	1	30	**30**	1	35	**35**
2	70	**30**	2	55	**25**	2	65	**30**
3	90	20	3	75	20	3	90	**25**
4	100	10	4	90	15	4	110	20
5	105	5	5	100	10	5	125	15
6	108	3	6	107	7	6	135	10
7	110	2	7	110	3	7	140	5

Once we know marginal product, we simply place each plow in the neighborhood with the highest possible marginal product. For example, the first plow should go to Reindeer Hollow. The second plow should go to Elf Village. Since we have seven plows, we need to identify the seven highest marginal products. Those are in bold above. Thus, we put **2 plows in Reindeer Hollow, 2 in Santa's Station, and 3 in Elf Village**. This yields a total of 215 miles of roads plowed (= 70 + 55 + 90).

A couple of common errors on this question were (1) not recognizing that the data were total output, not marginal output and (2) applying MP incorrectly. For example, some students said that the first plow should go to Reindeer Hollow, because the MP is highest there. Then, they compared the MP in row 2, saying that the second plow should go to either Reindeer Hollow or Elf Village, because both had a MP of 30 for the second plow.

That is incorrect. The MP depends on the quantity used *in each neighborhood*. After placing the first plow in Reindeer Hollow, the MP of putting a second one there is 30. We compare that to the MP of putting the first plow in either of the other neighborhoods. Thus, the second plow should go to Elf Village.