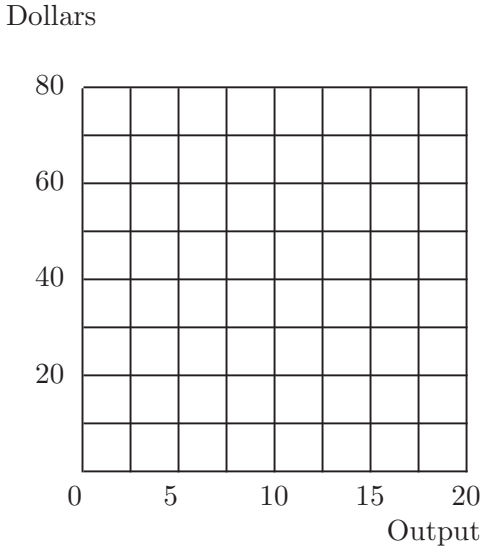
The short-run supply curve of a competitive firm is the portion of its short-run marginal cost curve that is upward sloping and lies above its average variable cost curve. The long-run supply curve of a competitive firm is the portion of its short-run marginal cost curve that is upward-sloping and lies above its long-run average cost curve.

A firm has the long-run cost function $c(y) = 2y^2 + 200$ for $y > 0$ and $c(0) = 0$. Let us find its long-run supply curve. The firm's marginal cost when its output is y is $MC(y) = 4y$. If we graph output on the horizontal axis and dollars on the vertical axis, then we find that the long-run marginal cost curve is an upward-sloping straight line through the origin with slope 4. The long-run supply curve is the portion of this curve that lies above the long-run average cost curve. When output is y, long-run average costs of this firm are $AC(y) = 2y + 200/y$. This is a *U-shaped* curve. As y gets close to zero, $AC(y)$ becomes very large because $200/y$ becomes very large. When y is very large, $AC(y)$ becomes very large because $2y$ is very large. When is it true that $AC(y) < MC(y)$? This happens when $2y + 200/y < 4y$. Simplify this inequality to find that $AC(y) < MC(y)$ when $y > 10$. Therefore the long-run supply curve is the piece of the long-run marginal cost curve for which $y > 10$. So the long-run supply curve has the equation $p = 4y$ for $y > 10$. If we want to find quantity supplied as a function of price, we just solve this expression for y as a function of p. Then we have $y = p/4$ whenever $p > 40$.

Suppose that $p < 40$. For example, what if $p = 20$, how much will the firm supply? At a price of 20, if the firm produces where price equals long-run marginal cost, it will produce $5 = 20/4$ units of output. When the firm produces only 5 units, its average costs are $2 \times 5 + 200/5 = 50$. Therefore when the price is 20, the best the firm can do if it produces a positive amount is to produce 5 units. But then it will have total costs of $5 \times 50 = 250$ and total revenue of $5 \times 20 = 100$. It will be losing money. It would be better off producing nothing at all. In fact, for any price $p < 40$, the firm will choose to produce zero output.

22.1 (0) Remember Otto's brother Dent Carr, who is in the auto repair business? Dent found that the total cost of repairing s cars is $c(s) = 2s^2 + 100$.

(a) This implies that Dent's average cost is equal to _____ , his average variable cost is equal to _____ , and his marginal cost is equal to _____ On the graph below, plot the above curves, and also plot Dent's supply curve.



(b) If the market price is \$20, how many cars will Dent be willing to repair? _____ If the market price is \$40, how many cars will Dent repair?_____.

(c) Suppose the market price is \$40 and Dent maximizes his profits. On the above graph, shade in and label the following areas: total costs, total revenue, and total profits.

22.2 (0) A competitive firm has the following short-run cost function: $c(y) = y^3 - 8y^2 + 30y + 5$.

(a) The firm's marginal cost function is $MC(y) =$_____.

(b) The firm's average variable cost function is $AVC(y) =$_____ (Hint: Notice that total variable costs equal $c(y) - c(0)$.)

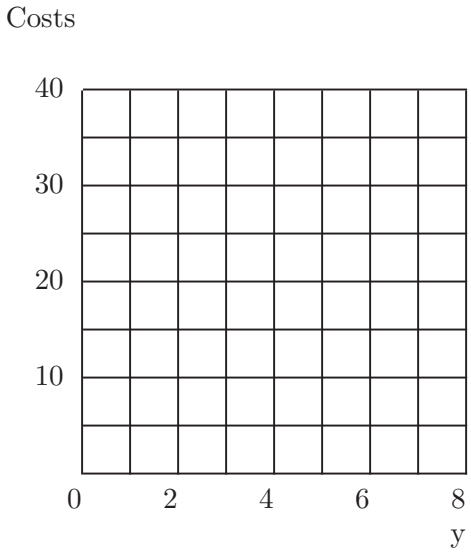
(c) On the axes below, sketch and label a graph of the marginal cost function and of the average variable cost function.

(d) Average variable cost is falling as output rises if output is less than _____ and rising as output rises if output is greater than_____.

(e) Marginal cost equals average variable cost when output is_____.

(f) The firm will supply zero output if the price is less than_____.

(g) The smallest positive amount that the firm will ever supply at any price is _____ At what price would the firm supply exactly 6 units of output?_____.



22.3 (0) Mr. McGregor owns a 5-acre cabbage patch. He forces his wife, Flopsy, and his son, Peter, to work in the cabbage patch without wages. Assume for the time being that the land can be used for nothing other than cabbages and that Flopsy and Peter can find no alternative employment. The only input that Mr. McGregor pays for is fertilizer. If he uses x sacks of fertilizer, the amount of cabbages that he gets is $10\sqrt{x}$. Fertilizer costs \$1 per sack.

(a) What is the total cost of the fertilizer needed to produce 100 cabbages? _____ What is the total cost of the amount of fertilizer needed to produce y cabbages?_____.

(b) If the only way that Mr. McGregor can vary his output is by varying the amount of fertilizer applied to his cabbage patch, write an expression for his marginal cost, as a function of y. $MC(y) =$_____.

(c) If the price of cabbages is \$2 each, how many cabbages will Mr. McGregor produce? _____ How many sacks of fertilizer will he buy? _____ How much profit will he make?_____.

(d) The price of fertilizer and of cabbages remain as before, but Mr. McGregor learns that he could find summer jobs for Flopsy and Peter in a local sweatshop. Flopsy and Peter would together earn $300 for the summer, which Mr. McGregor could pocket, but they would have no time to work in the cabbage patch. Without their labor, he would get no cabbages. Now what is Mr. McGregor's total cost of producing y cabbages?

_____.

(e) Should he continue to grow cabbages or should he put Flopsy and Peter to work in the sweatshop?_____.

22.4 (0) Severin, the herbalist, is famous for his hepatica. His total cost function is $c(y) = y^2 + 10$ for $y > 0$ and $c(0) = 0$. (That is, his cost of producing zero units of output is zero.)

(a) What is his marginal cost function? _____ What is his average cost function?_____.

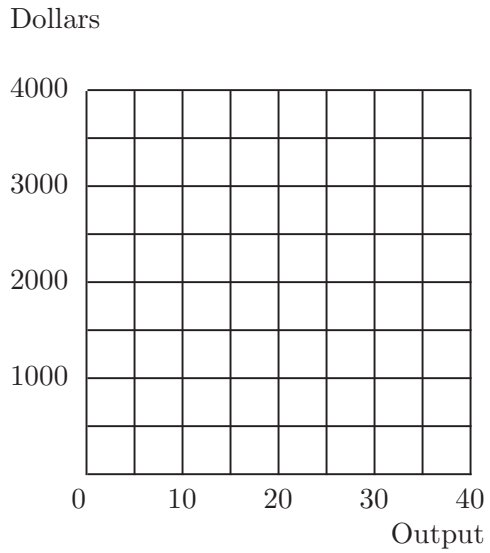
(b) At what quantity is his marginal cost equal to his average cost? _____ At what quantity is his average cost minimized?_____.

(c) In a competitive market, what is the lowest price at which he will supply a positive quantity in long-run equilibrium? _____ How much would he supply at that price?_____.

22.5 (1) Stanley Ford makes mountains out of molehills. He can do this with almost no effort, so for the purposes of this problem, let us assume that molehills are the only input used in the production of mountains. Suppose mountains are produced at constant returns to scale and that it takes 100 molehills to make 1 mountain. The current market price of molehills is $20 each. A few years ago, Stan bought an "option" that permits him to buy up to 2,000 molehills at $10 each. His option contract explicitly says that he can buy fewer than 2,000 molehills if he wishes, but he can not resell the molehills that he buys under this contract. In order to get governmental permission to produce mountains from molehills, Stanley would have to pay $10,000 for a molehill-masher's license.

(a) The marginal cost of producing a mountain for Stanley is _____ if he produces fewer than 20 mountains. The marginal cost of producing a mountain is _____ if he produces more than 20 mountains.

(b) On the graph below, show Stanley Ford's marginal cost curve (in blue ink) and his average cost curve (in red ink).



(c) If the price of mountains is \$1,600, how many mountains will Stanley produce?_____.

(d) The government is considering raising the price of a molehill-masher's license to \$11,000. Stanley claims that if it does so he will have to go out of business. Is Stanley telling the truth? _____ What is the highest fee for a license that the government could charge without driving him out of business?_____

_____.

(e) Stanley's lawyer, Eliot Sleaze, has discovered a clause in Stanley's option contract that allows him to resell the molehills that he purchased under the option contract at the market price. On the graph above, use a pencil to draw Stanley's new marginal cost curve. If the price of mountains remains \$1,600, how many mountains will Stanley produce now?_____.

22.6 (1) Lady Wellesleigh makes silk purses out of sows' ears. She is the only person in the world who knows how to do so. It takes one sow's ear and 1 hour of her labor to make a silk purse. She can buy as many sows' ears as she likes for \$1 each. Lady Wellesleigh has no other source of income than her labor. Her utility function is a Cobb-Douglas function $U(c, r) = c^{1/3}r^{2/3}$, where c is the amount of money per day that she has to spend on consumption goods and r is the amount of leisure that she has. Lady Wellesleigh has 24 hours a day that she can devote either to leisure or to working.

(a) Lady Wellesleigh can either make silk purses or she can earn \$5 an hour as a seamstress in a sweatshop. If she worked in the sweat shop, how many hours would she work? _____ (Hint: To solve for this amount, write down Lady Wellesleigh's budget constraint and recall how to find the demand function for someone with a Cobb-Douglas utility function.)

(b) If she could earn a wage of \$$w$ an hour as a seamstress, how much would she work?_____.

(c) If the price of silk purses is \$$p$, how much money will Lady Wellesleigh earn per purse after she pays for the sows' ears that she uses?_____.

(d) If she can earn \$5 an hour as a seamstress, what is the lowest price at which she will make any silk purses?_____.

(e) What is the supply function for silk purses? (Hint: The price of silk purses determines the "wage rate" that Lady W. can earn by making silk purses. This determines the number of hours she will choose to work and hence the supply of silk purses.)_____.

22.7 (0) Remember Earl, who sells lemonade in Philadelphia? You met him in the chapter on cost functions. Earl's production function is $f(x_1, x_2) = x_1^{1/3} x_2^{1/3}$, where x_1 is the number of pounds of lemons he uses and x_2 is the number of hours he spends squeezing them. As you found out, his cost function is $c(w_1, w_2, y) = 2w_1^{1/2} w_2^{1/2} y^{3/2}$, where y is the number of units of lemonade produced.

(a) If lemons cost \$1 per pound, the wage rate is \$1 per hour, and the price of lemonade is p, Earl's marginal cost function is $MC(y) =$ _____ _____ and his supply function is $S(p) =$_____ If lemons cost \$4 per pound and the wage rate is \$9 per hour, his supply function will be $S(p) =$_____.

(b) In general, Earl's marginal cost depends on the price of lemons and the wage rate. At prices w_1 for lemons and w_2 for labor, his marginal cost when he is producing y units of lemonade is $MC(w_1, w_2, y) =$_____ _____ The amount that Earl will supply depends on the three variables, p, w_1, w_2. As a function of these three variables, Earl's supply is $S(p, w_1, w_2) =$_____.

22.8 (0) As you may recall from the chapter on cost functions, Irma's handicrafts has the production function $f(x_1, x_2) = (\min\{x_1, 2x_2\})^{1/2}$, where x_1 is the amount of plastic used, x_2 is the amount of labor used, and $f(x_1, x_2)$ is the number of lawn ornaments produced. Let w_1 be the price per unit of plastic and w_2 be the wage per unit of labor.

(a) Irma's cost function is $c(w_1, w_2, y) =$_____.

(b) If $w_1 = w_2 = 1$, then Irma's marginal cost of producing y units of output is $MC(y) =$_____ The number of units of output that she would supply at price p is $S(p) =$_____ At these factor prices, her average cost per unit of output would be $AC(y) =$_____.

(c) If the competitive price of the lawn ornaments she sells is $p = 48$, and $w_1 = w_2 = 1$, how many will she produce?_____ How much profit will she make?_____.

(d) More generally, at factor prices w_1 and w_2, her marginal cost is a function $MC(w_1, w_2, y) =$_____ At these factor prices and an output price of p, the number of units she will choose to supply is $S(p, w_1, w_2) =$ _____.

22.9 (0) Jack Benny can get blood from a stone. If he has x stones, the number of pints of blood he can extract from them is $f(x) = 2x^{\frac{1}{3}}$. Stones cost Jack \$$w$ each. Jack can sell each pint of blood for \$$p$.

(a) How many stones does Jack need to extract y pints of blood?_____ _____.

(b) What is the cost of extracting y pints of blood?_____.

(c) What is Jack's supply function when stones cost \$8 each? _____ _____ When stones cost \$$w$ each?_____.

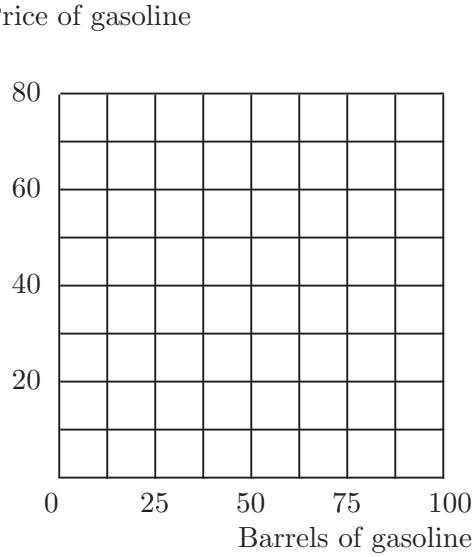
(d) If Jack has 19 relatives who can also get blood from a stone in the same way, what is the aggregate supply function for blood when stones cost $\$w$ each?_____.

22.10 (1) The Miss Manners Refinery in Dry Rock, Oklahoma, converts crude oil into gasoline. It takes 1 barrel of crude oil to produce 1 barrel of gasoline. In addition to the cost of oil there are some other costs involved in refining gasoline. Total costs of producing y barrels of gasoline are described by the cost function $c(y) = y^2/2 + p_o y$, where p_o is the price of a barrel of crude oil.

(a) Express the marginal cost of producing gasoline as a function of p_o and y._____.

(b) Suppose that the refinery can buy 50 barrels of crude oil for \$5 a barrel but must pay \$15 a barrel for any more that it buys beyond 50 barrels. The marginal cost curve for gasoline will be _____ up to 50 barrels of gasoline and _____ thereafter.

(c) Plot Miss Manners' supply curve in the diagram below using blue ink.



(d) Suppose that Miss Manners faces a horizontal demand curve for gasoline at a price of \$30 per barrel. Plot this demand curve on the graph above using red ink. How much gasoline will she supply?_____.

(e) If Miss Manners could no longer get the first 50 barrels of crude for $5, but had to pay $15 a barrel for all crude oil, how would her output change?_____.

(f) Now suppose that an entitlement program is introduced that permits refineries to buy one barrel of oil at $5 for each barrel of oil that they buy for $15. What will Miss Manners' supply curve be now? _____ _____ Assume that it can buy fractions of a barrel in the same manner. Plot this supply curve on the graph above using black ink. If the demand curve is horizontal at $30 a barrel, how much gasoline will Miss Manners supply now?_____.

To find the industry supply of output, just add up the supply of output coming from each individual firm. Remember to add quantities, not prices. The industry supply curve will have a kink in it where the market price becomes low enough that some firm reduces its quantity supplied to zero.

The series of problems about the garden gnome industry are designed to help you to understand the distinction between the long run and the short run. To solve these problems, you need to pay careful attention to the timing of decisions. In particular, in this problem, units of capital (gnome molds) can be produced and delivered only one year after they are ordered.

The last three questions of this chapter apply supply and demand analysis to some problems in the economics of illegal activities. In these examples, you will make use of your knowledge of where supply functions come from.

23.0 Warm Up Exercise. Here are some drills for you on finding market supply functions from linear firm supply functions. The trick here is to remember that the market supply function may have kinks in it. For example, if the firm supply functions are $s_1(p) = p$ and $s_2(p) = p - 2$, then the market supply function is $S(p) = p$ for $p \leq 2$ and $S(p) = 2p - 2$ for $p > 2$; that is, only the first firm supplies a positive output at prices below \$2, and both firms supply output at prices above \$2. Now try to construct the market supply function in each of the following cases.

(a) $s_1(p) = p, s_2(p) = 2p, s_3(p) = 3p$._____.

(b) $s_1(p) = 2p, s_2(p) = p - 1$._____.

(c) 200 firms each have a supply function $s_1(p) = 2p - 8$ and 100 firms each have a supply function $s_2(p) = p - 3$._____

_____.

(d) $s_1(p) = 3p-12, s_2(p) = 2p-8, s_3(p) = p-4$._____.

23.1 (1) Al Deardwarf's cousin, Zwerg, makes plaster garden gnomes. The technology in the garden gnome business is as follows. You need a gnome mold, plaster, and labor. A gnome mold is a piece of equipment that costs \$1,000 and will last exactly one year. After a year, a gnome

mold is completely worn out and has no scrap value. With a gnome mold, you can make 500 gnomes per year. For every gnome that you make, you also have to use a total of \$7 worth of plaster and labor. The total amounts of plaster and labor used are variable in the short run. If you want to produce only 100 gnomes a year with a gnome mold, you spend only \$700 a year on plaster and labor, and so on. The number of gnome molds in the industry cannot be changed in the short run. To get a newly built one, you have to special-order it from the gnome-mold factory. The gnome-mold factory only takes orders on January 1 of any given year, and it takes one whole year from the time a gnome mold is ordered until it is delivered on the next January 1. When a gnome mold is installed in your plant, it is stuck there. To move it would destroy it. Gnome molds are useless for anything other than making garden gnomes.

For many years, the demand function facing the garden-gnome industry has been $D(p) = 60,000 - 5,000p$, where $D(p)$ is the total number of garden gnomes sold per year and p is the price. Prices of inputs have been constant for many years and the technology has not changed. Nobody expects any changes in the future, and the industry is in long-run equilibrium. The interest rate is 10%. When you buy a new gnome mold, you have to pay for it when it is delivered. For simplicity of calculations, we will assume that all of the gnomes that you build during the one-year life of the gnome mold are sold at Christmas and that the employees and plaster suppliers are paid only at Christmas for the work they have done during the past year. Also for simplicity of calculations, let us approximate the date of Christmas by December 31.

(a) If you invested \$1,000 in the bank on January 1, how much money could you expect to get out of the bank one year later? _____ If you received delivery of a gnome mold on January 1 and paid for it at that time, by how much would your revenue have to exceed the costs of plaster and labor if it is to be worthwhile to buy the machine? (Remember that the machine will be worn out and worthless at the end of the year.)

_____.

(b) Suppose that you have exactly one newly installed gnome mold in your plant; what is your short-run marginal cost of production if you produce up to 500 gnomes? _____ What is your average *variable* cost for producing up to 500 gnomes? _____ If you have only one gnome mold, is it possible in the short run to produce more than 500 gnomes?

_____.

(c) If you have exactly one newly installed gnome mold, you would produce 500 gnomes if the price of gnomes is above _____ dollars. You would produce no gnomes if the price of gnomes is below _____ dol-

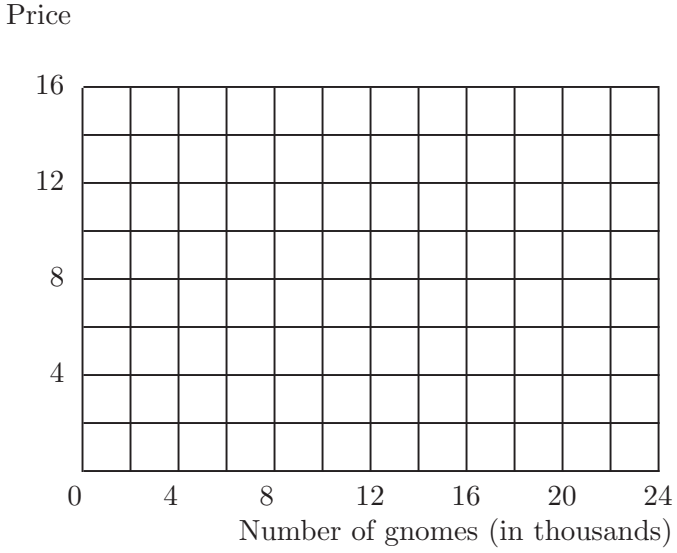
lars. You would be indifferent between producing any number of gnomes between 0 and 500 if the price of gnomes is _____ dollars.

(d) If you could sell as many gnomes as you liked for $10 each and none at a higher price, what rate of return would you make on your $1,000 by investing in a gnome mold? _____ Is this higher than the return from putting your money in the bank? _____ What is the lowest price for gnomes such that the rate of return you get from ivesting $1000 in a gnome mold is as at least 10%? _____ Could the long-run equilibrium price of gnomes be lower than this?_____.

(e) At the price you found in the last section, how many gnomes would be demanded each year? _____ How many molds would be purchased each year? _____ Is this a long-run equilibrium price?_____.

23.2 (1) We continue our study of the garden-gnome industry. Suppose that initially everything was as described in the previous problem. To the complete surprise of everyone in the industry, on January 1, 2001, the invention of a new kind of plaster was announced. This new plaster made it possible to produce garden gnomes using the same molds, but it reduced the cost of the plaster and labor needed to produce a gnome from $7 to $5 per gnome. Assume that consumers' demand function for gnomes in 2001 was not changed by this news. The announcement came early enough in the day for everybody to change his order for gnome molds to be delivered on January 1, 2002, but of course, but the total number of molds available to be used in 2001 was just the 28 molds that had been ordered the previous year. The manufacturer of garden gnome molds contracted to sell them for $1,000 when they were ordered, so it can't change the price it charges on delivery.

(a) On the graph below, draw the short run industry supply curve and teh demand curve for garden gnomes that applies in the year 2001, after the discovery of the new plaster is announced.



(b) In 2001, what is the short run equilibrium total output of garden gnomes, _____ and what is the short run equilibrium price of garden gnomes? _____ (Hint: Look at the intersection of the supply and demand curves you just drew. Cousin Zwerg bought a gnome mold that was delivered on January 1, 2001, and, as had been agreed, he paid $1,000 for it on that day. On January 1, 2002, when he sold the gnomes he had made during the year and when he paid the workers and the suppliers of plaster, he received a net cash flow of $_____ Did he make more than a 10% rate of return on his investment in the gnome mold?_____ _____ What rate of return did he make?_____.

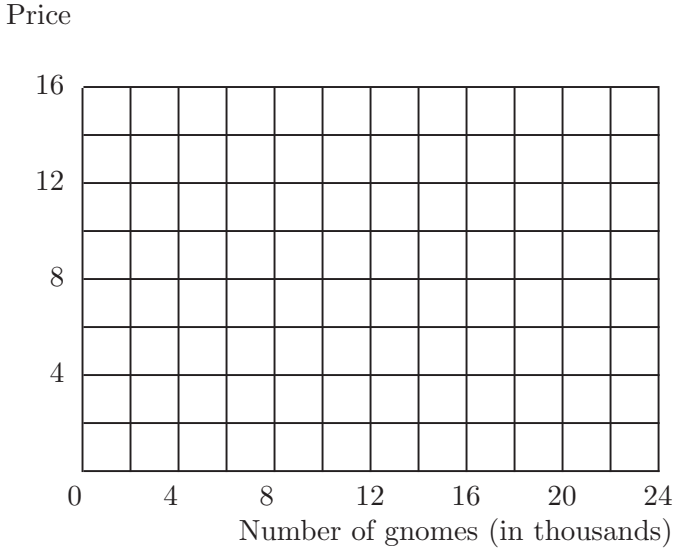
(c) Zwerg's neighbor, Munchkin, also makes garden gnomes, and he has a gnome mold that is to be delivered on January 1, 2001. On this day, Zwerg, who is looking for a way to invest some more money, is considering buying Munchkin's new mold from Munchkin and installing it in his own plant. If Munchkin keeps his mold, he will get a net cash flow of $_____ _____ in one year. If the interest rate that Munchkin faces, both for borrowing and lending is 10%, then should he be willing to sell his mold for $1,000? _____ What is the lowest price that he would be willing to sell it for?_____ If the best rate of return that Zwerg can make on alternative investments of additional funds is 10%, what is the most that Zwerg would be willing to pay for Munchkin's new mold?_____.

(d) What do you think will happen to the number of garden gnomes ordered for delivery on January 1, 2002? Will it be larger, smaller, or the same as the number ordered the previous year? _____ After the passage of sufficient time, the industry will reach a new long-run equilibrium. What will be the new equilibrium price of gnomes?_____

_____.

23.3 (1) In the previous problem, we studied the effects of a cost-saving invention. For this problem, we suppose that there was no such invention, but that a tax is introduced. Suppose that on January 1, 2001, the industry was as described in the previous problem (without the invention of the new kind of plaster). On this day, the government surprised the garden gnome industry by introducing a tax on the production of garden gnomes. For every garden gnome produced, the manufacturer must pay a $1 tax. The announcement came early enough in the day so that there was time for gnome producers to change their orders of gnome molds for 2002. But the gnome molds available to be used in 2001 are those that had been ordered a year previously. Gnome makers had signed contracts promising to pay $1,000 for each gnome mold that they ordered, and they couldn't back out of these promises. Thus in the short run, during the year 2001, the number of gnome molds is stuck at 28.

(a) On the graph below, draw the short run industry supply curve for garden gnomes that applies in the year 2001, after the new tax is introduced. On the same graph, show the demand curve for garden gnomes.



(b) In 2001, after the tax is introduced, what is the short run equilibrium total output of garden gnomes, _____ and what is the short run

equilibrium price of garden gnomes? _____ (Hint: Look at the intersection of the supply and demand curves you just drew.)

(c) If you have a garden gnome mold, the marginal cost of producing a garden gnome, including the tax, is _____ Therefore all gnome molds (will, will not) _____ be used up to capacity in 2001.

(d) In 2001, what will be the total output of garden gnomes? _____

What will be the price of garden gnomes? _____ What rate of return will Deardwarf's cousin Zwerg make on his investment in a garden gnome mold that he ordered a year ago and paid $1,000 for at that time?

_____.

(e) Remember that Zwerg's neighbor, Munchkin, also has a gnome mold that is to be delivered on January 1, 2001. Knowing about the tax makes Munchkin's mold a less attractive investment than it was without the tax, but still Zwerg would buy it if he can get it cheap enough so that he makes a 10% rate of return on his investment. How much should he be willing to pay for Munchkin's new mold?_____.

(f) What do you think will happen to the number of gnome molds ordered for delivery on January 1, 2002? Will it be larger, smaller, or the same as the number ordered the previous year?_____.

(g) The tax on garden gnomes was left in place for many years, and nobody expected any further changes in the tax or in demand or supply conditions. After the passage of sufficient time, the industry reached a new long-run equilibrium. What was the new equilibrium price of gnomes?

_____.

(h) In the short run, who would end up paying the tax on garden gnomes, the producers or the consumers? _____ In the long run, did the price of gnomes go up by more, less, or the same amount as the tax per gnome?_____.

(i) Suppose that early in the morning of January 1, 2001, the government had announced that there would be a $1 tax on garden gnomes, but that the tax would not go into effect until January 1, 2002. Would the producers of garden gnomes necessarily be worse off than if there were no tax? Why or why not?_____

_____.

(j) Is it reasonable to suppose that the government could introduce "surprise" taxes without making firms suspicious that there would be similar "surprises" in the future? Suppose that the introduction of the tax in January 2001 makes gnome makers suspicious that there will be more taxes introduced in later years. Will this affect equilibrium prices and supplies? How?

23.4 (0) Consider a competitive industry with a large number of firms, all of which have identical cost functions $c(y) = y^2 + 1$ for $y > 0$ and $c(0) = 0$. Suppose that initially the demand curve for this industry is given by $D(p) = 52 - p$. (The output of a firm does not have to be an integer number, but the number of firms does have to be an integer.)

(a) What is the supply curve of an individual firm? $S(p) =$ If there are n firms in the industry, what will be the industry supply curve?

(b) What is the smallest price at which the product can be sold?

(c) What will be the equilibrium number of firms in the industry? (Hint: Take a guess at what the industry price will be and see if it works.)

(d) What will be the equilibrium price? What will be the equilibrium output of each firm?

(e) What will be the equilibrium output of the industry?

(f) Now suppose that the demand curve shifts to $D(p) = 52.5 - p$. What will be the equilibrium number of firms? (Hint: Can a new firm enter the market and make nonnegative profits?)

(g) What will be the equilibrium price? _____ _____ What will be the equilibrium output of each firm? _____ What will be the equilibrium profits of each firm?_____.

(h) Now suppose that the demand curve shifts to $D(p) = 53 - p$. What will be the equilibrium number of firms? _____ What will be the equilibrium price?_____.

(i) What will be the equilibrium output of each firm? _____ What will be the equilibrium profits of each firm?_____.

23.5 (3) In 1990, the town of Ham Harbor had a more-or-less free market in taxi services. Any respectable firm could provide taxi service as long as the drivers and cabs satisfied certain safety standards.

Let us suppose that the constant marginal cost per trip of a taxi ride is \$5, and that the average taxi has a capacity of 20 trips per day. Let the demand function for taxi rides be given by $D(p) = 1,200 - 20p$, where demand is measured in rides per day, and price is measured in dollars. Assume that the industry is perfectly competitive.

(a) What is the competitive equilibrium price per ride? (Hint: In competitive equilibrium, price must equal marginal cost.) _____ What is the equilibrium number of rides per day? _____ How many taxicabs will there be in equilibrium?_____.

(b) In 1990 the city council of Ham Harbor created a taxicab licensing board and issued a license to each of the existing cabs. The board stated that it would continue to adjust the taxicab fares so that the demand for rides equals the supply of rides, but no new licenses will be issued in the future. In 1995 costs had not changed, but the demand curve for taxicab rides had become $D(p) = 1,220 - 20p$. What was the equilibrium price of a ride in 1995?_____.

(c) What was the profit per ride in 1995, neglecting any costs associated with acquiring a taxicab license? _____ What was the profit per taxicab license per day? _____ If the taxi operated every day, what was the profit per taxicab license per year?_____.

(d) If the interest rate was 10% and costs, demand, and the number of licenses were expected to remain constant forever, what would be the market price of a taxicab license?_____.

(e) Suppose that the commission decided in 1995 to issue enough new licenses to reduce the taxicab price per ride to \$5. How many more licenses would this take?_____.

(f) Assuming that demand in Ham Harbor is not going to grow any more, how much would a taxicab license be worth at this new fare?_____

_____.

(g) How much money would each current taxicab owner be willing to pay to prevent any new licenses from being issued? _____ What is the total amount that all taxicab owners together would be willing to pay to prevent any new licences from ever being issued? _____

_____ The total amount that consumers would be willing to pay to have another taxicab license issued would be (more than, less than, the same as) _____ this amount.

23.6 (2) In this problem, we will determine the equilibrium pattern of agricultural land use surrounding a city. Think of the city as being located in the middle of a large featureless plain. The price of wheat at the market at the center of town is \$10 a bushel, and it only costs \$5 a bushel to grow wheat. However, it costs 10 cents a mile to transport a bushel of wheat to the center of town.

(a) If a farm is located t miles from the center of town, write down a formula for its profit per bushel of wheat transported to market._____

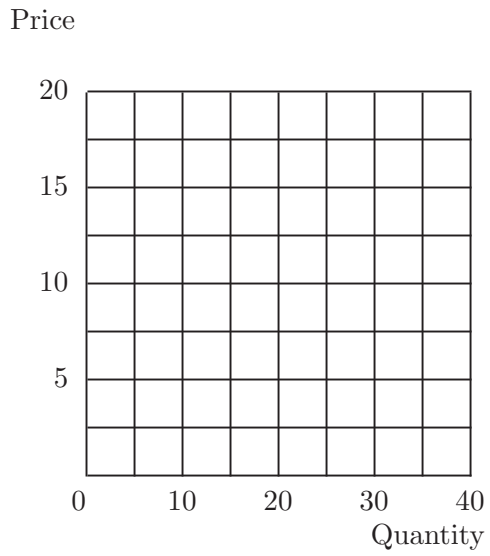
_____.

(b) Suppose you can grow 1,000 bushels on an acre of land. How much will an acre of land located t miles from the market rent for?_____

_____.

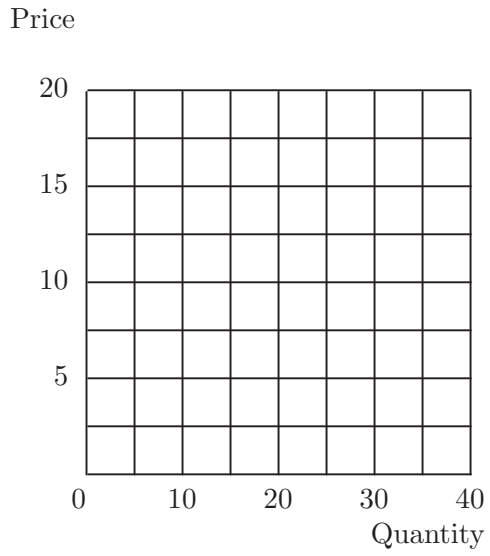
(c) How far away from the market do you have to be for land to be worth zero?_____.

23.7 (1) Consider an industry with three firms. Suppose the firms have the following supply functions: $S_1(p) = p$, $S_2(p) = p - 5$, and $S_3(p) = 2p$ respectively. On the graph below plot each of the three supply curves and the resulting industry supply curve.



(a) If the market demand curve has the form $D(p) = 15$, what is the resulting market price? _____ Output? _____ What is the output level for firm 1 at this price? _____ Firm 2? _____ Firm 3? _____.

23.8 (0) Suppose all firms in a given industry have the same supply curve given by $S_i(p) = p/2$. Plot and label the four industry supply curves generated by these firms if there are 1, 2, 3, or 4 firms operating in the industry.



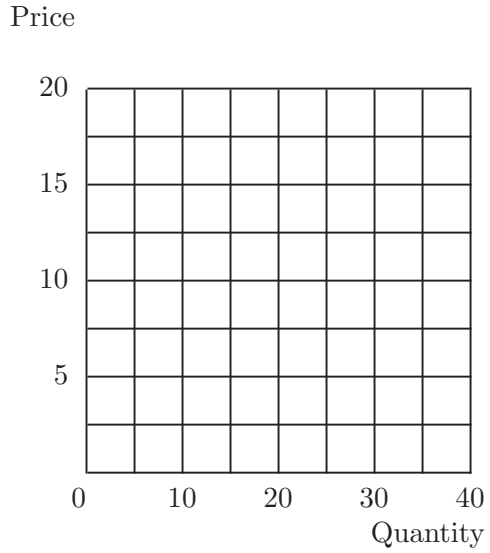
(a) If all of the firms had a cost structure such that if the price was below \$3, they would be losing money, what would be the equilibrium price and output in the industry if the market demand was equal to $D(p) = 3.5$?

Answer: price = _____ , quantity = _____ How many firms would exist in such a market?_____.

(b) What if the identical conditions as above held except that the market demand was equal to $D(p) = 8 - p$? Now, what would be the equilibrium price and output? _____ How many firms would operate in such a market?_____.

23.9 (0) There is free entry into the pollicle industry. Anybody can enter this industry and have the same U-shaped average cost curve as all of the other firms in the industry.

(a) On the diagram below, draw a representative firm's average and marginal cost curves using blue ink. Also, indicate the long-run equilibrium level of the market price.



(b) Suppose the government imposes a tax, t, on every unit of output sold by the industry. Use red ink to draw the new conditions on the above graph. After the industry has adjusted to the imposition of the tax, the competitive model would predict the following: the market price would (increase, decrease) _____ by amount _____ , there would be (more, the same, fewer) _____ firms operating in the industry, and the output level for each firm operating in the industry would _____ _____ (increase, stay the same, decrease).

(c) What if the government imposes a tax, l, on every *firm* in the industry. Draw the new cost conditions on the above graph using black ink. After the industry has adjusted to the imposition of the tax the competitive model would predict the following: the market price would (increase, decrease) _____ , there would be (more, the same, fewer) _____ _____ firms operating in the industry, and the output level for each firm operating in the industry would _____ (increase, stay the same, decrease).

23.10 (0) In many communities, a restaurant that sells alcoholic beverages is required to have a license. Suppose that the number of licenses is limited and that they may be easily transferred to other restaurant owners. Suppose that the conditions of this industry closely approximate perfect competition. If the average restaurant's revenue is $100,000 a year, and if a liquor license can be leased for a year for $85,000 from

an existing restaurant, what is the average variable cost in the industry?

_____.

23.11 (2) In order to protect the wild populations of cockatoos, the Australian authorities have outlawed the export of these large parrots. An illegal market in cockatoos has developed. The cost of capturing an Australian cockatoo and shipping him to the United States is about $40 per bird. Smuggled parrots are drugged and shipped in suitcases. This is extremely traumatic for the birds and about 50% of the cockatoos shipped die in transit. Each smuggled cockatoo has a 10% chance of being discovered, in which case the bird is confiscated and a fine of $500 is charged. Confiscated cockatoos that are alive are returned to the wild. Confiscated cockatoos that are found dead are donated to university cafeterias.*

(a) The probability that a smuggled parrot will reach the buyer alive and unconfiscated is _____ Therefore when the price of smuggled parrots is p, what is the expected gross revenue to a parrot-smuggler from shipping a parrot?_____.

(b) What is the expected cost, including expected fines and the cost of capturing and shipping, per parrot?_____.

(c) The supply schedule for smuggled parrots will be a horizontal line at the market price _____ (Hint: At what price does a parrot-smuggler just break even?)

(d) The demand function for smuggled cockatoos in the United States is $D(p) = 7,200 - 20p$ per year. How many smuggled cockatoos will be sold in the United States per year at the equilibrium price? _____ How many cockatoos must be caught in Australia in order that this number of live birds reaches U.S. buyers?_____.

(e) Suppose that instead of returning live confiscated cockatoos to the wild, the customs authorities sold them in the American market. The profits from smuggling a cockatoo do not change from this policy change. Since the supply curve is horizontal, it must be that the equilibrium price of smuggled cockatoos will have to be the same as the equilibrium price when the confiscated cockatoos were returned to nature. How many live cockatoos will be sold in the United States in equilibrium? _____

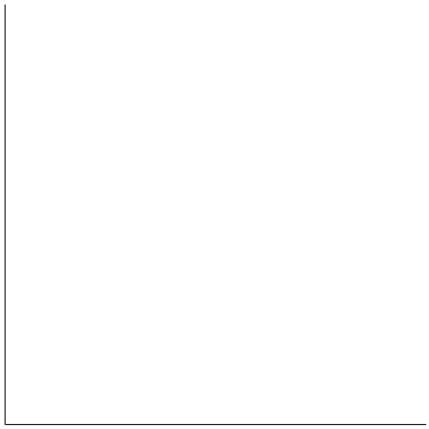
* The story behind this problem is based on actual fact, but the numbers we use are just made up for illustration. It would be very interesting to have some good estimates of the actual demand functions and cost functions.

How many cockatoos will be permanently removed from the Australian wild?_____.

(f) Suppose that the trade in cockatoos is legalized. Suppose that it costs about $40 to capture and ship a cockatoo to the United States in a comfortable cage and that the number of deaths in transit by this method is negligible. What would be the equilibrium price of cockatoos in the United States? _____ How many cockatoos would be sold in the United States? _____ How many cockatoos would have to be caught in Australia for the U.S. market?_____.

23.12 (0) The horn of the rhinoceros is prized in Japan and China for its alleged aphrodisiac properties. This has proved to be most unfortunate for the rhinoceroses of East Africa. Although it is illegal to kill rhinoceroses in the game parks of Kenya, the rhinoceros population of these parks has been almost totally depleted by poachers. The price of rhinoceros horns in recent years has risen so high that a poacher can earn half a year's wages by simply killing one rhinoceros. Such high rewards for poaching have made laws against poaching almost impossible to enforce in East Africa. There are also large game parks with rhinoceros populations in South Africa. Game wardens there were able to prevent poaching almost completely and the rhinoceros population of South Africa has prospered. In a recent program from the television series *Nova*, a South African game warden explained that some rhinoceroses even have to be "harvested" in order to prevent overpopulation of rhinoceroses. "What then," asked the interviewer, "do you do with the horns from the animals that are harvested or that die of natural causes?" The South African game warden proudly explained that since international trade in rhinoceros horns was illegal, South Africa did not contribute to international crime by selling these horns. Instead the horns were either destroyed or stored in a warehouse.

(a) Suppose that all of the rhinoceros horns produced in South Africa are destroyed. Label the axes below and draw world supply and demand curves for rhinoceros horns with blue ink. Label the equilibrium price and quantity.



(b) If South Africa were to sell its rhinoceros horns on the world market, which of the curves in your diagram would shift and in what direction?

_____ Use red ink to illustrate the shifted curve or curves. If South Africa were to do this, would world consumption of rhinoceros horns be increased or decreased? _____ Would the world price of rhinoceros horns be increased or decreased? _____ Would the amount of rhinoceros poaching be increased or decreased?_____.

23.13 (1) The sale of rhinoceros horns is not prohibited because of concern about the wicked pleasures of aphrodisiac imbibers, but because the supply activity is bad for rhinoceroses. Similarly, the Australian reason for restricting the exportation of cockatoos to the United States is not because having a cockatoo is bad for you. Indeed it is legal for Australians to have cockatoos as pets. The motive for the restriction is simply to protect the wild populations from being overexploited. In the case of other commodities, it appears that society has no particular interest in restricting the supply activities but wishes to restrict consumption. A good example is illicit drugs. The growing of marijuana, for example, is a simple pastoral activity, which in itself is no more harmful than growing sweet corn or brussels sprouts. It is the consumption of marijuana to which society objects.

Suppose that there is a constant marginal cost of $5 per ounce for growing marijuana and delivering it to buyers. But whenever the marijuana authorities find marijuana growing or in the hands of dealers, they seize the marijuana and fine the supplier. Suppose that the probability that marijuana is seized is .3 and that the fine if you are caught is $10 per ounce.

(a) If the "street price" is $\$p$ per ounce, what is the expected revenue net of fines to a dealer from selling an ounce of marijuana? _____

What then would be the equilibrium price of marijuana?_____.

(b) Suppose that the demand function for marijuana has the equation $Q = A - Bp$. If all confiscated marijuana is destroyed, what will be the equilibrium consumption of marijuana? _____ Suppose that confiscated marijuana is not destroyed but sold on the open market.

What will be the equilibrium consumption of marijuana?_____.

(c) The price of marijuana will (increase, decrease, stay the same)_____

_____.

(d) If there were increasing rather than constant marginal cost in marijuana production, do you think that consumption would be greater if confiscated marijuana were sold than if it were destroyed? Explain._____

_____

_____.