Intermediate Microeconomics
Economics 4351/7351
Fall 2011
Answers for Practice Problem Set 2, Chapters 6-8

Chapter 6

2. Suppose a chair manufacturer is producing in the short run (with its existing plant and equipment). The manufacturer has observed the following levels of production corresponding to different numbers of workers:

Number of Workers	Number of Chairs
1	10
2	18
3	24
4	28
5	30
6	28
7	25

a. Calculate the marginal and average product of labor for this production function.

The average product of labor, AP_L, is equal to $\frac{q}{L}$. The marginal product of labor, MP_L, is equal to $\frac{\Delta q}{\Delta L}$, the change in output divided by the change in labor input. For this production process we have:

L	q	AP_L	MP_L
0	0	–	–
1	10	10	10
2	18	9	8
3	24	8	6
4	28	7	4
5	30	6	2
6	28	4.7	-2
7	25	3.6	-3

b. Does this production function exhibit diminishing returns to labor? Explain.

This production process exhibits diminishing returns to labor. The marginal product of labor, the extra output produced by each additional worker, diminishes as workers are added, and is actually negative for the sixth and seventh workers.

7. The marginal product of labor in the production of computer chips is 50 chips per hour. The marginal rate of technical substitution of hours of labor for hours of machine-capital is 1/4. What is the marginal product of capital?

The marginal rate of technical substitution is defined at the ratio of the two marginal products. Here, we are given the marginal product of labor and the marginal rate of technical substitution. To determine the marginal product of capital, substitute the given values for the marginal product of labor and the marginal rate of technical substitution into the following formula:

$$\frac{MP_L}{MP_K} = MRTS, or \frac{50}{MP_K} = \frac{1}{4}, or$$

MP_K = 200 computer chips per hour.

8. Do the following functions exhibit increasing, constant, or decreasing returns to scale? What happens to the marginal product of each individual factor as the factor is increased, and the other factor is held constant?

a. $q = 3L + 2K$

This function exhibits constant returns to scale. When the inputs are doubled, output will double. Show this explicitly by substituting 2L for L and 2K for K. Then demonstrate the analogous result for any multiple $\lambda \neq 1$ and positive. Each marginal product is constant for this total product function. When L increases by 1, q will increase by 3. When K increases by 1, q will increase by 2.

b. $q = (2L + 2K)^{\frac{1}{2}}$

This function exhibits decreasing returns to scale. When the inputs are doubled, output will less than double. Demonstrate this explicitly. Then demonstrate with positive $\lambda \neq 1$. The marginal product of each input is decreasing. This can be determined using calculus by differentiating the production function with respect to either input, while holding the other input constant. For example, the marginal product of labor is

$$\frac{\partial q}{\partial L} = \frac{2}{2(2L + 2K)^{\frac{1}{2}}}$$

Since L is in the denominator, as L gets bigger, the marginal product gets smaller. If you do not know calculus, then you can choose several values for L, find q (for some fixed value of K), and then find the marginal product. For example, if L=4 and K=4 then q=4. If L=5 and K=4 then q=4.24. If L=6 and K=4 then q=4.47. Marginal product of labor falls from 0.24 to 0.23.

c. $q = 3LK^2$

This function exhibits increasing returns to scale.

Notice that if we increase each input by the same factor λ then we get the following:

$$q' = 3(\lambda L)(\lambda K)^2 = \lambda^3 3LK^2 = \lambda^3 q.$$

Since λ is raised to a power greater than 1, we have increasing returns to scale.

The marginal product of labor is constant and the marginal product of capital is increasing. For any given value of K, when L is increased by 1 unit, q will go up by $3K^2$ units, which, for a given value of K, is a constant number. Using calculus, the marginal product of capital is $MPK = 2 \cdot 3 \cdot L \cdot K = 6LK$. As K increases, MPK will increase. If you do not know calculus then you can fix the value of L, choose a starting value for K, and find q. Now increase K by 1 unit and find the new q. Do this a few more times and you can calculate marginal product. This was done in part b above, and is done in part d below.

d. $q = L^{\frac{1}{2}} K^{\frac{1}{2}}$

This function exhibits constant returns to scale. Notice that if we increase each input by the same factor λ then we get the following:

$$q' = (\lambda L)^{\frac{1}{2}} (\lambda K)^{\frac{1}{2}} = \lambda L^{\frac{1}{2}} K^{\frac{1}{2}} = \lambda q.$$

Since λ is raised to the power of 1, we have constant returns to scale.

The marginal product of labor is decreasing, and the marginal product of capital is decreasing. Using calculus, the marginal product of capital is

$$MPK = \frac{L^{\frac{1}{2}}}{2K^{\frac{1}{2}}}.$$

For any given value of L, as K increases, MPK will increase. If you do not know calculus then you can fix the value of L, choose a starting value for K, and find q. Let L=4 for example. If K is 4 then q is 4, if K is 5 then q is 4.47, and if K is 6 then q is 4.89. The marginal product of the 5th unit of K is 4.47-4=0.47, and the marginal product of the 6th unit of K is 4.89-4.47=0.42. Hence we have diminishing marginal product of capital. You can do the same thing for the marginal product of labor.

e. $q = 4L^{\frac{1}{2}} + 4K$

This function exhibits decreasing returns to scale. When the inputs are doubled, output will less than double. Demonstrate this explicitly, and then demonstrate the analogous result for all positive $\lambda \neq 1$.

The marginal product of labor is decreasing and the marginal product of capital is constant. For any given value of L, when K is increased by 1 unit, q will go up by 4 units, which is a constant number. To see that the marginal product of labor is decreasing, fix K=1 and choose values for L. If L=1 then q=8, if L=2 then q=9.65, and if L=3 then q=10.93. The marginal product of the second unit of labor is 9.65-8=1.65 and the marginal product of the third unit of labor is 10.93-9.65=1.28. Marginal product of labor is diminishing.

10. In Example 6.3, wheat is produced according to the production function shown in fn. 6, p. 213.

a. Beginning with a capital input of 4 and a labor input of 49, show that the marginal product of labor and the marginal product of capital are both decreasing.

For fixed labor and variable capital:

$$K = 4 \Rightarrow q = (100)(4^{0.8})(49^{0.2}) = 660.22$$
$$K = 5 \Rightarrow q = (100)(5^{0.8})(49^{0.2}) = 789.25 \Rightarrow MP_K = 129.03$$
$$K = 6 \Rightarrow q = (100)(6^{0.8})(49^{0.2}) = 913.19 \Rightarrow MP_K = 123.94$$
$$K = 7 \Rightarrow q = (100)(7^{0.8})(49^{0.2}) = 1033.04 \Rightarrow MP_K = 119.85.$$

For fixed capital and variable labor:

$$L = 49 \Rightarrow q = (100)(4^{0.8})(49^{0.2}) = 660.22$$
$$L = 50 \Rightarrow q = (100)(4^{0.8})(50^{0.2}) = 662.89 \Rightarrow MP_L = 2.67$$
$$L = 51 \Rightarrow q = (100)(4^{0.8})(51^{0.2}) = 665.52 \Rightarrow MP_L = 2.63$$
$$L = 52 \Rightarrow q = (100)(4^{0.8})(52^{0.2}) = 668.11 \Rightarrow MP_L = 2.59.$$

Notice that the marginal products of both capital and labor are decreasing, as the variable input increases.

b. Does this production function exhibit increasing, decreasing or constant returns to scale?

Constant (increasing, decreasing) returns to scale imply that proportionate increases in inputs lead to the same (more than, less than) proportionate increases in output. If we were to increase labor and capital by the same proportionate amount (λ) in this production function, output would change by the same proportionate amount:

$$\lambda q = 100(\lambda K)^{0.8}(\lambda L)^{0.2}, \text{ or}$$
$$\lambda q = 100(\lambda K)^{0.8}(L)^{0.2}\lambda^{(0.8+0.2)} = q\lambda.$$

Therefore, this production function exhibits constant returns to scale.

Chapter 7

3. A firm has a fixed production cost of \$5,000 and a constant marginal cost of production of \$500 per unit produced.

a. What is the firm's total cost function? Average cost?

The variable cost of producing an additional unit, marginal cost, is constant at \$500, so VC=\$500q, and $AVC = \frac{VC}{q} = \frac{\$500q}{q} = \$500$. Fixed cost is \$5,000 and average fixed cost is $\frac{\$5,000}{q}$. The total cost function is fixed cost plus variable cost or TC=\$5000+\$500q. Average total cost is the sum of average variable cost and average fixed cost: $ATC = \$500 + \frac{\$5000}{q}$.

b. If the firm wanted to minimize the average total cost, would it choose to be very large or very small? Explain.

The firm should choose a very large output because average total cost will continue to decrease as q is increased. As q becomes infinitely large, ATC will equal \$500.

4. Suppose a firm must pay an annual tax, which is a fixed sum, independent of whether it produces any output.

a. How does this tax affect the firm's fixed, marginal, and average costs?

Total cost, TC, is equal to fixed cost, FC, plus variable cost, VC. Fixed costs do not vary with the quantity of output. Because the franchise fee, FF, is a fixed sum, the firm's fixed costs increase by this fee. Thus, average costs, equal to $\frac{FC+VC}{q}$, and average fixed cost, equal to $\frac{FC}{q}$, increase by the average franchise fee $\frac{FF}{q}$. Note that the franchise fee does not affect average variable cost. Also, because marginal cost is the *change* in total cost with the production of an additional unit and because the fee is constant, marginal cost is unchanged.

b. Now suppose the firm is charged a tax that is proportional to the number of items it produces. Again, how does this tax affect the firm's fixed, marginal, and average costs?

Let t equal the per unit tax. When a tax is imposed on each unit produced, variable costs increase by tq. Average variable costs increase by t, and because fixed costs are constant, average total costs also increase by t. Further, because total costs increase by t with each additional unit, marginal costs increase by t.

8. You manage a plant that mass produces engines by teams of workers using assembly machines. The technology is summarized by the production function.

q = 5KL

where q is the number of engines per week, K is the number of assembly machines, and L is the number of labor teams. Each assembly machine rents for r=\$10,000 per week and each team costs w=\$5,000 per week. Engine costs are given by the cost of labor teams and machines, plus \$2,000 per engine for raw materials. Your plant has a fixed installation of 5 assembly machines as part of its design, i.e. K is fixed at K=5 in the short run.

Note: First do this problem, ignoring the raw materials input. Then go over it with the raw materials input.

a. What is the cost function for your plant – namely, how much would it cost to produce q engines? What are average and marginal costs for producing q engines? How do average costs vary with output?

K is fixed at 5. The short-run production function is therefore q=25L. This implies that for any level of output q, the number of labor teams hired (the "labor requirement function") will be $L = \frac{q}{25}$. The total cost function is thus given by the sum of the costs of capital, labor and raw materials:

$$TC(q) = rK + wL + 2000q = (10{,}000)(5) + (5{,}000)(\frac{q}{25}) + 2{,}000q$$

$$TC(q) = 50{,}000 + 2{,}200q$$

For this linear cost function, the average cost function is given by:

$$AC(q) = \frac{TC(q)}{q} = \frac{50{,}000 + 2{,}200q}{q}.$$

and the marginal cost function is given by:

$$MC(q) = \frac{\partial TC}{\partial q} = 2200.$$

If you do not know calculus, simply compute $TC(q+1) - TC(q) = MC(q)$. Marginal costs are constant and average costs will decrease as quantity increases (due to the fixed cost of capital).

b. How many teams are required to produce 250 engines? What is the average cost per engine?

To produce q=250 engines we need labor teams $L = \frac{q}{25}$ or L=10. Average costs are given by

$$AC(q = 250) = \frac{50{,}000 + 2{,}200(250)}{250} = 2400$$

c. You are asked to make recommendations for the design of a new production facility. What capital/labor (K/L) ratio should the new plant accommodate if the firm wants to minimize the total cost of producing any level of output q?

We no longer assume that K is fixed at 5. We need to find the combination of K and L that minimizes costs at any level of output q. The cost-minimization rule is given by

$$\frac{MP_K}{r} = \frac{MP_L}{w}.$$

To find the marginal product of capital, observe that increasing K by 1 unit increases q by 5L, so $MP_K = 5L.$ Similarly, observe that increasing L by 1 unit increases q by 5K, so $MP_L = 5K.$ Mathematically,

$$MP_K = \frac{\partial q}{\partial K} = 5L \text{ and } MP_L = \frac{\partial q}{\partial L} = 5K.$$

Using these formulas in the cost-minimization rule, we obtain:

$$\frac{5L}{r} = \frac{5K}{w} \Rightarrow \frac{K}{L} = \frac{w}{r} = \frac{5{,}000}{10{,}000} = \frac{1}{2}.$$

The new plant should accommodate a capital to labor ratio of 1 to 2. Note that the current plant is presently operating at this capital-to-labor ratio.

9. The short-run cost function of a company is given by the equation TC=200+55q, where TC is the total cost and q is the total quantity of output both measured in thousands.

a. What is the company's fixed cost?

When q=0, TC=200, so fixed cost is equal to 200 (or $200,000)

b. If the company produces 100,000 units of goods, what is its average variable cost?

With 100,000 units, q=100. Variable cost is 55q = (55)(100) = 5500 (or $5,500,000).

Average variable cost is $\frac{TVC}{q} = \frac{\$5500}{100} = \$55$, or $55,000.

c. What is its marginal cost *per unit* produced?

With constant average variable cost, marginal cost is equal to average variable cost, $55 (or $55,000).

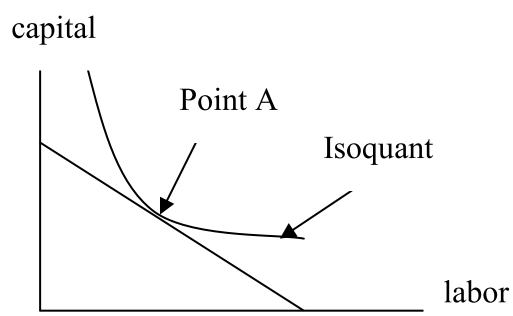
d. What is its average fixed cost?

At q=100, average fixed cost is $\frac{TFC}{q} = \frac{\$200}{100} = \$2$, or $2,000.

11. Suppose that a firm's production function is $q = 10L^{\frac{1}{2}}K^{\frac{1}{2}}$. The cost of a unit of labor is $20 and the cost of a unit of capital is $80.

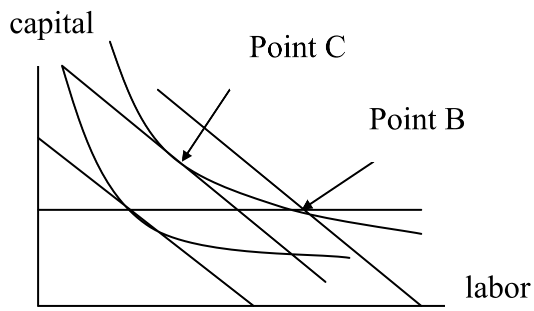
a. The firm is currently producing 100 units of output, and has determined that the cost-minimizing quantities of labor and capital are 20 and 5 respectively. Graphically illustrate this situation on a graph using isoquants and isocost lines.

The isoquant is convex. The optimal quantities of labor and capital are given by the point where the isocost line is tangent to the isoquant. The isocost line has a slope of ¼, given labor is on the horizontal axis. The total cost is TC=$20*20+$80*5=$800, so the isocost line has the equation $800=20L+80K. On the graph, the optimal point is point A.



b. The firm now wants to increase output to 140 units. If capital is fixed in the short run, how much labor will the firm require? Illustrate this point on your graph and find the new cost.

The new level of labor is 39.2. To find this, use the production function $q = 10L^{\frac{1}{2}}K^{\frac{1}{2}}$ and substitute 140 in for output and 5 in for capital. The new cost is TC=$20*39.2+$80*5=$1184. The new isoquant for an output of 140 is above and to the right of the old isoquant, the latter being for an output of 100. Since capital is fixed in the short run, the firm will move out horizontally to the new isoquant and new level of labor. This is point B on the graph below. This is not likely to be the cost minimizing point. Given the firm wants to produce more output, it is likely to want to hire more capital in the long run. Notice also that there are points on the new isoquant that are below the new isocost line. These points all involve hiring more capital.



c. Graphically identify the cost-minimizing level of capital and labor in the long run if the firm wants to produce 140 units.

This is point C in the graph above. When the firm is at point B it is not minimizing cost. The firm will find it optimal to hire more capital and less labor and move to the new lower isocost line. All three isocost lines above are parallel, (have the same slope).

d. If the marginal rate of technical substitution is K/L, find the optimal level of capital and labor required to produce the 140 units of output.

Set the marginal rate of technical substitution equal to the ratio of the input costs so that $\frac{K}{L} = \frac{20}{80} \Rightarrow K = \frac{L}{4}$. Now substitute this into the production function for K, set q equal to 140, and solve for L: $140 = 10L^{\frac{1}{2}}\left(\frac{L}{4}\right)^{\frac{1}{2}} \Rightarrow L = 28, K = 7$. The new cost is TC=$20*28+$80*7 or $1120.

Chapter 8

1. The data in the following table give information about the price (in dollars) for which a firm can sell a unit of output, and about the total cost of production.

a. Fill in the blanks in the table.

b. Show what happens to the firm's output choice and profit if the price of the product falls from \$60 to \$50.

q	*P*	*TR* *P=60*	*TC*	π *P=60*	*MC*	*MR* *P=60*	*TR* *P=50*	*MR* *P=50*	π *P=50*
0	60		100						
1	60		150						
2	60		178						
3	60		198						
4	60		212						
5	60		230						
6	60		250						
7	60		272						
8	60		310						
9	60		355						
10	60		410						
11	60		475						

The table below shows the firm's revenue and cost for the two prices.

q	*P*	*TR* *P=60*	*TC*	π *P=60*	*MC*	*MR* *P=60*	*TR* *P=50*	*MR* *P=50*	π *P=50*
0	60	0	100	-100	–	–	0	–	-100
1	60	60	150	-90	50	60	50	50	-100
2	60	120	178	-58	28	60	100	50	-78
3	60	180	198	-18	20	60	150	50	-48
4	60	240	212	28	14	60	200	50	-12
5	60	300	230	70	18	60	250	50	20
6	60	360	250	110	20	60	300	50	50
7	60	420	272	148	22	60	350	50	78
8	60	480	310	170	38	60	400	50	90
9	60	540	355	185	45	60	450	50	95
10	60	600	410	190	55	60	500	50	90
11	60	660	475	185	65	60	550	50	75

At a price of \$60, the firm should produce ten units of output to maximize profit because this is the point closest to where price equals marginal cost without having marginal cost exceed price. At a price of \$50, the firm should produce nine units to maximize profit. When price falls from \$60 to \$50, profit falls from \$190 to \$95.

3. Use the same information as in Exercise 1.

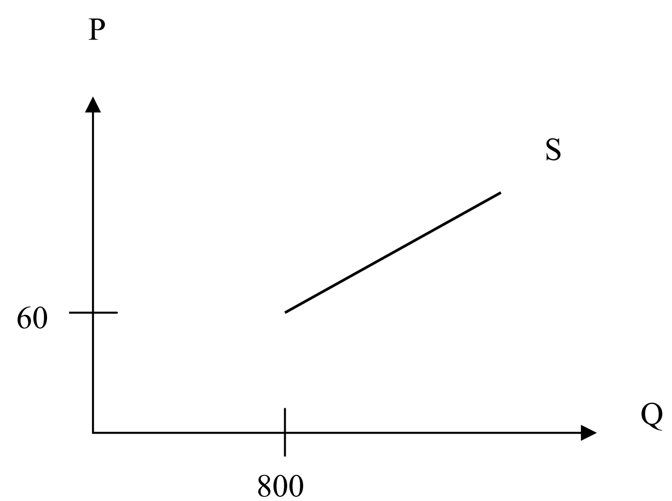
a. Derive the firm's short-run supply curve. (Hint: you may want to plot the appropriate cost curves.)

The firm's short-run supply curve is its marginal cost curve above average variable cost. The table below lists marginal cost, total cost, variable cost, fixed cost, and average variable cost. The firm will produce 8 or more units depending on the market price and will not produce in the 0-7 units of output range because in this range AVC is greater than MC. When AVC is greater than MC, the firm minimizes losses by producing nothing.

q	*TC*	*MC*	*TVC*	*TFC*	*AVC*
0	100	–	0	100	–
1	150	50	50	100	50.0
2	178	28	78	100	39.0
3	198	20	98	100	32.7
4	212	14	112	100	28.0
5	230	18	130	100	26.0
6	250	20	150	100	25.0
7	272	22	172	100	24.6
8	310	38	210	100	26.3
9	355	45	255	100	28.3
10	410	55	310	100	31.0
11	475	65	375	100	34.1

b. If 100 identical firms are in the market, what is the industry supply curve?

For 100 firms with identical cost structures, the market supply curve is the horizontal summation of each firm's output at each price.



4. Suppose you are the manager of a watchmaking firm operating in a competitive market. Your cost of production is given by C=200 +2q^2, where q is the level of output and C is total cost. (The marginal cost of production is 4q. The fixed cost of production is $200.)

a. If the price of watches is $100, how many watches should you produce to maximize profit?

Profits are maximized where marginal cost is equal to marginal revenue. Here, marginal revenue is equal to $100; recall that price equals marginal revenue in a competitive market:

$$100=4q, \text{ or } q=25.$$

b. What will the profit level be?

Profit is equal to total revenue minus total cost:

$$\pi = (100)(25) - (200 + 2 * 25^2) = \$1050.$$

c. At what minimum price will the firm produce a positive output?

A firm will produce in the short run if the revenues it receives are greater than its variable costs. Remember that the firm's short-run supply curve is its marginal cost curve above the minimum of average variable cost. Here, average variable cost is $\frac{VC}{q} = \frac{2q^2}{q} = 2q.$ Also, MC is equal to $4q$. So, MC is greater than AVC for any quantity greater than 0. This means that the firm produces in the short run as long as price is positive.

5. Suppose that a competitive firm's marginal cost of producing output q is given by MC(q)=3+2q. Assume that the market price of the firm's product is $9

a. What level of output will the firm produce?

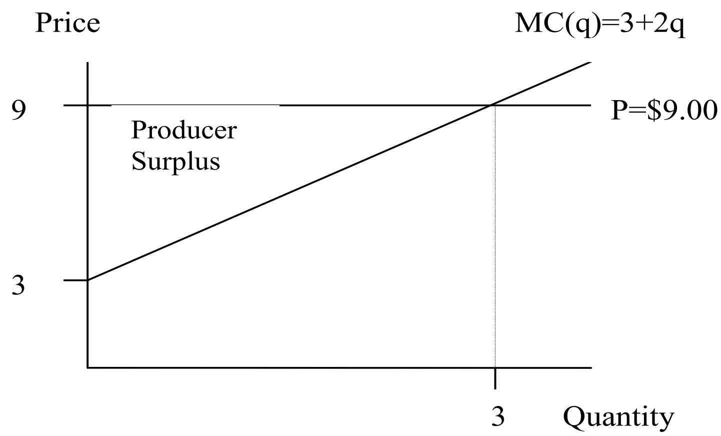
To maximize profits, the firm should set marginal revenue equal to marginal cost. Given the fact that this firm is operating in a competitive market, the market price it faces is equal to marginal revenue. Thus, the firm should set marginal cost equal to price to maximize its profits:

$$9=3+2q, \text{ or } q=3.$$

b. What is the firm's producer surplus?

Producer surplus is equal to the area below the market price, i.e. $9.00, and above the marginal cost, i.e., $3+2q$. Because MC is linear, producer surplus is a triangle with a base equal to $6 (9-3=6). The height of triangle is 3, where $P=MC$. Therefore, producer surplus is

$$(0.5)(6)(3)=\$9.$$


Price
MC(q)=3+2q
9
P=$9.00
Producer
Surplus
3
3
Quantity

c. Suppose that the average variable cost of the firm is given by AVC(q)=3+q. Suppose that the firm's fixed costs are known to be $3. Will the firm be earning a positive, negative, or zero profit in the short run?

Profit is equal to total revenue minus total cost. Total cost is equal to total variable cost plus fixed cost. Total variable cost is equal to (AVC)(q). Therefore, at q=3,

$$TVC = (3+3)(3) = \$18.$$

Fixed cost is equal to $3. Therefore, total cost equals *TVC* plus *TFC,* or

$$TC = 18 + 3 = \$21.$$

Total revenue is price times quantity:

$$TR = (\$9)(3)=\$27.$$

Profit is total revenue minus total cost:

$$\pi = \$27 - \$21 = \$6.$$

Therefore, the firm is earning positive economic profits. More easily, you might recall that profit equals producer surplus minus fixed cost. Since we found that producer surplus was $9 in part b, profit equals 9-3 or $6.

7. **Suppose the (short-run) cost function is $C(q)=4q^2+16$.**

a. Find variable cost, fixed cost, average cost, average variable cost, and average fixed cost. Hint: Marginal cost is MC=8q.

Variable cost is that part of total cost that depends on q ($4q^2$) and fixed cost is that part of total cost that does not depend on q (16).

$$VC = 4q^2$$
$$FC = 16$$
$$AC = \frac{C(q)}{q} = 4q + \frac{16}{q}$$
$$AVC = \frac{VC}{q} = 4q$$
$$AFC = \frac{FC}{q} = \frac{16}{q}$$

b. Show the average (total) cost, marginal cost, and average variable cost curves on a graph.

Average (total) cost is u-shaped. Average cost is relatively large at first because the firm is not able to spread the fixed cost over many units of output. As output increases, average fixed costs will fall relatively rapidly. Average cost will increase at some point because although average fixed cost will become very small, average variable cost is increasing as q increases. Average variable cost will increase because of diminishing returns to the variable factor labor. MC and AVC are linear, and both pass through the origin. In the case at hand, diminishing returns prevail for all output levels. Average variable cost is everywhere below average cost. Marginal cost is everywhere above average variable cost. If the average is rising, then the marginal must be above the average. Marginal cost will hit average cost at its minimum point.

c. Find the output that minimizes average cost.

The minimum average cost quantity is where MC is equal to AC:

$$AC = 4q + \frac{16}{q} = 8q = MC$$
$$\frac{16}{q} = 4q$$
$$16 = 4q^2$$
$$4 = q^2$$
$$2 = q.$$

d. For what range of prices will the firm produce a positive output?

The firm will supply positive levels of output as long as P=MC>AVC, or as long as the firm is covering its variable costs of production. In this case, marginal cost is everywhere above average variable cost so the firm will supply positive output at any positive price.

e. For what range of prices will the firm earn a negative profit?

The firm will earn negative profit when P=MC<AC, or at any price below minimum average cost. In part c above we found that the minimum average cost quantity was q=2. Plug q=2 into the average cost function to find AC=16. The firm will therefore earn negative profit if price is below 16.

f. For what range of prices will the firm earn a positive profit?

In part e we found that the firm would earn negative profit at any price below 16. The firm therefore earns positive profit as long as price is above 16.

9. a. Suppose that a firm's production function is $q = 9x^{\frac{1}{2}}$ in the short run, where there are fixed costs of $1,000 and x is the variable input, whose cost is $4,000 per unit. What is the total cost of producing a level of output q? In other words, derive the (short-run) total cost function C(q).

The total cost function C(q) = fixed cost + variable cost . Fixed cost is 1000. Variable cost for an output level q is the cost of the quantity of variable input that, in conjunction with the fixed input(s), is required to produce that level q. To find variable cost, first rewrite the production function to express x in terms of q, so that $x = \frac{q^2}{81}$. Then multiply by the input price of the variable input x, $4,000, to gain total variable cost: $VC(q) = (4000)\left(\frac{q^2}{81}\right)$. Now one can write down the total cost function:

$$C(q) = \frac{4000q^2}{81} + 1000.$$

The total cost function, as we usually use this term, is a function directly of *output*. However, the structure of this function is determined by input prices and by the (optimal) use of inputs, given the production function and those input prices.

b. Write down the equation for the supply curve.

The firm supplies output where P=MC so the marginal cost curve is the supply curve, or $P = \frac{8000q}{81}$.

c. If price is $1000, how many units will the firm produce? What is the level of profit? Illustrate on a cost curve graph.

To figure this out, set price equal to marginal cost to find:

$$P = \frac{8000q}{81} = 1000 \Rightarrow q = 10.125.$$

Profit is 1000*10.125-[1000+(4000*10.125*10.125)/81]=4062.5. Graphically, the firm produces where the price line hits the MC curve. Since profit is positive, this will occur at a quantity where price is greater than average cost. To find profit on the graph, take the difference of the revenue box (price times quantity) and the cost box (average cost times quantity). This rectangle is the profit area.

10. Suppose you are given the following information about a particular industry:

$Q^D = 6500 - 100P$	Market Demand
$Q^S = 1200P$	Market Supply
$C(q) = 722 + \frac{q^2}{200}$	Firm total cost function
$MC(q) = \frac{2q}{200}$	Firm marginal cost function

Assume that all firms are identical, and that the market is characterized by pure competition.

a. Find the equilibrium price, the equilibrium quantity at the total market level, the output supplied by the representative firm, (i.e. "representative," because all firms are identical), the profit of the firm, and the number of firms in the industry.

Equilibrium price and quantity are found by setting market supply equal to market demand, so that 6500-100P=1200P. Solve to find P=5 and substitute into either equation to find Q=6000. To find output for the firm set price equal to marginal cost so that $5 = \frac{2q}{200}$ and q=500. Profit of the firm is total revenue minus total cost or $\Pi = pq - C(q) = 5(500) - 722 - \frac{500^2}{200} = 528.$ Finally, since the total output in the market is 6000, and the firm output is 500, there must be 6000/500=12 firms in the industry.

b. Would you expect to see entry into or exit from the industry in the long run? Explain. What effect will entry or exit have on market equilibrium?

Entry because the firms in the industry are making positive profit. As firms enter, the supply curve for the industry will shift down and to the right and the equilibrium price will fall, all else the same. This will reduce each firm's profit down to zero until there is no incentive for further entry.

d. What is the lowest price at which each firm would sell its output in the short run? Is profit positive, negative, or zero at this price? Explain.

The firm will sell for any positive price, because at any positive price marginal cost will be above average variable cost (AVC=q/200). Profit is negative as long as price is below minimum average cost, or as long as price is below 3.8.

11. Suppose that a competitive firm has a total cost function $C(q)=450+15q+2q^2$ **and a marginal cost function** $MC(q)=15+4q$. **If the market price is P=$115 per unit, find the level of output produced by the firm. Find the level of profit and the level of producer surplus.**

The firm should produce where price is equal to marginal cost so that P=115=15+4q=MC and q=25. Profit is $\pi = 115(25) - 450 - 15(25) - 2(25^2) = 800.$ Producer surplus is profit plus fixed cost, which is 1250. Note that producer surplus can also be found graphically by calculating the area below the price line and above the marginal cost (supply) curve, so that PS=0.5*(115-15)*25=1250.