Mirror Images: Marginal Product and Marginal Cost

Most of the activities in this unit concern a firm's costs of production. You will learn about a firm's costs of producing a given amount of its product—total fixed cost (TFC), total variable cost (TVC), and total cost (TC). You also will work with the firm's costs of a typical (average) unit of output—average fixed cost (AFC), average variable cost (AVC), and average total cost (ATC). The most important measure of a firm's cost is marginal cost (MC) because it shows the change in the firm's total cost when it produces one more unit of output. You will not be surprised to find that the cost of producing output is based on the productivity of the firm. If a firm is highly productive, that means it is producing a lot of output from a given amount of resources, thus reducing its costs of production. Firms that are inefficient will have high production costs and be at a competitive disadvantage. Because high productivity implies low cost, economists treat a firm's cost measures as mirror images of its productivity measures.

A firm makes production decisions in two time horizons. The “short run” is a period of time in which the amount of some key factor of production, often capital, is fixed. Other factors, such as labor, are variable because the firm can increase or decrease the amount of these resources in the short run. In the “long run,” all resources are variable and can be increased or decreased by the firm.

There are three measures of the productivity of a firm.

1. The firm's total physical product or total output (Q) is how many units of its good or service the firm produces in a specified period of time. If a firm produces 100 units per week, we express this as Q = 100.

2. The firm's average physical product (APP) shows how many units of output are produced by an average unit of labor (the variable resource). If the firm uses five units of labor (L) to produce 100 units of output each week, we say APP = Q/L = 100/5 = 20 units of output.

3. The firm's marginal physical product (MPP) tells us the change in total product when the firm adds an extra unit of labor to its fixed stock of capital. If, as a result of adding a sixth unit of labor, the firm's total output increases from 100 units to 114 units, then the MPP of the sixth labor unit is +14 units: MPP = ΔQ/ΔL = +14/+1 = +14.

⚠️ Student Alert: The terms average physical product and average product mean the same thing. Also, marginal physical product is the same as marginal product. Some textbooks use APP and MPP, while others use AP and MP. But you cannot use “average” terms interchangeably with “marginal” terms!

The key productivity principle in the short run is the “law of diminishing marginal productivity” (also called the law of diminishing marginal returns). Assume a firm operates in the short run with a fixed amount of capital and with labor as its variable resource. The law of diminishing marginal productivity states that as the firm adds more labor units to its fixed stock of capital, eventually the MPP from an extra unit of labor will diminish.
Part A: The Productivity Measures of a Firm

Table 3-2.1 is a short-run production chart showing how the productivity of the firm changes as it adds additional units of labor to its fixed stock of capital. Assume the data refer to the firm’s productivity in a one-week period.

1. Complete Table 3-2.1. Some data are already included in the chart. Put the values of MPP at the new labor level. For example, when the firm increases its labor from one to two units per week, its total output increases by 15 units. Write “+15” at L = 2 in the MPP column.

<table>
<thead>
<tr>
<th>L</th>
<th>Q</th>
<th>MPP = ΔQ/ΔL</th>
<th>APP = Q/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>+10</td>
<td>10.0</td>
</tr>
<tr>
<td>2</td>
<td>25</td>
<td>+15</td>
<td>12.5</td>
</tr>
<tr>
<td>3</td>
<td>36</td>
<td>+11</td>
<td>12.0</td>
</tr>
<tr>
<td>4</td>
<td>46</td>
<td>+10</td>
<td>11.5</td>
</tr>
<tr>
<td>5</td>
<td>55</td>
<td>+9</td>
<td>11.0</td>
</tr>
<tr>
<td>6</td>
<td>63</td>
<td>+8</td>
<td>10.5</td>
</tr>
<tr>
<td>7</td>
<td>63</td>
<td>+0</td>
<td>9.0</td>
</tr>
<tr>
<td>8</td>
<td>60</td>
<td>–3</td>
<td>7.5</td>
</tr>
</tbody>
</table>
2. When you have completed Table 3-2.1, plot the L and Q data in Figure 3-2.1. (The first two combinations are plotted for you already.) This Q curve shows how much total output the firm produces with different amounts of labor. Note that the firm's total product increases as it adds more labor, but eventually the total product declines if the firm adds too many labor units on its limited amount of equipment.

![Figure 3-2.1](image)

**Total Product**
3. Now plot the L, MPP, and APP data in Figure 3-2.2. You can connect the MPP points with a solid line and the APP points with a dotted line. (Some combinations are plotted for you already.) Plot the values of MPP at the new labor level. For example, put a dot on the graph at the combination of $L = 2$ and $MPP = +15$ since the MPP resulting from adding the second labor unit is 15 units of output. Note that both MPP and APP increase initially but then decrease as the firm adds more units of labor.

![Figure 3-2.2](image)

**Marginal Physical Product and Average Physical Product**

4. Diminishing marginal productivity sets in with the addition of the **third** labor unit.

5. The average physical product continues to increase as long as the marginal physical product is **greater than** the average physical product.

6. Can the average physical product of labor be negative? Why?

   *APP cannot be negative because it is the ratio Q/L and neither Q nor L can be negative.*
7. Can the marginal physical product of labor be negative? Why?

   Yes, because MPP shows the change in Q when an extra labor unit is added. If Q decreases when labor is increased, then MPP will be negative.

8. Total product increases as the firm adds units of labor as long as the marginal physical product is (positive / zero / negative).

9. Although our graphs have no information about the price of the good or the price of labor, we can conclude that the firm will not want to hire a unit of labor for which marginal physical product is (diminishing / negative). Explain your answer.

   As long as MPP is positive, Q is increasing. This is true even if MPP is diminishing. It is possible that the extra unit of labor adds more to the firm’s total revenue than to its total cost. But if MPP is negative, that means Q decreased when an extra unit of labor was hired. A firm will not want to pay for an extra worker if its total output decreases; its total profit will decrease if it does.

10. What is the relationship between marginal physical product and total product?

    The relationship between MPP and Q can be expressed as follows:

    (1) If MPP is positive, Q will increase.
    (2) If MPP is zero, Q will not change as Q is at its maximum value.
    (3) If MPP is negative, Q will decrease.

11. What is the relationship between marginal physical product and average physical product?

    The relationship between MPP and APP can be expressed as follows:

    (1) If MPP is greater than APP, APP will increase.
    (2) If MPP is equal to APP, APP will not change as APP is at its maximum value.
    (3) If MPP is less than APP, APP will decrease.

Part B: Productivity and Cost: A Mirror View of Each Other

As you work with productivity and cost graphs, note how the axes are labeled. The productivity graphs typically have L on the horizontal axis because that is the variable resource that the firm changes in order to alter its level of total output. The vertical axis has some measure of productivity (such as Q or APP). There are no dollar signs on a productivity graph because such graphs are not dealing with revenue or cost. The cost graphs always have total output or total physical product (Q) on the horizontal axis because costs are expressed in relation to the Q of the firm. Cost graphs always have a dollar-measured concept on the vertical axis (such as total cost [TC] or marginal cost [MC]).

   Figure 3-2.3 shows the relationship between a firm’s MPP and APP. The graph assumes MPP initially increases as the firm adds labor units due to specialization of labor on the firm’s equipment. Eventually diminishing marginal productivity sets in, which means that at some point APP also will decline as more labor units are added.
12. Diminishing marginal productivity sets in at \((L_1 / L_2)\) labor units.

13. APP increases as long as MPP is (greater than / equal to / less than) APP.

14. APP decreases as long as MPP is (greater than / equal to / less than) APP.

15. Why is APP maximized at \(L_2\) labor units?
   
   *APP is maximized at \(L_2\) labor units because that is where MPP = APP. Before that quantity of labor, MPP is greater than APP so APP is increasing. Beyond that quantity of labor, MPP is less than APP so APP is decreasing.*

16. “If MPP is diminishing, then APP must also be diminishing.” Is this a correct statement? Why?
   
   *This is an incorrect statement. There is a range of labor of units for which MPP is diminishing but APP is increasing because MPP is still greater than APP. In Figure 3-2.3, this is between \(L_1\) and \(L_2\) labor units.*
Figure 3-2.4 shows the relationship between a firm’s MC and AVC. AVC = TVC/Q. If the firm has L as its only variable resource, then AVC represents the labor cost per unit of output. Suppose a firm pays each of its 10 workers a daily wage of $80 and produces a Q of 400 units. Its TVC is $800 = (10)($80), and its AVC is $2 = $800/400. Each of its 400 units has a labor cost component of $2.

17. AVC decreases as long as MC is (greater than / equal to / less than) AVC.

18. AVC increases as long as MC is (greater than / equal to / less than) AVC.

19. Why is AVC minimized at Q₂ units of output?

   AVC is minimized at Q₂ units because that is where MC = AVC. Before that quantity of output, MC is less than AVC so AVC is decreasing. Beyond that quantity of output, MC is greater than AVC so AVC is increasing.

20. “If MC is increasing, then AVC must also be increasing.” Is this a correct statement? Why?

   This is an incorrect statement. There is a range of output units for which MC is increasing but AVC is decreasing because MC is still less than AVC. In Figure 3-2.4, this is between Q₁ and Q₂ output units.
The productivity of a firm is the basis of its cost. A firm wants to be highly productive in order to keep its costs low. Refer to Figure 3-2.5 to answer the following questions based on a firm’s productivity and cost measures. Assume outputs Q₁ and Q₂ are produced by this firm when it uses L₁ and L₂ labor units, respectively.

21. As long as the MPP of labor is increasing, the MC of producing extra units of output will **increase / not change / decrease**.
22. As long as the MPP of labor is decreasing, the MC of producing extra units of output will \((\text{increase} / \text{not change} / \text{decrease})\).

23. The MC of producing extra units of output will be minimized when the MPP of labor is \textit{maximized at } L_1 \text{ labor units and } Q_1 \text{ output units.}

24. As long as the APP of labor is increasing, the AVC of producing output will \((\text{increase} / \text{not change} / \text{decrease})\).

25. As long as the APP of labor is decreasing, the AVC of producing output will \((\text{increase} / \text{not change} / \text{decrease})\).

26. The AVC of producing output will be minimized when the APP of labor is \textit{maximized at } L_2 \text{ labor units and } Q_2 \text{ output units.}
Part 2

Understanding the Different Cost Measures of a Firm

Part A: Different Meanings of the Word “Profit”

Economists assume the goal of a firm is to maximize its total profit. This sounds like an easy goal to understand, but the economist’s view of profit is different from that of an accountant. Let’s use a short story about Pat to illustrate the differences. First, we must define two categories of cost. An explicit cost is an expenditure by the firm; it could be a payment for items such as wages, rent, or advertising. An implicit cost is the opportunity cost of an entrepreneur using his/her own resource in the company.

An economic short story: Pat is a banker who earned an annual salary of $50,000 last year. She invested a total of $100,000 of her own money in various savings assets, which gave her interest income of $6,000. Pat also owns a small building, which she leased to someone last year for $14,000. But now Pat decides she wants to leave banking and set up her own landscaping company. Rather than borrowing money to buy new equipment, she uses her $100,000 in savings to buy it. She also decides to stop leasing her building so she can use it for her new enterprise. In her first year of landscaping, Pat brings in total revenue of $300,000. She spends $220,000 for such things as her equipment, workers, supplies, and insurance.

1. An accountant defines total profit to be total revenue minus explicit costs. Pat’s accounting profit from her landscaping company is $80,000 this year.
   
   \[ \text{Accounting profit} = \text{total revenue} - \text{explicit costs} = 300,000 - 220,000 = 80,000. \]

2. In addition to explicit costs, an economist considers implicit costs as well. This year, Pat’s economic profit from her landscaping business is $10,000.
   
   \[ \text{Economic profit} = \text{total revenue} - (\text{explicit costs} + \text{implicit costs}) \]
   
   \[ = 300,000 - (220,000 + 50,000 + 6,000 + 14,000) \]
   
   \[ = 300,000 - 290,000 = 10,000. \]

3. Another type of profit is called normal profit. It recognizes that Pat should “pay herself” for using her resources in her own company. Her normal profit, which is equal to her implicit costs, indicates the income Pat’s resources would have earned had they been used in their best alternative occupations. Pat’s normal profit is $70,000.

   \[ \text{Normal profit} = 50,000 + 6,000 + 14,000 = 70,000. \]

4. If Pat’s total revenue from her landscaping business is only $280,000, what would be the values of the different measures of profit?
   
   (A) Accounting profit = $60,000 (Accounting profit = $280,000 – $220,000.)

   (B) Economic profit = $–10,000 (Economic profit = $280,000 – $290,000.)

   (C) Normal profit = $70,000
Part B: The Seven Measures of a Firm’s Short-Run Costs

The Morton Boat Company produces the very popular Jazzy Johnboat, which is desired by many fishermen and fisherwomen. Assume the firm operates in the short run with a fixed amount of equipment (capital) and views labor as its only variable resource. If it wants to produce more output, it will add more units of labor to its stock of equipment. Of course, the firm will have to pay its workers and also the owners of its capital, which means its total cost will increase as it produces more boats. Table 3-3.1 defines the seven cost measures the Morton Boat Company must consider.

Table 3-3.1
The Seven Short-Run Cost Measures of a Firm

<table>
<thead>
<tr>
<th>Cost measure</th>
<th>What it means</th>
<th>How to calculate it</th>
</tr>
</thead>
</table>
| Total fixed cost (TFC) | All costs that do not change when output changes. TFC is a constant amount at all Q levels. | TFC = total cost of all fixed factors of production  
                        |                                                                               | TFC = Q × AFC                                                                     |
| Total variable cost (TVC) | All costs that do change when output changes. TVC gets bigger as Q increases because the firm needs more labor to make more output. | TVC = total cost of all variable factors of production  
                        |                                                                               | TVC = Q × AVC                                                                     |
| Total cost (TC)      | All costs at a given output level. TC is the sum of TFC and TVC. TC increases as the level of output increases. | TC = TFC + TVC  
                        |                                                                               | TC = Q × ATC                                                                     |
| Average fixed cost (AFC) | Fixed cost (capital cost) per unit of output. AFC always falls as Q rises since TFC is a constant value. | AFC = TFC/Q                                                                       |
| Average variable cost (AVC) | Variable cost (labor cost) per unit of output. AVC falls at first, and then rises as Q increases. | AVC = TVC/Q                                                                       |
| Average total cost (ATC) | Total cost per unit of output. It is the sum of AFC and AVC. ATC falls at first, and then rises as Q increases. | ATC = TC/Q  
                        |                                                                               | ATC = AFC + AVC                                                                  |
| Marginal cost (MC)   | Change in the firm’s TC when it produces another unit of output. Also shows change in TVC from an extra unit of output. MC falls at first, and then rises as Q increases. | MC = ∆TC/∆Q  
                        |                                                                               | MC = ∆TVC/∆Q because the only part of TC that changes when more Q is produced is TVC. |
Reminder: The AVC curve is U-shaped (falls, then rises as Q increases) because its shape is the mirror image of the APP curve as shown in Activity 3-2. The MC curve also is U-shaped because it is the mirror image of the MPP curve. Refer back to Figure 3-2.5.

Table 3-3.2 is the cost spreadsheet for the Morton Boat Company. It has information on all seven short-run cost measures based on different Q levels of the firm.

5. Complete Table 3-3.2. Some of the data have been posted for you already.

Table 3-3.2
The Seven Short-Run Cost Measures of the Morton Boat Company (daily data)

<table>
<thead>
<tr>
<th>Q boats per day</th>
<th>(1) TFC</th>
<th>(2) TVC</th>
<th>(3) TC = TFC + TVC</th>
<th>(4) AFC = TFC/Q</th>
<th>(5) AVC = TVC/Q</th>
<th>(6) ATC = TC/Q = AFC + AVC</th>
<th>(7) MC = ΔTC/ΔQ = ΔTVC/ΔQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$300</td>
<td>$0</td>
<td>$300</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>1</td>
<td>$300</td>
<td>$700</td>
<td>$1,000</td>
<td>$300</td>
<td>$700</td>
<td>$1,000</td>
<td>$700</td>
</tr>
<tr>
<td>2</td>
<td>$300</td>
<td>$1,300</td>
<td>$1,600</td>
<td>$150</td>
<td>$650</td>
<td>$800</td>
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<td>$2,700</td>
<td>$75</td>
<td>$600</td>
<td>$675</td>
<td>$600</td>
</tr>
<tr>
<td>5</td>
<td>$300</td>
<td>$3,100</td>
<td>$3,400</td>
<td>$60</td>
<td>$620</td>
<td>$680</td>
<td>$700</td>
</tr>
<tr>
<td>6</td>
<td>$300</td>
<td>$3,840</td>
<td>$4,140</td>
<td>$50</td>
<td>$640</td>
<td>$690</td>
<td>$740</td>
</tr>
</tbody>
</table>

6. What trend do you observe in the value of TFC as the level of Q is increased? How do you explain this trend?

_TFC does not change as Q increases._ TFC represents costs that do not depend on Q.

7. What trend do you observe in the value of TVC as the level of Q is increased? How do you explain this trend?

_TVC increases as Q increases._ TVC represents costs of variable resources such as labor. Because the firm must add more variable resources to produce more output, TVC increases as Q increases. The changing slope of TVC reflects increasing marginal productivity (the slope of the TVC curve decreases) and diminishing marginal productivity (the slope of the TVC curve increases) of the variable resources.

8. Compare the ATC value at any Q level with the MC value at the next Q level. What relationship do you see between ATC and MC?

_The relationship between ATC and MC can be expressed as follows:_

1. If MC is greater than ATC, then ATC will increase.
2. If MC is equal to ATC, then ATC does not change and is at its minimum value.
3. If MC is less than ATC, then ATC will decrease.
9. Compare the AVC value at any Q level with the MC value at the next Q level. What relationship do you see between AVC and MC?

The relationship between AVC and MC can be expressed as follows:

1) If MC is greater than AVC, then AVC will increase.
2) If MC is equal to AVC, then AVC does not change and is at its minimum value.
3) If MC is less than AVC, then AVC will decrease.

10. Compare the AFC value at any Q level with the MC value at the next Q level. What relationship do you see between AFC and MC?

Because TFC does not change as Q increases, AFC always decreases as Q increases. There is no relationship between AFC and MC.

Part C: Graphing the Cost Functions of a Firm

The relationships that exist among the firm’s cost functions can be illustrated by plotting the data in Table 3-3.1 in cost graphs. Figure 3-3.1 is the “total” cost graph because it contains information about the firm’s TC, TVC, and TFC functions. Figure 3-3.2 is the “marginal-average” cost graph because it shows the data for the firm’s MC, ATC, AVC, and AFC functions.

11. Plot the data from Table 3-3.1 in the appropriate graphs. Two observations of TC and AVC have already been plotted for you.

12. Plot the values of MC at the new output level. For example, put a dot on the graph at the combination of Q = 4 and MC = $600 since the MC resulting from producing the fourth boat is $600. Connect the MC dots in your graph with a dotted line.
13. Why is the vertical gap between the TC and TVC curves the same at all Q levels?

*That vertical gap is TFC, which has the same value at all Q levels.*

14. The slope of the TC curve can be expressed as rise/run = ΔTC/ΔQ. Do you know another cost function that is found using the ratio ΔTC/ΔQ?

*The slope of the TC curve is equal to MC.*
15. Why do both the TC and TVC curves keep climbing higher and higher as the Morton Boat Company increases the number of boats it produces?

To produce more output, the firm must add more variable resources which means TVC increases as Q increases. Since TC = TVC + TFC, this means TC also increases as Q increases.

16. Why does the TC curve not begin at the origin?

When the firm produces no output, it still has TFC. The TC curve intersects the vertical axis at the level of TFC.
17. AVC continues to decrease as long as MC is (greater than / equal to / less than) AVC.
18. AVC continues to increase as long as MC is (greater than / equal to / less than) AVC.
19. ATC continues to decrease as long as MC is (greater than / equal to / less than) ATC.
20. ATC continues to increase as long as MC is (greater than / equal to / less than) ATC.
21. Mr. Burpin, your AP teacher, asks you to explain the following statement: “Average fixed cost falls as long as marginal cost is less than average fixed cost.” What is your response?
   
   **AFC is not affected by whether MC is greater than or less than AFC. AFC always decreases as the firm produces more output.**

22. Do you agree with the following statement? “Average variable cost is minimized at the output level where marginal cost is equal to average variable cost.” Explain.
   
   **Yes. When MC is below AVC, AVC decreases. When MC is above AVC, AVC increases. When MC is equal to AVC, AVC is at its minimum value.**

23. What do you say to someone who says, “Fixed cost is the same at all output levels”?
   
   **I would tell that person to be accurate when referring to fixed cost. TFC is the same at all output levels, but AFC decreases as Q increases.**

24. Can you tell from Table 3-3.1 how many boats the Morton Boat Company should produce to maximize its total profit? Explain.
   
   **No. We have no information about the revenue the firm receives from the sale of its boats. We will need revenue and cost data to determine the profit-maximizing number of boats.**
Part 3

A Firm’s Long-Run Average Total Cost Curve

The cost curves that we used in previous activities were the short-run cost curves of a firm. In the short run, a firm can vary its output by changing its variable resources, but it cannot change its plant capacity. In this activity we turn to the long run, defined as a time period in which all resources, including plant capacity, can be changed. In the short run, the shapes of the firm’s average total cost (ATC) and marginal cost (MC) curves result from the principle of diminishing marginal productivity of resources. In the long run, the shape of the firm’s long-run average total cost (LRATC) curve results from economies of scale and diseconomies of scale. Economies of scale explain why the firm’s ATC decreases as it expands its scale of operations. Sources of economies of scale include specialization of resources, more efficient use of equipment, a reduction in per-unit costs of factor inputs, an effective use of production by-products, and an increase in shared facilities. Diseconomies of scale explain why the firm’s ATC can increase as it increases its level of production. Sources of diseconomies of scale include limitations on effective management decision making and competition for factor inputs.

Part A: A Firm’s Long-Run Average Total Cost Curve

A firm’s LRATC curve shows the lowest ATC at which a firm can produce different levels of output when all inputs are variable. The LRATC is derived from a set of the firm’s short-run average total cost (SRATC) curves. Figure 3-4.1 shows four SRATC curves for the Goodman Company, which is considering which of four different plant sizes it should use to produce various levels of output. Each SRATC curve represents the ATC of the firm as it produces output in the short run with a fixed plant size. As the firm increases its level of output, at some point it will need to increase its plant size. As it does so, we see that its SRATC falls as it moves from Plant Size 1 to Plant Size 2, and it falls again as it moves to Plant Size 3. As it moves to the larger Plant Size 4 to produce even larger output levels, its SRATC curve shifts upward. Note that the graph shows four SRATC curves of one firm, not one SRATC for each of four different firms.
1. What does each of the SRATC curves represent?

Each SRATC represents the firm’s short-run ATC based on a given plant size. Decisions made by the firm when it has a fixed plant size are short-run decisions. When all inputs, including plant size, are variable, the firm is making long-run decisions.

2. At what output level in the long run will the firm minimize its ATC? Does this mean the firm will maximize its total profit if it produces this output level? Why?

Q₄ is the output that will minimize the firm’s average total cost in the long-run. Since we have no information about the firm’s revenue, we cannot determine its profit-maximizing Q level.

3. The Goodman Company can produce output Q₁ with either Plant Size 1 or Plant Size 2. If the demand facing the firm is for this level of output, which plant size should the firm use? Why?

It should produce Q₁ with Plant Size 1 since the ATC of that output is less with Plant Size 1 than with Plant Size 2.

4. As the long-run demand for the company’s product increases, it must decide which plant size is best as it tries to produce an output level at the lowest possible ATC. In the following chart, circle the firm’s best plant size for these output levels.

<table>
<thead>
<tr>
<th>Output level</th>
<th>Optimal plant size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q₁</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Q₂</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Q₃</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Q₄</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Q₅</td>
<td>1 2 3 4</td>
</tr>
</tbody>
</table>
5. Since the LRATC curve shows the lowest ATC at which different output levels can be produced, we can show it on Figure 3-4.1. Mark heavily the portions of each SRATC curve that will minimize the firm’s ATC as the firm increases its scale of production. Label this heavily shaded curve as “LRATC.”

![Diagram showing cost and output](image)

**Part B: Economies and Diseconomies of Scale**

The opening section of this activity explained the concepts of economies and diseconomies of scale. They explain why the firm’s LRATC curve slopes downward and then upward as the firm increases the scale of its production.

6. In Figure 3-4.1, as the firm increases its level of output from 0 to Q₄, it is experiencing *(economies of scale / diseconomies of scale).*

7. As the firm increases its production level beyond Q₄, it is experiencing *(economies of scale / diseconomies of scale).*

**Part C: Returns to Scale**

There are three concepts that are special cases of economies and diseconomies of scale where a firm increases all its inputs by the same percentage. A firm has *increasing returns to scale* if a proportionate increase in all resources results in an increase in output that is larger than the increase in resources. For example, if a firm increases all of its resources by 10 percent, and output increases by 14 percent, the firm experiences increasing returns to scale. *Decreasing returns to scale* are present if the increase in output is less than the proportionate increase in all resources. If output increases by only 7 percent when all inputs are increased by 10 percent, the firm has decreasing returns to scale. If output increases by the same proportion as all inputs were increased, the firm has *constant returns to scale.*
If we know the nature of the firm's returns to scale, we can determine what happens to the firm's ATC in the long run when it increases all resources by the same proportion. Since $ATC = \frac{TC}{Q}$, whether the firm's ATC increases, decreases, or stays the same depends on the resulting increase in output.

8. Assume the Goodman Company increases all of its inputs by 15 percent.

(A) Its total cost will increase by (more than / exactly / less than) 15 percent.

   If all inputs are increased by 15 percent, then its expenditures on all inputs also will increase by 15 percent.

(B) If it has increasing returns to scale, its output will increase by (more than / exactly / less than) 15 percent, and its ATC will (increase / not change / decrease).

   Since $Q$ is increasing by more than 15 percent while $TC$ increases by 15 percent, the firm's ATC will decrease if it has increasing returns to scale.

(C) If it has decreasing returns to scale, its output will increase by (more than / exactly / less than) 15 percent, and its ATC will (increase / not change / decrease).

   Since $Q$ is increasing by less than 15 percent while $TC$ increases by 15 percent, the firm's ATC will increase if it has decreasing returns to scale.

(D) If it has constant returns to scale, its output will increase by (more than / exactly / less than) 15 percent, and its ATC will (increase / not change / decrease).

   Since $Q$ is increasing by 15 percent while $TC$ also increases by 15 percent, the firm's ATC will not change if it has constant returns to scale.

9. In Figure 3-4.2, draw the LRATC curve for a firm that experiences increasing returns to scale between output levels $Q_1$ and $Q_2$, constant returns to scale between $Q_2$ and $Q_3$, and decreasing returns to scale between $Q_3$ and $Q_4$. Label the curve as “LRATC.” Be sure to label the axes.

---

**Figure 3-4.2**

**Returns to Scale**
Part 4

Revenue, Profit, and Rules to Maximize Total Profit

Now that you have explored the productivity and cost functions of a firm, you are ready to learn about its revenue and profit functions. It is important to note that the productivity and cost graphs look the same for any firm, regardless of whether the firm sells its output in a perfectly competitive, monopolistic, monopolistically competitive, or oligopolistic product market. Think of it this way: suppose you run a firm that produces computers. The productivity of your workers in your factory will determine your cost of producing computers. But now you are ready to take your computers from the factory and transport them to the product market to sell them. As we will see in subsequent activities, the shapes of your revenue functions will depend on how much competition you face in the product market. So although your productivity and cost functions are not affected by the product market, your revenue and profit functions will be. (We will see in Unit 4 that the factor markets for your resources will affect the prices you pay for inputs and thus will affect your cost functions.)

Part A: Revenue Terms

Student Alert: The distinction between total, marginal, and average measures is important!

There are three revenue terms you need to understand before you can answer questions about profit maximization. When a firm sells its product, the revenue it receives can be described in the three ways shown in Table 3-5.1.

<table>
<thead>
<tr>
<th>Measure of revenue</th>
<th>Meaning</th>
<th>How to calculate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total revenue (TR)</td>
<td>The total income the firm receives from selling a given level of output (Q) at a particular price (P)</td>
<td>TR = P × Q</td>
</tr>
<tr>
<td>Average revenue (AR)</td>
<td>The revenue the firm receives from one unit at a given level of output</td>
<td>AR = TR/Q</td>
</tr>
<tr>
<td>Marginal revenue (MR)</td>
<td>The change in total revenue resulting from the firm selling one more unit of output</td>
<td>MR = ΔTR/ΔQ</td>
</tr>
</tbody>
</table>

The shapes of these revenue functions will depend on the type of product market in which a firm sells its good or service. The key point to watch for is whether a firm has to lower its price to sell more of its product. You will calculate values of these revenue measures and draw graphs of them in other activities where the type of product market is specified.
Part B: Profit Terms

In Activity 3-3 you learned the difference between accounting profit and economic profit. Since this book is preparing you to succeed on the AP Microeconomics Exam, it is time to focus on how a firm maximizes its total economic profit. A good habit to learn now is always to use the correct adjective in front of the word “profit”: total, average, or marginal. Accuracy counts when you are answering exam questions. (The same habit also should be applied to measures of productivity, cost, and revenue!)

There are three profit (Π) terms you need to master so you will understand the decisions made by a firm as it tries to maximize its total profit. When a firm sells its product, the profit (or loss) it receives can be described in the three ways shown in Table 3-5.2.

Table 3-5.2
Three Measures of (Economic) Profit

<table>
<thead>
<tr>
<th>Measure of profit</th>
<th>Meaning</th>
<th>How to calculate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total profit (TP)</td>
<td>The difference between the firm’s total revenue (TR) and total cost (TC) at a given level of output (Q)</td>
<td>TP = TR – TC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TP = Q × AP</td>
</tr>
<tr>
<td>Average profit (AP)</td>
<td>The profit the firm receives from one unit at a given level of output (= per-unit profit)</td>
<td>AP = TP/Q</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AP = TR – ATC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AP = P – ATC</td>
</tr>
<tr>
<td>Marginal profit (MP)</td>
<td>The change in total profit resulting from the firm selling one more unit of output</td>
<td>MP = ΔTP/ΔQ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MP = MR – MC</td>
</tr>
</tbody>
</table>

Note: While some college textbooks do not introduce the concept of marginal profit, it is a useful concept as you explain why a firm should (or should not) sell an extra unit of output.

Here’s another useful hint: Be careful about mixing “totals,” “averages,” and “marginals.” Look again at the three basic ways to calculate the measures of profit:

- Total profit = total revenue – total cost.
- Average profit = average revenue – average total cost.
- Marginal profit = marginal revenue – marginal cost.
Part C: Key Rules for Any Firm to Follow

Economists assume firms try to maximize their total profit. This means a firm must decide how many units of its good or service to produce and what price to charge for that product. Fortunately, there are several basic rules that apply to any firm as it makes these decisions. At this point, we will give a general overview of the rules. You will work in detail with each rule as you move through other activities for firms in different types of product markets. Although the basic rules apply to all firms, the different levels of competition in the various markets will require that you stay focused to help the firm make the correct decisions.

Rule 1: A firm should produce the output level at which $\text{MR} = \text{MC}$.

This rule sounds so simple, but many students never really understand it (although many memorize it). How can producing a unit for which $\text{MR} = \text{MC}$ maximize total profit? After all, doesn’t $\text{MP} = \$0$ for that unit? Yes, and ironically, that is why the rule works. Look at Table 3-5.3 which has information about the Sosin Company.

Table 3-5.3

<table>
<thead>
<tr>
<th>Output units</th>
<th>MR compared to MC</th>
<th>MP compared to MC</th>
<th>TII</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–499</td>
<td>MR &gt; MC</td>
<td>MP &gt; $0$</td>
<td>TII increases.</td>
</tr>
<tr>
<td>500</td>
<td>MR = MC</td>
<td>MP = $0$</td>
<td>TII has reached its peak.</td>
</tr>
<tr>
<td>501 and beyond</td>
<td>MR &lt; MC</td>
<td>MP &lt; $0$</td>
<td>TII decreases.</td>
</tr>
</tbody>
</table>

If $\text{MR} > \text{MC}$ for the first 499 units, the firm certainly wants to produce all of them. These units create positive $\text{MP}$, which means $\text{TII}$ increases with each additional unit. What does the 500th unit do for the firm’s TII? Nothing at all. The $\text{MP}$ of the 500th unit is $\$0$ because its $\text{MR}$ is equal to its $\text{MC}$. But check out units beyond 500. Each of these units adds less to $\text{TR}$ than it adds to $\text{TC}$ (or, $\text{MR} < \text{MC}$). If the Sosin Company produces these units, each unit will have a negative $\text{MP}$, which means $\text{TII}$ will decrease, and the firm does not want that to happen.

So what is so special about the 500th unit where $\text{MR} = \text{MC}$? The answer is surprisingly simple. If the firm produces 500 units, it has produced all the units that increased its TII ($\text{MP} > \$0$) and stopped before it produced any units that would decrease its TII ($\text{MP} < \$0$). The 500th unit itself had no effect on TII, but economists like the simple “$\text{MR} = \text{MC}$” rule as an efficient way to locate the output level that will maximize a firm’s TII.
Rule 2: A firm should charge the price on the demand curve for its optimal output level.

Suppose your boss offers you a $5 per hour pay raise. Are you going to decline that offer? Of course not! You want to get the highest pay you can for your labor. A firm is no different. Once it decides on the optimal number of units of its product (where MR = MC), it wants to receive the highest possible price for that output level. And that is exactly the information the firm gets from its demand curve. Basically, it will go up to the demand curve at its optimal output level and hang a direct left to the vertical price axis.

Rule 3: A firm should shut down and produce zero output if TR is less than total variable cost (TVC).

Unfortunately, there are times when a firm cannot earn a positive total profit. Perhaps the high prices of resources have made the firm’s production costs unprofitably high. Or perhaps a downturn in the economy has so reduced demand that the firm cannot get a profitable price for its product. When a firm earns a negative total profit at its best output level, it has two choices in the short-run: It can go ahead and produce that output and accept the loss, or it can produce no output at all (shut down).

Here is the rule the firm should follow: If its TR is greater than its TVC, it should produce its optimal output (where MR = MC) rather than shut down.

Here’s the logic behind this rule:

■ If the firm shuts down (Q = 0), it will have no TR or TVC, but it will still have its total fixed cost (TFC). Thus, by shutting down, the firm is committed to a loss equal to its TFC (loss = TFC).

■ If the firm produces its best output and has TR that is less than TVC, then the firm will make a loss on its variable resources and still have all of its TFC. Its loss will be larger if it produces than if it shuts down (loss > TFC).

■ If the firm produces its best output and has TR that exceeds TVC, then after it pays all its TVC the firm has some leftover TR to apply toward its TFC. This will makes its loss less than its TFC (loss < TFC).

Part D: Do You Get It?

Here are some questions to see if you understand the revenue and profit terms and the three key rules to maximize total profit. Circle “T” if you feel the statement is true and “F” if you think it is false. Explain your answer for each statement.

1. If a firm sells 200 units of its product at a price of $8, its total profit will be $1,600. The firm’s total revenue will be $1,600. To find its total profit, we would need information about the firm’s total cost of producing 200 units. (T/F)

2. If the average revenue from 150 units is $20, the firm’s total revenue is $3,000. Total revenue can be calculated by multiplying the number of units by the average revenue per unit. TR = (Q)(AR) = (150)($20) = $3,000. (T/F)
3. If the marginal revenue from the twenty-first unit is $30, then the total revenue from 22 units is $30 greater than the total revenue from 21 units.

Marginal revenue is the change in total revenue resulting from the firm selling one more unit of output. The increase in TR is $30 when the firm increased Q from 20 to 21 units, not from 21 to 22 units.

4. As long as MR is greater than MC, a firm’s TP will increase if it increases its level of output.

If MR is greater than MC, an extra unit of output will add more to TR than it adds to TC so the firm’s TP will increase.

5. When MPI is $0, we know TP also is $0.

TP is maximized when MPI = $0. TP is $0 when TR = TC.

6. If MPI is negative, a firm’s TP will increase if the firm produces fewer units of output.

If MPI is negative, that means MR is less than MC for the last unit produced. By reducing its output, the firm will increase its TP.

7. At its current output level, the Placone Firm has AR = $12 and MC = $10, which means its AP = $2.

AP = AR – ATC. Since MC is not the same thing as ATC, this statement is false.

8. A firm determines it will maximize its total profit by producing 800 units per week because at that output both MR and MC are $600. The price the firm should charge for its output also is $600.

This question anticipates topics to be covered in later activities in this unit. If the firm sells its product in a perfectly competitive market, this statement would be true because price would be equal to MR. But in an imperfectly competitive market, the statement would be false because price would be greater than MR.

Answer Questions 9 and 10 based on this information: The Wright Company estimates the following values at its optimal level of output: TR = $20,000, TVC = $18,000, and TFC = $5,000.

9. This firm should shut down rather than produce its optimal level of output.

Even though the firm will suffer a loss of $3,000 by producing its optimal output, it should do so. If it shuts down, it will have a larger loss of $5,000 equal to its TFC. As long as TR is greater than TVC, the firm is better off producing its optimal output than shutting down. In this example, the firm has enough TR to cover all its TVC and contribute $2,000 toward its TFC.

10. If its optimal output is 5,000 units, the price it charges for its good is $4.00.

Since TR = (P)(Q) and we know TR = $20,000, the firm’s price must be $4.00 if it is selling 5,000 units.
Part 5

Profit Maximization by a Perfectly Competitive Firm

A perfectly competitive firm will maximize its total profit by producing the output level at which marginal revenue equals marginal cost. You need to understand how economists find these two important “marginal” measures.

Part A: Revenue Measures of a Perfectly Competitive Firm

A perfectly competitive firm is a “price taker.” This means it has no control over price and will charge the market-determined price for its product. In fact, because it is such a small participant in the market, a perfectly competitive firm can sell all the output it wants at the market price. It does not have to reduce its price to sell additional units. This makes the revenue measures of a perfectly competitive firm easy to calculate and to graph.

1. Assume the market for yo-yos is perfectly competitive and that the market price currently is $17 per box of yo-yos. Complete Table 3-6.1, which has the three revenue measures of a typical firm in this market. Put the MR values at the new output level. For example, when the firm increases output from four to five units, its total revenue increases by $17, so put “+ $17” in the MR column for Q = 5.

Table 3-6.1
Revenue Measures of a Perfectly Competitive Firm

<table>
<thead>
<tr>
<th>Output (Q) [boxes of yo-yos]</th>
<th>Price (P) [per box]</th>
<th>Total revenue $TR = P × Q $</th>
<th>Marginal revenue $MR = ΔTR/ΔQ $</th>
<th>Average revenue $AR = TR/Q $</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$17</td>
<td>$0</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>1</td>
<td>$17</td>
<td>+$17</td>
<td>+$17</td>
<td>$17</td>
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<tr>
<td>2</td>
<td>$17</td>
<td>+$34</td>
<td>+$17</td>
<td>$17</td>
</tr>
<tr>
<td>3</td>
<td>$17</td>
<td>$51</td>
<td>+$17</td>
<td>$17</td>
</tr>
<tr>
<td>4</td>
<td>$17</td>
<td>+$68</td>
<td>+$17</td>
<td>$17</td>
</tr>
<tr>
<td>5</td>
<td>$17</td>
<td>+$85</td>
<td>+$17</td>
<td>$17</td>
</tr>
<tr>
<td>6</td>
<td>$17</td>
<td>+$102</td>
<td>+$17</td>
<td>$17</td>
</tr>
<tr>
<td>7</td>
<td>$17</td>
<td>+$119</td>
<td>+$17</td>
<td>$17</td>
</tr>
<tr>
<td>8</td>
<td>$17</td>
<td>$136</td>
<td>+$17</td>
<td>$17</td>
</tr>
<tr>
<td>9</td>
<td>$17</td>
<td>+$153</td>
<td>+$17</td>
<td>$17</td>
</tr>
<tr>
<td>10</td>
<td>$17</td>
<td>+$170</td>
<td>+$17</td>
<td>$17</td>
</tr>
</tbody>
</table>
2. What happens to the value of MR as more output is sold? Why?
   
   MR is a constant value because the firm does not have to lower price to sell an extra unit. Thus, the change in total revenue for an extra unit is equal to the market price.

3. What is the relationship between MR and AR at every output level? Why?
   
   The two measures are equal because the firm does not have to lower price to sell an extra unit of output.

4. What happens to the value of TR each time the firm sells one more unit of its good? Why?
   
   TR increases by an amount equal to the market price. Since it does not have to reduce price, TR increases by the same amount with each new unit of output. This increase in TR is the firm's MR.

5. Why is P equal to $17 at every level of Q?
   
   Because the firm is a price taker, it can sell all it wants at the market price of $17.

6. What is the relationship between P, MR, and AR? Why?
   
   For a perfectly competitive firm, these three measures are equal to each other because the firm does not have to lower price to sell more output.
7. Plot the firm’s total revenue data in Figure 3-6.1.

![Figure 3-6.1](image)

**Total Revenue Function of a Perfectly Competitive Firm**

<table>
<thead>
<tr>
<th>QUANTITY</th>
<th>TOTAL REVENUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$10</td>
</tr>
<tr>
<td>1</td>
<td>$20</td>
</tr>
<tr>
<td>2</td>
<td>$30</td>
</tr>
<tr>
<td>3</td>
<td>$40</td>
</tr>
<tr>
<td>4</td>
<td>$50</td>
</tr>
<tr>
<td>5</td>
<td>$60</td>
</tr>
<tr>
<td>6</td>
<td>$70</td>
</tr>
<tr>
<td>7</td>
<td>$80</td>
</tr>
<tr>
<td>8</td>
<td>$90</td>
</tr>
<tr>
<td>9</td>
<td>$100</td>
</tr>
<tr>
<td>10</td>
<td>$110</td>
</tr>
</tbody>
</table>

8. The slope of the total revenue function is $\Delta TR/\Delta Q$. What economic function does this ratio represent? Why is the TR curve a straight line?

*The slope of the TR function is MR. For a perfectly competitive firm, the TR function is a straight line because MR is a constant value.*

9. If the market price increases, what will happen to the slope of the firm’s TR curve? Will the TR curve still begin at the origin?

*The TR function will be steeper because MR will be larger. The TR curve will still begin at the origin.*
10. Plot the firm’s marginal revenue, average revenue, and demand data in Figure 3-6.2.

**Figure 3-6.2**
**Marginal Revenue, Average Revenue, and Demand Functions of a Perfectly Competitive Firm**

11. Does the demand curve D represent the firm’s demand for something, such as inputs?
   *No, it is the demand of consumers for the product of the firm.*

12. Why is the demand function horizontal?
   *It is horizontal because the firm does not have to reduce its price to sell more output. It can sell all it wants at the market price of $17.*

13. What would happen to the quantity demanded of the firm’s product if it increased the price above the market price of $17? What does this tell you about the price elasticity of demand for the firm’s product?
   *The quantity demanded would drop to zero because consumers would buy yo-yos from other firms at the market price. This means the demand facing a perfectly competitive firm is perfectly elastic—a slight price increase moves the firm from being able to sell all it wants to selling no units at all.*
14. Would you recommend that this firm lower its price below the market price of $17? Why?
   No. It can sell all it wants at the market price, so why reduce the price?

15. What do you note about the relationship between price and marginal revenue for a perfectly competitive firm? What about between price and average revenue?
   $P = MR$ and $P = AR$ for a perfectly competitive firm.

Part B: Cost Measures of a Perfectly Competitive Firm

The short-run cost curves of a perfectly competitive firm give you values of the various cost measures at different output levels.

16. Complete Table 3-6.2, which has the seven cost measures of a typical firm in this market. Put the MC values at the new output level. For example, when the firm increases output from four to five units, its total cost increases by $4, so put “$+4” in the MC column for Q = 5. Some of the cost values are provided for you.

<table>
<thead>
<tr>
<th>(1) Output (Q) [boxes]</th>
<th>(2) Total fixed cost (TFC)</th>
<th>(3) Total variable cost (TVC)</th>
<th>(4) Total cost (TC)</th>
<th>(5) Marginal cost (MC) = $\Delta TC/\Delta Q$</th>
<th>(6) Average fixed cost (AFC) = $TFC/Q$</th>
<th>(7) Average variable cost (AVC) = $TVC/Q$</th>
<th>(8) Average total cost (ATC) = $TC/Q$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$40.00</td>
<td>$0.00</td>
<td>$40.00</td>
<td>–</td>
<td>–</td>
<td>–</td>
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<tr>
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<td>$+10.50</td>
<td>$5.00</td>
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</tr>
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<td>$40.00</td>
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<td>$112.00</td>
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<td>$4.44</td>
<td>$8.00</td>
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<td>$130.00</td>
<td>$+18.00</td>
<td>$4.00</td>
<td>$9.00</td>
<td>$13.00</td>
</tr>
</tbody>
</table>
17. What happens to the value of AFC as Q rises? Why?
   *AFC always decreases as Q rises because AFC = TFC/Q. Since TFC is constant, an increase in Q must reduce AFC.*

18. What happens to the value of AVC as Q increases? Why?
   *AVC decreases, then increases as the firm increases its level of output. Initially, MC is less than AVC which makes AVC decrease. When MC eventually rises above AVC, AVC will increase.*

19. What happens to the value of MC as Q increases? Is this trend related to the marginal physical productivity of the firm’s variable resources? Explain.
   *MC decreases, then increases as the firm increases output. Yes, the shape of the MC curve is inversely related to the shape of the MPP curve. When MPP increases, MC decreases. When MPP decreases, MC increases. When MPP is maximized, MC is minimized.*

20. Is the value of MC the same whether it is computed as a change in TC or as a change in TVC? Why?
   *Yes, the only change in a firm’s TC is the change in its TVC. So MC is the same using a change in either TC or TVC when an extra unit of output is produced.*

21. Why does the value of TVC continue to get larger as the firm produces more Q?
   *In the short run, the only way the firm can produce more output is by adding more units of its variable resource (labor). Thus, its total outlay on labor must increase as the firm makes more output.*

22. The slope of the TC curve is ΔTC/ΔQ. Do you recognize this ratio as the expression of some other important economic function?
   *Yes, the slope of the TC curve is MC.*
23. Plot the firm’s TC, TVC, and TFC data in Figure 3-6.3.

![Figure 3-6.3](image)

**TC, TVC, and TFC Functions of a Perfectly Competitive Firm**

24. What does the vertical gap between the TC and TVC represent? What happens to the size of this gap as the firm increases its level of production?

*The gap represents TFC which does not change with output. The TFC gap is the same at all output levels.*

25. Why does the TC cost curve not begin at the origin?

*Because even if it produces no output, the firm still has TFC. The TC curve begins at the level of TFC.*

26. Why does the TVC curve have the same slope as the TC curve?

*Both the TVC and TC curves have slope equal to MC. $MC = \frac{\Delta TC}{\Delta Q} = \frac{\Delta TVC}{\Delta Q}$.*
27. Plot the firm’s ATC, AVC, AFC, and MC data in Figure 3-6.4 and answer the questions that follow the graph. Connect the MC values with a dotted line in your graph.

Figure 3-6.4
ATC, AVC, AFC, and MC Functions of a Perfectly Competitive Firm

28. Why does the vertical gap between the ATC and AVC curves get smaller as the firm increases its Q? That gap is AFC which decreases as the level of output increases.

29. At what unique point does the MC curve intersect both the AVC curve and the ATC curve? Why?
The MC curve intersects the AVC and ATC curves at their minimum points. When MC is below these average curves, they decrease. When MC is above them, they increase.

30. Between Q = 6 and Q = 8, AVC is rising while ATC is falling. How can this be? This is because over this output range, the decrease in AFC is greater than the increase in AVC. As a result, ATC continues to fall.
Part C: Profit Maximization by a Perfectly Competitive Firm

Now that you have mastered the revenue and cost terms for a perfectly competitive firm, you can bring them together to determine how many units of output the firm should produce to maximize its total profit.

31. Complete Table 3-6.3 using your data from Tables 3-6.1 and 3-6.2. Some data have been entered for you.

<table>
<thead>
<tr>
<th>Q</th>
<th>TR</th>
<th>TC</th>
<th>TII</th>
<th>MR</th>
<th>MC</th>
<th>MII</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$0.00</td>
<td>$40.00</td>
<td>$-40.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>$17.00</td>
<td>$50.00</td>
<td>$-33.00</td>
<td>+$17.00</td>
<td>+$10.00</td>
<td>+$7.00</td>
</tr>
<tr>
<td>2</td>
<td>$34.00</td>
<td>$56.00</td>
<td>$-22.00</td>
<td>+$17.00</td>
<td>+$6.00</td>
<td>+$11.00</td>
</tr>
<tr>
<td>3</td>
<td>$51.00</td>
<td>$61.00</td>
<td>$-10.00</td>
<td>+$17.00</td>
<td>+$5.00</td>
<td>+$12.00</td>
</tr>
<tr>
<td>4</td>
<td>$68.00</td>
<td>$66.00</td>
<td>$2.00</td>
<td>+$17.00</td>
<td>+$5.00</td>
<td>+$12.00</td>
</tr>
<tr>
<td>5</td>
<td>$85.00</td>
<td>$70.00</td>
<td>$15.00</td>
<td>+$17.00</td>
<td>+$4.00</td>
<td>+$13.00</td>
</tr>
<tr>
<td>6</td>
<td>$102.00</td>
<td>$76.00</td>
<td>$26.00</td>
<td>+$17.00</td>
<td>+$6.00</td>
<td>+$11.00</td>
</tr>
<tr>
<td>7</td>
<td>$119.00</td>
<td>$85.50</td>
<td>$33.50</td>
<td>+$17.00</td>
<td>+$9.50</td>
<td>+$7.50</td>
</tr>
<tr>
<td>8</td>
<td>$136.00</td>
<td>$96.00</td>
<td>$40.00</td>
<td>+$17.00</td>
<td>+$10.50</td>
<td>+$6.50</td>
</tr>
<tr>
<td>9</td>
<td>$153.00</td>
<td>$112.00</td>
<td>$41.00</td>
<td>+$17.00</td>
<td>+$16.00</td>
<td>+$1.00</td>
</tr>
<tr>
<td>10</td>
<td>$170.00</td>
<td>$130.00</td>
<td>$40.00</td>
<td>+$17.00</td>
<td>+$18.00</td>
<td>$-1.00</td>
</tr>
</tbody>
</table>

32. The value of TII is greatest at Q = 9 units. The maximum TII = $41.00.

33. The firm should produce each unit for which MR > MC. The last unit with MR > MC is the ninth unit, which has MII = $+1.00.

34. Should the firm produce the tenth unit of Q? Why?
   No, because that unit has MR < MC which means it has a negative MII. If the firm sold that unit, TII would fall by $1.00.
35. M\(\Pi\) has its greatest value at \(Q = \underline{5}\) units. Should this be the \(Q\) level the firm decides to produce? Why?

\textit{No, because the sixth through the ninth units each have positive M\(\Pi\) (MR > MC) which means they will increase the firm’s TP.}

36. Go back to Figure 3-6.3 and draw the firm’s TR function. (You can get it from Figure 3-6.1). Label the function “TR.”

37. What do we call the vertical gap between the TR and TC curves?

\textit{That vertical gap is total profit (T\(\Pi\)).}

38. We saw in Table 3-6.3 that this firm should produce \(Q = \underline{9}\) units to maximize its T\(\Pi\). Indicate the part of Figure 3-6.3 that represents this maximum T\(\Pi\).

39. Go back to Figure 3-6.4 and draw the firm’s D, MR, and AR functions at the current market price of $17. (You can get these from Figure 3-6.2). Label the functions.

40. The last unit of output for which MR > MC is the \(\underline{\text{ninth}}\) unit. This is the last unit the firm should produce in order to maximize its T\(\Pi\).

41. What does the vertical gap between the MR and MC curves represent?

\textit{That vertical gap is marginal profit (M\(\Pi\)). As long as the gap is positive, the firm should keep producing more units of output.}
Part D: When Is a Firm's Best Just Not Good Enough?

You proved this firm can earn a positive total profit if the market price is $17. But what if the market price drops? Since a perfectly competitive firm is a price taker, it will have to sell its product at the lower market price, which will reduce its total profit.

42. Assuming all its costs are unchanged, what will happen to the perfectly competitive firm if the market price drops to $10? In Figure 3-6.4, draw a new “D1 = MR1” line at the price of $10.

(A) Based on a comparison of MR and MC, the firm’s optimal Q level is 7 units.

(B) Its TR will be (greater than / equal to / less than) its TC at this Q level.

(C) Its TR will be (greater than / equal to / less than) its TVC.

(D) What should the firm do? Choose one of these decisions:

   (1) **It should produce its optimal Q even though it will make a loss.**

   (2) It should shut down and produce no Q this period.

43. Assuming all its costs are unchanged, what will happen to the perfectly competitive firm if the market price drops to $5? In Figure 3-6.4, draw a new “D2 = MR2” line at the price of $5.

(A) Based on a comparison of MR and MC, the firm's optimal Q level is 5 units.

(B) Its TR will be (greater than / equal to / less than) its TC at this Q level.

(C) Its TR will be (greater than / equal to / less than) its TVC.

(D) What should the firm do? Choose one of these decisions:

   (1) It should produce its optimal Q even though it will make a loss.

   (2) **It should shut down and produce no Q this period.**

Note: Even though economists chant, “Produce where MR = MC,” in a discrete case with a limited number of Q levels being considered, there might not be a level of Q where MR = MC. In such a case, the firm should produce units for which MR > MC and stop before it produces units for which MR < MC. That's what you did in this example.

44. A puzzle for you! Economists say a perfectly competitive firm can sell at the Q it wants at the going market price. So why doesn’t a single firm decide to produce all the Q that is demanded in the market?

   **It will only produce more output as long as MR is greater than or equal to MC. Once the firm's MC rises about its MR, the firm will decide not to produce any more units.**
Part 6

Short-Run Equilibrium and Short-Run Supply in Perfect Competition

The word “equilibrium” refers to being in a state of rest or balance. You know the meaning of this term in the context of a competitive market: the equilibrium price is the one at which the quantity demanded is equal to the quantity supplied. Neither the buyers nor the sellers have reason to move from this spot, unless factors cause the demand or supply curve to shift.

Part A: Short-Run Equilibrium for a Perfectly Competitive Firm

A perfectly competitive firm is in a short-run equilibrium position when it produces the output level \( Q^* \) at which marginal revenue (MR) is equal to marginal cost (MC). The firm will stay at this output level unless something causes a change in its MR curve or MC curve. In its short-run equilibrium position, the firm could be in any of four profit scenarios as shown in Table 3-7.1.

1. In the last column, circle what you feel the firm should do in each of these cases—produce or shut down.

Table 3-7.1

Four Possible Total Profit Positions of a Firm in Short-Run Equilibrium

<table>
<thead>
<tr>
<th>Total profit (( T\Pi )) at ( Q^* ) where MR = MC</th>
<th>Total revenue (TR) compared to total cost (TC) and total variable cost (TVC) at ( Q^* )</th>
<th>What should the firm do?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ( T\Pi &gt; $0 )</td>
<td>TR &gt; TC</td>
<td>Produce ( Q^* ) / shut down</td>
</tr>
<tr>
<td>2. ( T\Pi = $0 )</td>
<td>TR = TC</td>
<td>Produce ( Q^* ) / shut down</td>
</tr>
<tr>
<td>3. ( T\Pi &lt; $0 )</td>
<td>TVC &lt; TR &lt; TC</td>
<td>Produce ( Q^* ) / shut down</td>
</tr>
<tr>
<td>4. ( T\Pi &lt; $0 )</td>
<td>TR &lt; TVC &lt; TC</td>
<td>Produce ( Q^* ) / shut down</td>
</tr>
</tbody>
</table>

Note: You will see in Activity 3-8 how a perfectly competitive firm moves from a position of short-run equilibrium to one of long-run equilibrium where it must break even (total profit = $0).
Part B: Short-Run Supply Curve of a Perfectly Competitive Firm

A market supply curve tells you how many units of a good or service producers will provide at different prices, other things being constant. The typical market supply curve is upward sloping because producers will put more units on the market at a higher price. A perfectly competitive firm also has a supply curve that is upward sloping. The basis of its short-run supply curve is its marginal cost curve as shown in the following exercise. Table 3-7.2 has information about some of the daily cost functions of the Fiasco Company, which sells its product in a perfectly competitive market.

2. Fill in the missing cost values in Table 3-7.2.

<table>
<thead>
<tr>
<th>Q</th>
<th>TC</th>
<th>TVC</th>
<th>MC</th>
<th>Average total cost (ATC)</th>
<th>Average variable cost (AVC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$12.00</td>
<td>$0.00</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>1</td>
<td>$16.00</td>
<td>$4.00</td>
<td>$4.00</td>
<td>$16.00</td>
<td>$4.00</td>
</tr>
<tr>
<td>2</td>
<td>$19.00</td>
<td>$7.00</td>
<td>$3.00</td>
<td>$9.50</td>
<td>$3.50</td>
</tr>
<tr>
<td>3</td>
<td>$21.00</td>
<td>$9.00</td>
<td>$2.00</td>
<td>$7.00</td>
<td>$3.00</td>
</tr>
<tr>
<td>4</td>
<td>$24.00</td>
<td>$12.00</td>
<td>$3.00</td>
<td>$6.00</td>
<td>$3.00</td>
</tr>
<tr>
<td>5</td>
<td>$30.00</td>
<td>$18.00</td>
<td>$6.00</td>
<td>$6.00</td>
<td>$3.60</td>
</tr>
<tr>
<td>6</td>
<td>$39.00</td>
<td>$27.00</td>
<td>$9.00</td>
<td>$6.50</td>
<td>$4.50</td>
</tr>
<tr>
<td>7</td>
<td>$49.00</td>
<td>$37.00</td>
<td>$10.00</td>
<td>$7.00</td>
<td>$5.29</td>
</tr>
<tr>
<td>8</td>
<td>$61.00</td>
<td>$49.00</td>
<td>$12.00</td>
<td>$7.63</td>
<td>$6.13</td>
</tr>
<tr>
<td>9</td>
<td>$75.00</td>
<td>$63.00</td>
<td>$14.00</td>
<td>$8.33</td>
<td>$7.00</td>
</tr>
<tr>
<td>10</td>
<td>$91.00</td>
<td>$79.00</td>
<td>$16.00</td>
<td>$9.10</td>
<td>$7.90</td>
</tr>
</tbody>
</table>
3. In Figure 3-7.1, plot and label the ATC, AVC, and MC curves of the firm. Plot the MC values at the higher of the two output levels. For example, when the firm increases output from 5 units to 6 units, its TC increases by $9, so plot the MC = $9 value at Q = 6. Use a dotted line to draw the MC curve.

Figure 3-7.1
Cost Curves of the Fiasco Company

How many units of Q should the firm produce to maximize its total profit? Given its cost functions, the answer depends on the market price that the perfectly competitive firm must charge for its product. Consider these four possible market prices: $15.00, $11.00, $5.50, and $2.50.

4. In Figure 3-7.1, draw the appropriate marginal revenue curve for each of these prices (P) and label them as follows: MR₁ (for P = $15.00), MR₂ (for P = $11.00), MR₃ (for P = $5.50), and MR₄ (for P = $2.50).
5. Using Figure 3-7.1 and Table 3-7.2, complete Table 3-7.3 and determine how many units of Q the firm should produce at each of the four market prices.

### Table 3-7.3
**Optimal Output Level for the Fiasco Firm at Different Market Prices**

<table>
<thead>
<tr>
<th>P</th>
<th>Q* (units)</th>
<th>TR</th>
<th>TVC</th>
<th>TFC</th>
<th>TPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>$15.00</td>
<td>9 units</td>
<td>$135.00</td>
<td>$63.00</td>
<td>$12.00</td>
<td>$60.00</td>
</tr>
<tr>
<td>$11.00</td>
<td>7 units</td>
<td>$77.00</td>
<td>$37.00</td>
<td>$12.00</td>
<td>$28.00</td>
</tr>
<tr>
<td>$5.50</td>
<td>4 units</td>
<td>$22.00</td>
<td>$12.00</td>
<td>$12.00</td>
<td>–$2.00</td>
</tr>
<tr>
<td>$2.50</td>
<td>3 units</td>
<td>$7.50</td>
<td>$9.00</td>
<td>$12.00</td>
<td>–$13.50</td>
</tr>
</tbody>
</table>

6. What rule did you use to determine the Q level that would maximize the firm’s TPI if P were $15.00? Why?

   *The rule to use is MR = MC. At the price of $15.00, you can see how many units had MR greater than or equal to MC. This gives 9 units.*

7. Did you use this same rule to find the profit-maximizing Q level at P of $11.00? Why?

   *Yes. The first 7 units had MR greater than MC. Since the MR of the eighth unit was less than its MC, the eighth unit is not profitable at a price of $11.00.*

8. Should the firm shut down if P is $5.50? What if P is $2.50? Explain.

   *At both of these prices the firm will make a loss because P < ATC. However, P > AVC at a price of $5.50, so the firm should use the MR = MC rule to produce 4 units at a smaller loss than it would have if it shut down. At a price of $2.50, P < AVC, so the firm is better off shutting down and having a loss equal to its TFC.*

9. Complete Table 3-7.4, which is the supply schedule for the Fiasco Firm. It shows how many units the firm will provide to the market at different prices.

### Table 3-7.4
**Supply Schedule for the Fiasco Firm**

<table>
<thead>
<tr>
<th>P</th>
<th>Q supplied (units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$15.00</td>
<td>9 units</td>
</tr>
<tr>
<td>$11.00</td>
<td>7 units</td>
</tr>
<tr>
<td>$5.50</td>
<td>4 units</td>
</tr>
<tr>
<td>$2.50</td>
<td>0 units</td>
</tr>
</tbody>
</table>
10. Plot the supply curve of the Fiasco Firm in Figure 3-7.2. Label the curve as “S.”

![Figure 3-7.2
Supply Curve of the Fiasco Firm](image)

11. To create the supply curve of this perfectly competitive firm, you used two important rules of profit maximization:
   
   (A) The firm’s optimal Q level is the one where \( MR = MC \).
   
   (B) The firm should shut down if at its best Q level, \( TR < TVC \) or \( P < AVC \).

12. In general, the supply curve of a perfectly competitive firm is that part of its **marginal** cost curve that lies above its **average variable** cost curve. Refer back to Figure 3-7.1 to see where you went at each of the four prices to find the best Q level for the firm.

13. What is the connection between a perfectly competitive firm having diminishing marginal productivity and its short-run supply curve being upward sloping?

   *The short-run supply curve of a perfectly competitive firm is that portion of its MC curve above its AVC curve. The reason the MC curve is upward sloping is that the MPP of extra units of labor (the variable resource) is diminishing. The firm must receive a higher price to cover its higher MC if it is to produce additional units of output.*
Part C: Short-Run Supply Curve of a Perfectly Competitive Industry

The industry (or market) supply curve tells you how many units will be supplied by all firms at each possible price. To get the industry supply, you add the quantity supplied by each firm at each price. Economists call this *adding horizontally* because you add the quantity supplied (measured on the horizontal axis) at each price. Assume the Fiasco Firm is a typical firm in a perfectly competitive industry with 800 firms.

14. Complete Table 3-7.5. Refer to Table 3-7.4 for how many units a typical firm supplies at each price.

Table 3-7.5
Supply Schedule for the Industry (800 firms)

<table>
<thead>
<tr>
<th>P</th>
<th>Q supplied (units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$15.00</td>
<td>7,200 units</td>
</tr>
<tr>
<td>$11.00</td>
<td>5,600 units</td>
</tr>
<tr>
<td>$5.50</td>
<td>3,200 units</td>
</tr>
<tr>
<td>$2.50</td>
<td>0 units</td>
</tr>
</tbody>
</table>

15. Plot the data from Table 3-7.5 in Figure 3-7.3. Is the market supply curve upward sloping? Why?

*The market supply curve is upward sloping because it is the summation of the upward-sloping supply curves of all the firms in the industry.*

Figure 3-7.3
Market Supply Curve
Part 7

Long-Run Equilibrium and Long-Run Supply in Perfect Competition

A firm is in a short-run equilibrium (SRE) position when it maximizes its total profit by producing the output level where marginal revenue equals marginal cost: MR = MC. When firms in short-run equilibrium in a perfectly competitive market are earning positive total profits, other firms will enter the market. If firms are making a loss in their short-run equilibrium position, over time some of the firms will exit the market. Eventually the perfectly competitive market reaches a long-run equilibrium (LRE) where all of the firms in the industry are earning zero total profits, based on the current market demand. Firms in other industries thus have no incentive to enter this market. And firms in this market have no incentive to leave it because they are earning their normal profit. An industry’s long-run supply (LRS) curve is the set of LREs where each LRE is based on a different level of market demand. The shape of the LRS curve depends on how the production costs of firms change as the industry expands. The three cases to consider are constant-cost, increasing-cost, and decreasing-cost industries.

Part A: Movement from Short-Run Equilibrium to Long-Run Equilibrium

Table 3-8.1 presents some cost data for a typical firm in the perfectly competitive market for bricks. These cost data are shown in Figure 3-8.1.

<table>
<thead>
<tr>
<th>Output (Q) (tons)</th>
<th>Average total cost (ATC)</th>
<th>Average variable cost (AVC)</th>
<th>MC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>1</td>
<td>$50.00</td>
<td>$40.00</td>
<td>+$40.00</td>
</tr>
<tr>
<td>2</td>
<td>$40.00</td>
<td>$35.00</td>
<td>+$30.00</td>
</tr>
<tr>
<td>3</td>
<td>$33.33</td>
<td>$30.00</td>
<td>+$20.00</td>
</tr>
<tr>
<td>4</td>
<td>$32.50</td>
<td>$30.00</td>
<td>+$30.00</td>
</tr>
<tr>
<td>5</td>
<td>$34.00</td>
<td>$32.00</td>
<td>+$40.00</td>
</tr>
<tr>
<td>6</td>
<td>$36.67</td>
<td>$35.00</td>
<td>+$50.00</td>
</tr>
<tr>
<td>7</td>
<td>$40.00</td>
<td>$38.57</td>
<td>+$60.00</td>
</tr>
<tr>
<td>8</td>
<td>$43.75</td>
<td>$42.50</td>
<td>+$70.00</td>
</tr>
</tbody>
</table>
1. Complete Table 3-8.2, which shows how many units a firm will make available at different prices. Assume a firm cannot produce fractions of a unit.

**Table 3-8.2**

**Supply Schedule of a Typical Firm**

<table>
<thead>
<tr>
<th>Price (P)</th>
<th>Quantity supplied (Q_s) (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$70</td>
<td>8</td>
</tr>
<tr>
<td>$60</td>
<td>7</td>
</tr>
<tr>
<td>$50</td>
<td>6</td>
</tr>
<tr>
<td>$40</td>
<td>5</td>
</tr>
<tr>
<td>$30</td>
<td>4</td>
</tr>
<tr>
<td>$20</td>
<td>0</td>
</tr>
<tr>
<td>$10</td>
<td>0</td>
</tr>
</tbody>
</table>
2. Assume there are 1,000 firms in the brick industry. Complete Table 3-8.3, which shows the market supply schedule. Information about the market demand schedule is included in Table 3-8.3.

Table 3-8.3
Market Supply and Demand Schedules

<table>
<thead>
<tr>
<th>P</th>
<th>Qs (tons)</th>
<th>Quantity demanded (Qd) (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$70</td>
<td>8,000</td>
<td>2,000</td>
</tr>
<tr>
<td>$60</td>
<td>7,000</td>
<td>3,000</td>
</tr>
<tr>
<td>$50</td>
<td>6,000</td>
<td>4,000</td>
</tr>
<tr>
<td>$40</td>
<td>5,000</td>
<td>5,000</td>
</tr>
<tr>
<td>$30</td>
<td>4,000</td>
<td>6,000</td>
</tr>
<tr>
<td>$20</td>
<td>0</td>
<td>7,000</td>
</tr>
<tr>
<td>$10</td>
<td>0</td>
<td>8,000</td>
</tr>
</tbody>
</table>

3. Figure 3-8.2 shows the market demand curve D1. Draw the market supply curve S1 from Table 3-8.3. What is the equilibrium price of bricks? What is the equilibrium quantity? Label the SRE intersection of D1 and S1 as “SRE.”

The equilibrium price of a ton of bricks is $40 and the equilibrium quantity is 5,000 tons.
4. In Figure 3-8.1, draw the marginal revenue (MR), average revenue (AR), and demand (D) curves of a firm at the equilibrium price. How many units will the firm produce to maximize its total profit? (Assume the firm cannot produce fractions of a unit.) Does this number agree with your work in Table 3-8.2?

*The perfectly competitive firm will produce 5 tons of bricks. Yes, it agrees.*

5. What is the value of the firm's average profit? What is the value of its total profit? In Figure 3-8.1, shade in the area representing its total profit.

\[
\begin{align*}
\text{Average Profit} & = AR - ATC = \$40.00 - \$34.00 = \$6.00. \\
\text{Total Profit} & = Q \times AR = 5 \times \$6.00 = \$30.00.
\end{align*}
\]

6. Is the industry in a position of LRE? How do you know?

*No, because firms are earning positive total profit.*

7. Why will other firms want to enter this industry? Assume the cost curves of a typical firm in the industry do not change as new firms enter.

*Other firms will enter the industry because firms are earning positive total economic profits.*

8. As more firms enter the industry, the market supply curve shifts to the (right / left), which makes the market price (increase / decrease).

9. The industry is in a position of LRE when all firms break even based on the current level of market demand D. What is the LRE price? Why?

*More firms will enter the market until the price falls to the minimum value of a firm's ATC curve. As seen in Table 3-8.1, this is $32.50.*

10. In Figure 3-8.2, draw the new market S curve (label it S) that will result in this LRE price. Do not change the existing market demand curve D. Label the LRE point as “LRE.”
11. In Figure 3-8.1, draw the firm’s MR, AR, and D curves at the LRE price. How many units will the typical firm produce at this price? What is the total profit of a firm in this LRE position?

The typical firm will produce 4 units and earn a total economic profit of $0.

12. If all firms in the market earn $0 in economic profit, will other firms still want to enter the market? Will some firms want to exit the market? Why?

No other firms will want to enter the market because there are no economic profits. Firms now in the market will have no incentive to leave because they are earning their normal profits.

Part B: Long-Run Equilibrium for a Perfectly Competitive Firm

Let’s leave the brick market and move to some other perfectly competitive market. Figure 3-8.3 shows a perfectly competitive firm in LRE, selling 640 units at a price of $18.

13. What does it mean for a firm to be productively efficient? Is this firm productively efficient? How do you know?

A firm is productively efficient if its price is equal to the minimum value of its average total cost. This firm does exhibit productive efficiency. Consumers are getting the product at the lowest possible price.

14. What does it mean for a firm to be allocatively efficient? Is this firm allocatively efficient? How do you know?

A firm is allocatively efficient if its price is equal to marginal cost. This firm is allocatively efficient. It is producing the output level society wants it to produce. If there are no externalities (effects on other parties), then price measures the marginal social benefit (MSB) and MC measures the marginal social cost (MSC) of the last unit. Because MSB = MSC, the correct amount of society’s scarce resources are being allocated to the production of this firm’s product.
Part C: Long-Run Supply for a Perfectly Competitive Industry

The industry shown in Figure 3-8.4 is in LRE at point A with supply curve $S_1$ and demand curve $D_1$. The market price is $20, and the equilibrium quantity is 500 units. Now the demand for the industry’s product increases to $D_2$. The price increases to $27 and quantity increases to 620 units. Because this boost in the market price results in positive total profits for firms in the industry, point B is considered a short-run equilibrium (SRE). How the industry moves to its new LRE in response to this increase in demand depends on whether it is a constant-cost, increasing-cost, or decreasing-cost industry.

15. Assume the industry is a constant-cost industry. Explain how the industry moves to its new LRE. Show changes in supply and/or demand in Figure 3-8.4 and indicate the new LRE as point C. Because of profits in the industry, other firms will enter. This makes the market supply curve shift to the right which reduces the market price. Since this is a constant-cost industry, the average total cost of production does not change as the industry expands. Thus, the supply curve will shift to the right to $S_2$, where it intersects $D_2$ at point C at the price of $20. Firms will break even at this price as they did at point A. Point C is the long-run equilibrium based on demand curve $D_2$.

16. Is the new LRE price greater than, equal to, or less than $20? Why?

*The new LRE price is equal to $20 because the average total cost of firms did not change as the industry expanded. The firms will break even at the original LRE price of $20. The industry quantity has increased due to the inflow of new firms.*

17. The industry’s LRS curve is the collection of LREs where each LRE is based on a different market demand curve. Draw a line connecting point A and point C, and label this line as “LRS.” Is the LRS curve of a constant-cost industry upward sloping, horizontal, or downward sloping? What does this tell you about how price and quantity change as the industry expands in response to increases in demand?

*The LRS curve of a constant-cost industry is horizontal. As the industry expands, the market price will not change as the market output increases.*
18. Now assume the industry is an increasing-cost industry. In Figure 3-8.5, the industry is in LRE at point A. When demand increases to $D_2$, the industry moves to SRE at point B, where firms enjoy positive total profit. Explain how the industry moves to its new LRE. Show changes in supply and/or demand in Figure 3-8.5 and indicate the new LRE as point C.

Because of profits in the industry, other firms will enter. Two things happen to eliminate profits in the market. First, the market supply curve shifts to the right which reduces the market price. Second, since this is an increasing-cost industry, the average total cost of production increases as the industry expands. Thus, the supply curve will shift to the right to $S_2$, where it intersects with $D_2$ at point C at a price higher than $20$, say $24$. Firms will break even at this price as they did at point A. Point C is the long-run equilibrium based on demand curve $D_2$.

![Figure 3-8.5](image)

**A Perfectly Competitive Industry**

19. Is the new LRE price greater than, equal to, or less than $20$? Why?

The new LRE is greater than $20$ because this is an increasing-cost industry. As the industry expanded, firms competing for needed resources drove up the prices of those resources, thus increasing the average total cost of production. This means the price will fall from $27$ but will not fall all the way back to $20$. Firms will break even at some price above $20$, say $24$.

20. Draw a line connecting point A and point C, and label this line as “LRS” for long-run supply. Is the LRS curve of an increasing-cost industry upward sloping, horizontal, or downward sloping? What does this tell you about how price and quantity change as the industry expands in response to increases in demand?

The LRS curve of an increasing-cost industry is upward sloping. As the industry expands, both the market price and output will increase.

21. If the industry were a decreasing-cost industry, what would happen to the market price and quantity as the industry expanded? What would be the shape of the industry LRS curve?

In a decreasing-cost industry, the market price will decrease and output increase as the industry expands. The LRS curve will be downward sloping.
Part 8

Graphing Perfect Competition

Figures 3-9.1 through 3-9.6 show side-by-side graphs of perfectly competitive industries and firms. Each pair of graphs illustrates the specific situation that is given.

(A) For the industry’s graph, draw the supply (S) and demand (D) curves. Indicate by $P^*$ and $Q^*$ the equilibrium price and quantity.

(B) For the firm’s graph, draw the average total cost (ATC), average variable cost (AVC), average revenue (AR), and demand (D) curves. Indicate by $P^*$ and $Q^*$ the firm’s optimal price and output.

(C) Explain the reasoning for your graphs in each situation.

1. A firm earning positive total profit in the short run.

**Figure 3-9.1**

**Short-Run Economic Profit**

Explanation: *The firm produces $Q^*$ where $MR = MC$. Because the market price $P^*$ is greater than $ATC$, the firm earns positive total profit.*
2. A firm operating with an economic loss but not wanting to shut down in the short run.

Figure 3-9.2
**Short-Run Economic Loss but Not Shutting Down**

Explanation: *The firm’s optimal output is Q* where MR = MC. Even though it will make a loss because the market price P* is less than ATC, the firm will not shut down because P* is greater than AVC. The firm is able to pay all its TVC and part of its TFC.*

3. A firm in a classic shutdown position in the short run.

Figure 3-9.3
**Classic Shutdown Position**

Explanation: *At Q*, where MR = MC, the market price P* is less than AVC. The firm will shut down rather than produce Q*. By shutting down, the firm’s loss will be equal to its TFC. If it produces Q* it will have a loss which is greater than its TFC.*
4. LRE for a firm and the industry.

**Figure 3-9.4**

**Long-Run Equilibrium**

![Graph showing long-run equilibrium in microeconomics](image)

**Explanation:** The firm will break even with output $Q^*$, where $MR = MC$, because the market price $P^*$ is equal to ATC at the minimum point on the ATC curve. The industry is in LRE: firms will neither enter nor leave the industry because the firms in the industry are earning a normal profit but no economic profit.

5. Illustrate how economic profits will disappear in the long run.

**Figure 3-9.5**

**From Short-Run Profit to Long-Run Equilibrium**

![Graph showing transition from short-run to long-run equilibrium in microeconomics](image)

**Explanation:** With supply $S_1$, the typical firm is earning a positive total profit at $Q^*$ because the market price $P^*_1$ is greater than ATC. As new firms enter the industry, attracted by the presence of profits, the market supply curve shifts to the right until it becomes $S_2$ which creates the market price $P^*_2$. At $P^*_2$, each firm breaks even because $P^*_2$ is equal to ATC at the minimum point on the ATC curve. The industry is in long-run equilibrium. A firm produces $Q^*_2$ and charges $P^*_2$. 
6. Illustrate how economic losses will disappear in the long run.

**Figure 3-9.6**
**From Short-Run Loss to Long-Run Equilibrium**

**Explanation:** With supply $S_1$, the typical firm is earning a negative total profit at $Q_1^*$ because the market price $P_1^*$ is less than ATC. As some firms leave the industry because of losses, the market supply curve shifts to the left until it becomes $S_2$ which creates the market price $P_2^*$. At $P_2^*$, each firm breaks even because $P_2^*$ is equal to ATC at the minimum point on the ATC curve. The industry is in long-run equilibrium. A firm produces $Q_2^*$ and charges $P_2^*$. 