This long-run average cost curve is U shaped because the production function first exhibits increasing returns to scale (output more than doubles as inputs double between D and F) and then decreasing returns to scale (output rises at a slower rate than inputs between points E and F).

Step three: Calculate the short-run costs.

In the short run, capital is fixed. There are an infinite number of short-run average, variable, fixed, and marginal cost curves—one for each level of capital. Figure 7.6 allows us to calculate the short-run cost curves for $K = 4$. To expand output in the short run, the firm will move from point D to G to H.

Fixed cost = rK, or $\$10 \times 4 = 40$ in all cases.

Variable cost = wL. $w = \$20$ and we can find the amount of labor from Figure 7.6.

Total cost = Fixed cost + variable cost.

Marginal cost = Δtotal cost/Δoutput.

Point	Output q	Fixed Cost F	Variable Cost VC	Total Cost C	Marginal Cost MC
D	100	\$40	$\$20 \times 2 = \$40$	\$80	
G	170	\$40	$\$20 \times 6 = \$120$	\$160	\$80/70 = \$1.14
H	210	\$40	$\$20 \times 10 = \$200$	\$240	\$80/40 = \$2.00

Point	Output	Average Fixed Cost $AFC = F/q$	Average Variable Cost $AVC = VC/q$	Average Cost $AC = C/q$
D	100	\$0.400	\$0.400	\$0.800
G	170	\$0.235	\$0.706	\$0.941
H	210	\$0.190	\$0.952	\$1.143

Practice Problems

Multiple-Choice

1. A lump-sum tax (franchise fee) will cause a parallel upward shift in
   a. the marginal cost curve.
   b. the average fixed cost curve.
   c. the average variable cost curve.
   d. the average cost curve.
   e. none of the cost curves.

2. The minimum point on a short-run average cost curve will also be on the long-run average cost curve if the long-run average cost curve exhibits
   a. economies of scale.
   b. constant returns to scale.
   c. diseconomies of scale.
   d. economies of scope.

Fill-in

3. Miracle Drug Inc. has spent \$100,000,000 on research in developing its product, Elixir of Life, which it hopes will add years to the average life span. So far, the company has not discovered anything that is commercially valuable. The \$100,000,000 is a _____ .

wood pulp will cause the isocost line to rotate toward isocost line C_0. The company will continue using only newspaper (point *A*). Cutting the price of wood pulp by a small amount will cause the isocost line to rotate to isocost line C_2. Again, the firm will minimize costs at point *A*. If the price of wood pulp falls even more, the isocost line could have the same slope as the isoquant line. In this case, the firm can pick any point along the isoquant. (If newspaper and wood pulp have the same price per pound, the company does not care which one it uses.) Finally if the price of wood pulp falls below that of newspapers, we'll have isocost lines with a slope like that of C_3 and C_4. The firm will choose point *B*, along isocost line C_1, because this costs less than any point along C_3. Thus, the firm will use newspaper whenever newspaper is cheaper and wood pulp whenever wood pulp is cheaper.

2. Using the information from the isoquants and isocost lines in Figure 7.6, derive the firm's long-run average total costs, average fixed costs, average variable costs, marginal costs, and short-run average total costs. All the isocost lines have the same slope. The capital rental rate is $10 per hour.

Step one: Calculate the cost associated with each isocost line.

Along any isocost line, cost, *C*, equals $wL + rK$. We don't know the wage rate, *w*, but we can calculate the cost at the end point where no labor is used. Along the isocost that is closest to the origin, C_1, cost must be $C_1 = (w \times 0) + (\$10 \times 8) = \$80$, because 8 units of capital are used at point *A* and $r = \$10$ per hour. Therefore, wage must be $20 per hour, since cost is $80 at point *B* and 4 hours of labor are used (with no capital). Knowing that $w = \$20$, it follows that $C_2 = \$160$ and $C_3 = \$240$.

Step two: Calculate the long-run average cost.

In the long run, both capital and labor can adjust, so the firm will produce any quantity at the cost-minimizing point—at the point of tangency between the isoquant and the lowest possible isocost line. Three points on the long-run average cost curve are at *D*, *E*, and *F*. Average cost = Cost/Quantity, so

Point	Long-run Average Cost
D	$80/100 = $0.80
E	$160/210 = $0.76
F	$240/300 = $0.80

FIGURE 7.6