Exercise 3.1. Suppose that the costs of a large newspaper company consist of

1. workers and machines who print the newspaper;
2. newsprint and ink; and
3. reporters/editors/typesetters who prepare the content.

For each of the listed costs, determine if it is a long-run fixed cost. You can answer this by examining the following scenario: the newspaper decides to keep the same quality newspaper (i.e., sell the same product) while cutting its circulation in half. A long-run fixed cost is one that could never be reduced without changing the quality of the product and hence that is not linked to the size of circulation.

Solution: The workers and machines for printing the paper can eventually be reduced—perhaps by half—when the number of copies printed is cut in half. The same is true for the newsprint and ink. These are not long-run fixed costs.

The wages of the reporters, editors, and typesetters cannot be reduced without changing the quality of the product. Their tasks are unaffected by the size of the circulation.

Exercise 3.2. Recall the example of a large newspaper company from Exercise 3.1. The costs of the company are:

1. workers and machines who print the newspaper;
2. newsprint and ink; and
3. reporters/editors/typesetters who prepare the content.

Which costs are fixed in the short run, that is, which cannot be adjusted quickly even if the firm shuts down (but meets its financial obligations rather than entering into bankruptcy)? This is a question of degree, not a black-and-white categorization, so it is better to give a qualitative discussion of how long it would take to reduce or increase each input.

(In Exercise 3.1, you identified the long-run fixed costs. Remember that this question about short-run fixed costs bears no direct relationship to Exercise 3.1.)

Solution: Newsprint and ink can be reduced (or increased) very quickly, e.g., within weeks, depending on the contracts the newspaper has with suppliers. Their costs are not fixed in the short-run.

Machines will likely take a long time to sell off, depreciate, or redeploy, e.g., six months or more (similarly for buying and installing machines). Hence, their costs are fixed in the short run.

The time it takes to lay off or fire employees—whether workers who print the newspaper or the reporters, editors, and typesetters—is probably in the middle, e.g., from one to six months, depending on the country and labor contracts (similarly for hiring new workers). Their wages may or may not be defined as short-run fixed costs, depending on the time horizon by which one defines the “short run”.

Chapter 3
Production and Costs

SOLUTIONS TO EXERCISES
Exercise 3.3. A firm may develop software for blocking pop-up windows. The software is to be sold on a subscription basis, giving users access to regular updates that are needed to adapt to changing tactics of advertisers. The product has the following costs:

1. Initial development of software: $10 million.
2. Development of updates: $200K per month.
3. Distribution costs (e.g., payment processing): $4 per customer per year.

**a.** Decision problem 1: You have not yet decided to develop the software and enter the market, but you are putting together a business plan to decide whether to do so and what price to charge. What are the long-run fixed costs? What are the sunk costs?

**Solution:** Costs (1) and (2) are long-run fixed costs. There are no sunk costs.

**b.** Decision problem 2: You have already developed the product and have been operating for a year. A new competitor has entered the market, shifting your demand curve. You are now deciding how to adjust your pricing and whether to shut down. What are the long-run fixed costs? What are the sunk costs?

**Solution:** Cost (1) is a sunk cost; cost (2) is a long-run fixed cost.

Note: All prior operating expenses, such as the distribution costs and update development costs incurred in the first year of operation, are also trivially sunk costs. When we say that cost (2) is a long-run fixed cost, we are referring to the future update development costs needed to continue operating.

Exercise 3.4. Consider the following cost function:

\[ c(Q) = 100 + 10Q + Q^2. \]

**a.** What are the formulas for the fixed cost, variable cost, average cost, and marginal cost?

**Solution:**

\[
FC &= 100; \\
vc(Q) &= 10Q + Q^2; \\
ac(Q) &= \frac{100}{Q} + 10 + Q; \\
mc(Q) &= 10 + 2Q.
\]

**b.** At what output level \( Q^* \) is average cost lowest?

**Solution:** One way to solve this is to find the quantity at which \( AC = MC \). We solve \( \frac{100}{Q} + 10 + Q = 10 + 2Q \), or \( 100 = Q^2 \). Hence, \( Q^* = 10 \).

**c.** What is the minimum average cost \( AC^* \)?

**Solution:** \( AC^* = ac(Q^*) = 100/10 + 10 + 10 = 30. \)
Exercise 3.5. Suppose a firm has a fixed cost as well as increasing marginal cost and thus has a U-shaped average cost curve. Suppose that its marginal cost increases by a fixed amount $\Delta MC$ at all output levels—for example, a per-unit tax is imposed on the firm’s output. Based only on this information, what can you say about how $Q^*$ and $AC^*$ change? A graph can help you figure out the answer and should be used to illustrate it.

Solution: I use $\hat{\cdot}$ on values after the increase in marginal cost.

Both the average cost curve and the marginal cost curve shift up by exactly $\Delta MC$.

Therefore:

1. The quantity at which the two curves intersect does not change: $\hat{Q}^* = Q^*$.
2. The value at their intersection point increases by $\Delta MC$: $\hat{AC}^* = AC^* + \Delta MC$.

You are expected to draw freehand curves with these properties. That is all.

For my own graph in Figure S1, I have used $c(Q) = 125 + 2Q^{1.5}$ and $\Delta MC = 10$. 

Figure S1

Exercise 3.6. Suppose a firm has a fixed cost as well as increasing marginal cost and thus has a U-shaped average cost curve. Suppose that its fixed cost increases by $\Delta FC$—for example, the government imposes a yearly license fee to operate in the market or there is an increase in the firm’s R&D cost. Based only on this information, what can you say about how $Q^*$ and $AC^*$ change? A graph can help you figure out the answer and should be used to illustrate it.

Solution: I use $\hat{\cdot}$ on values after the increase in the fixed cost.
The \( MC \) curve does not change at all. The \( AC \) curve shifts up. This is all we need to understand that the quantity at which the \( MC \) and \( AC \) curve intersects must increase: \( \hat{Q} > Q^u \). (This is the main difference compared to Exercise 3.5 and the most interesting part of this exercise.) Of course, the minimum average cost has to go up also: \( \hat{AC} > AC^u \). You are expected to give a freehand drawing that illustrates the this paragraph. My own examples assumes \( c(Q) = 125 + 2Q^{1.5} \) and \( \Delta FC = 91 \).

**Exercise 3.7.** Figure E3.1 shows the \( AC \) and the \( MC \) curves of a manufacturing firm. Without any further information, can you tell which one is which?

Figure E3.1
Solution: Since one of these is the AC curve, AC is decreasing. This can only happen when $MC < AC$. Therefore, the top curve is the AC curve and the bottom curve is the MC curve.

Exercise 3.8. Consider the following cost function:

$$c(Q) = 144 + 3Q + Q^2.$$  

a. What are the formulas for the fixed cost, variable cost, average cost, and marginal cost?

Solution:

$$FC = 144;$$
$$vc(Q) = 3Q + Q^2;$$
$$ac(Q) = \frac{144}{Q} + 3 + Q;$$
$$mc(Q) = 3 + 2Q.$$  

b. At what output level $Q^u$ is average cost lowest?

Solution: We solve

$$AC = MC,$$
$$144/Q + 3 + Q = 3 + 2Q,$$
$$144/Q = Q,$$
$$144 = Q^2,$$
$$Q = 12.$$  

c. What is the minimum average cost $AC^u$?

Solution: $AC^u = ac(Q^u) = 144/12 + 3 + 12 = 27.$