Bergstrom & Miller
"Experiments with economic principles: microeconomics"
2000. Boston: McGraw Hill

Experiment 1

Supply and Demand

An Apple Market

It is a sunny Saturday morning at the Farmers' Apple Market. You and your classmates have come to the market to buy and sell apples. Your objective is to make as much profit as possible.

Buying and Selling

At the beginning of today's class, you will be given a personal information sheet that indicates whether you are a **supplier** or a **demander** in the market.

If you are a supplier, you will find your **Seller Cost** for a bushel of apples listed on your personal information sheet. Your Seller Cost is the cost to you of producing a bushel of apples to sell. If you don't sell any apples, you don't have to produce any apples, and you will have zero costs. You are allowed to sell *at most one* bushel of apples in any round of this experiment. If your Seller Cost is $\$C$ and you agree to sell a bushel of apples for a price $\$P$, then your **profit** (or **loss**) will be the difference, $\$P - \$C$, between the price and your seller cost. Sometimes you may not find any demanders who are willing to pay you as much as your Seller Cost. If this is the case, you are better off not selling any apples and taking zero profits.

Example:

A supplier has a Seller Cost of $10 and she can sell one bushel of apples. If she sells a bushel of apples for a price of $16, she will make a profit of $\$16 - \$10 = \$6$. If she sells a bushel for $30, she will make a profit of $\$30 - \$10 = \$20$. If she sells a bushel for $7, she will make a *loss* of $3. If she does not sell, her profit is zero.

If you are a demander, your **Buyer Value** for a bushel of apples will be listed on your personal information sheet. Your Buyer Value is the amount of money that it is worth to you to have a bushel of apples. You are not allowed to buy *more than one* bushel in any round of this experiment. If your Buyer Value is $\$V$ and you agree to buy a bushel of apples for a price $\$P$, then your profit (or loss) will be the difference, $\$V - \$P$, between your Buyer Value and the price you pay. If you don't buy any apples, your profit is zero. If you cannot find a supplier who is willing to sell you a bushel of apples for your Buyer Value or less, then you are better off not buying any apples and taking zero profits.

Example:

A demander has a Buyer Value of $40. If he buys a bushel of apples for $16, he will make a profit of $\$40 - \$16 = \$24$. If he buys a bushel of apples for $30, he will make a profit of $\$40 - \$30 = \$10$. If he buys a bushel of apples for $45, he will make a *loss* of $5. If he doesn't buy any apples, his profit is zero.

To make a purchase or sale, first find somebody who might be willing to make a deal with you. Suppliers can make deals only with demanders and demanders can make deals only with suppliers. When a supplier meets a demander, they can negotiate about the price in any way they wish. You don't have to reveal your Seller Cost or Buyer Value to your bargaining partner, but you can if you want.

When a supplier (seller) and demander (buyer) agree on a price, they should fill out a *sales contract* and bring it to the market manager. **Only one sales contract should be turned in for each sale.** The sales contract records the seller's and buyer's names or identification numbers, the price, and a few other details about the sale. As sales contracts are turned in, the sales prices will be written on the blackboard where everyone can see them.

When you have completed your transaction and turned in your sales contract, please return to your seat. **In any single round of trading you are not allowed to buy or sell more than one bushel of apples, but you can always choose not to trade if no profitable trades are available.**

Transactions, Rounds, and Sessions

A **transaction** is a single deal between a buyer and a seller and is completed when the buyer and seller give a filled-in sales contract to the market manager. A **round** of trading begins when the market manager declares trading to be open and ends when there are no more transactions to be made between willing buyers and sellers. A market **session** can include two or more *rounds* of trading.

After the first round of trading is completed, your instructor may conduct one or more additional rounds within the same session. In later rounds of a session, everyone has the same Buyer Value or Seller Cost as in the first round. The reason for having more than one round of trading in a session is that in later rounds, buyers and sellers know what happened in earlier rounds and may use this information to decide what prices to ask or offer. After a round of play is completed, you should look at the record of transactions on the blackboard to see whether you can expect to get a better price in the next round by seeking a new trading partner and/or by holding out for a more favorable price.

Your role as a supplier or demander and your Seller Cost or Buyer Value do not change as you move from one round to another within the same session. When you start a new session, you will have a new role, as described on your Personal Information Sheet.

Some Advice to Traders

Even if you are normally a shy person, let your "trading personality" be more flamboyant. Shrinking violets, though charming in many situations, are likely to miss profitable trading opportunities. To maximize your profits, you should approach trading aggressively. Don't be afraid to shout or gesture for attention. Let people know how much you are willing to pay or the price at which you are willing to sell. When you think that you could get a better price than someone offers you, do not hesitate to propose a price that you like better.

Remember that you don't have to deal with the first person you encounter. Different people have different Buyer Values and Seller Costs. If someone can't, or won't, offer you a favorable price, be ready to shop around for a better deal with someone else.

If you haven't yet made a trade, keep an eye on the prices of previous transactions that are posted on the blackboard. This may give you some idea of what price to demand or what price to offer in your own negotiations.

Keep in mind that you want to "buy low, sell high." Demanders make greater profits, the lower the price they have to pay. Suppliers make greater profits, the higher the price they can get.

Remember that it is better to make no trade at all than to trade at a loss.

Warm-up Exercise

After reading the instructions for this experiment, please check your understanding by answering the following questions.[1]

Suppose that a supplier with a Seller Cost of $20 meets a demander with a Buyer Value of $40.

W 1.1 If the supplier sells a bushel of apples to the demander for a price of $35, how much profit will the supplier make? $ ______ And how much profit will the demander make? $ ______ How much is the total profit made by the two traders? (Find this by adding the buyer's profits to the seller's profits.) $ ______

W 1.2 What is the *highest* price of apples that would permit both the seller and the buyer to make a profit of $1 or more? $ ______ If this price is charged, how much is the sum of buyer's profits plus seller's profits? $ ______

W 1.3 What is the *lowest* price of apples that would permit both the seller and the buyer to make a profit of $1 or more? $ ______ At this price, how much is the sum of buyer's profits plus seller's profits? $ ______

Discussion of Experiment 1

In Search of a Theory

We have a mystery on our hands. In the Apple Market experiment, the prices at which apples were traded seemed to be closing in on certain values. But what determines the values to which prices converged?

It would be nice to have a *theory* that predicts outcomes, not only for the specific market that we observed experimentally, but for a variety of markets under widely varying conditions. We would like a theory that allows us to answer questions like:

- If every supplier's Seller Cost increases by \$10, will the market price increase by exactly \$10, by less than \$10, or by more than \$10?

- Suppose that the government decides to pay \$10 to every person who buys a bushel of apples. Such a payment is called a **subsidy** to apple consumption. Will suppliers absorb some or all of the subsidy by increasing their prices, or will demanders get all of the benefits from the \$10 subsidy?

- If bad weather reduces the quantity of apples that each producer could supply, what will be the effect on the price of apples and what will happen to the total revenue of suppliers?

Economists have just such a theory. It is known as **supply and demand theory** or, more formally, as **competitive equilibrium theory**. This theory offers answers to the above questions and to many others. These answers are often quite surprising and interesting. Of course, a theory that predicts market outcomes will not be much good if these predictions are badly wrong. Therefore it is important to see whether supply and demand theory does a good job of predicting the outcomes of our experiments. If the theory does well in these experimental environments and continues to do well as we add more elements of realism, then we can put some credence in its predictions for actual markets. If this simple theory does not perform well, then we must look for a better theory.

A Model of Competitive Markets

In our classroom experiment, particularly in the early rounds, some sellers were able to get higher prices for their apples than others. Similarly, some buyers were able to find a seller who would sell cheaply and others could only find sellers who insisted on a high price. Every participant in the market would like to get the best deal possible, but different participants will have different ideas about what is possible. To describe all market participants' beliefs about the prices at which they can trade and their luck about whom they meet would be an overwhelmingly complicated task, even for this simple market.

Instead of trying to describe this complex reality in full detail, let's try to make a simplified *model* of competitive markets. The art of good modeling in economics, as in all of science, is to find the "right" simplifications. The model should remove enough complication from the actual situation to allow us to analyze and predict outcomes, without removing so much reality that it seriously distorts our predictions about the way the market will behave. We are looking for a manageable model of markets that makes good predictions of the outcomes that we observe in experimental markets and in actual markets of the commercial world. Specifically, we would like a model that uses the information that we have about the distribution of Buyer Values and Seller Costs to predict the average price and number of transactions that are likely to take place in the market.

An effective way to simplify this problem is to assume that all buyers pay the same price for apples and that all sellers sell at this same price. As you found in your classroom experiment, this assumption is not very accurate, especially in the first rounds of trading, but in later rounds, as traders become better informed about the prices they can hope to find, the differences between prices paid for apples by different people tend to disappear.

If there were just one price for apples, those suppliers who could make a profit at this price would sell apples and those who would take a loss would not sell any. Similarly, those demanders who could profit by buying apples at the prevailing price would buy and those who would lose money would not buy. At this price, it would be possible to satisfy everybody's wishes only if the quantity of apples that demanders wanted to buy were *the same* as the quantity that suppliers wanted to sell. At an arbitrarily chosen price, there is no reason to expect that demanders would want to buy the same amount that suppliers would want to sell. But as we will see, there will be *some* price at which the total quantity of apples that demanders are willing to buy is equal to the total quantity of apples that suppliers are willing to sell. This price, at which "supply equals demand," is known as the **competitive equilibrium price**. The number of units bought and sold at this price is known as the **competitive equilibrium quantity**.

Graphing Supply and Demand

Supply curves and **demand curves** are the main tools that we use to study competitive equilibrium. The supply curve tells us the total amount of a good that suppliers would want to sell at each possible price. We can draw a supply curve if we know each supplier's Seller Cost. In this experiment, since each supplier supplies at most one unit, the number of units that suppliers are willing to supply at any price P is equal to the number of suppliers whose Seller Costs are less than or equal to P.

The demand curve tells us the total amount of a good that buyers would want to buy at each possible price. We can draw this curve if we know each demander's Buyer Value. In this experiment, each demander buys either one bushel of apples or no apples, and thus the total number of bushels that demanders are willing to buy at any price P is equal to the number of demanders whose Buyer Values are greater than or equal to P.

We can show the way that the interaction of suppliers and demanders determines the outcome in a market by drawing the supply and demand curves on the same graph. Competitive equilibrium prices and quantities are found where the supply curve crosses the demand curve.

An Example

We will use a specific example to show how to draw supply and demand curves and find equilibrium prices and quantities. In this example:

- There are 10 high-cost suppliers who have Seller Costs of $25 a bushel.
- There are 20 low-cost suppliers who have Seller Costs of $5 a bushel.
- There are 15 high-value demanders who have Buyer Values of $30 for a bushel of apples.
- There are 15 low-value demanders who have Buyer Values of $10 for a bushel of apples.

This information is summarized in Table 1.1

Table 1.1: Distribution of Types–Example Market

Type of Agent	Number of Agents	Cost	Value
Low-Cost Supplier	20	5	[redacted]
High-Cost Supplier	10	25	[redacted]
High-Value Demander	15	[redacted]	30
Low-Value Demander	15	[redacted]	10

Making a Supply Table

A **Supply Table** shows the number of bushels of apples that suppliers would offer at each possible price. We can construct a Supply Table for the example market using the information in Table 1.1.

Table 1.2: Supply Table–Example Market

Price Range	Amount Supplied
$P < \$5$	0
$\$5 < P < \$25$	20
$P > \$25$	30

In the example market, low-cost suppliers have a Seller Cost of $5 a bushel and high-cost suppliers have a Seller Cost of $25 a bushel. At any price below $5 a bushel, a supplier who sold a bushel of apples would lose money because it costs every supplier at least $5 to produce a bushel of apples. Thus at prices below $5, nobody would want to supply any apples, so the total number of bushels supplied to the market would be zero. We therefore enter 0 as the amount supplied in the first line of Table 1.2.

If the price, P, is between $5 and $25, the 20 low-cost suppliers can each make money by selling a bushel of apples, since their costs are only $5. But the high-cost suppliers would lose money if they sold apples for any price that is below $25, since it costs them $25 to produce a bushel of apples. Therefore at prices between $5 and $25, the 20 low-cost suppliers will each sell a bushel of apples, but the high-cost suppliers won't sell any apples. The total quantity of apples supplied at prices between $5 and $25 will be 20 bushels, and so we enter 20 as the amount supplied in the second line of the Supply Table.

At prices above $25, all of the high-cost suppliers *and* all of the low-cost suppliers can make money by selling apples. Since there are 10 high-cost suppliers and 20 low-cost suppliers, the total amount supplied at prices above \$25 is 30 bushels. Therefore we enter 30 as the amount supplied in the last line of the Supply Table.

Making a Demand Table

We can construct a **Demand Table** for this market in much the same way. The Demand Table shows the number of bushels of apples that demanders want to buy at all possible prices.

The highest Buyer Value for a bushel of apples is \$30. If the price is above \$30, no buyer will want to buy any apples. So for all prices above \$30, the number of bushels demanded is 0. We record this fact in the first line of Table 1.3.

Table 1.3: Demand Table–Example Market

Price Range	Amount Demanded
$P > \$30$	0
$\$10 < P < \$30$	15
$P < \$10$	30

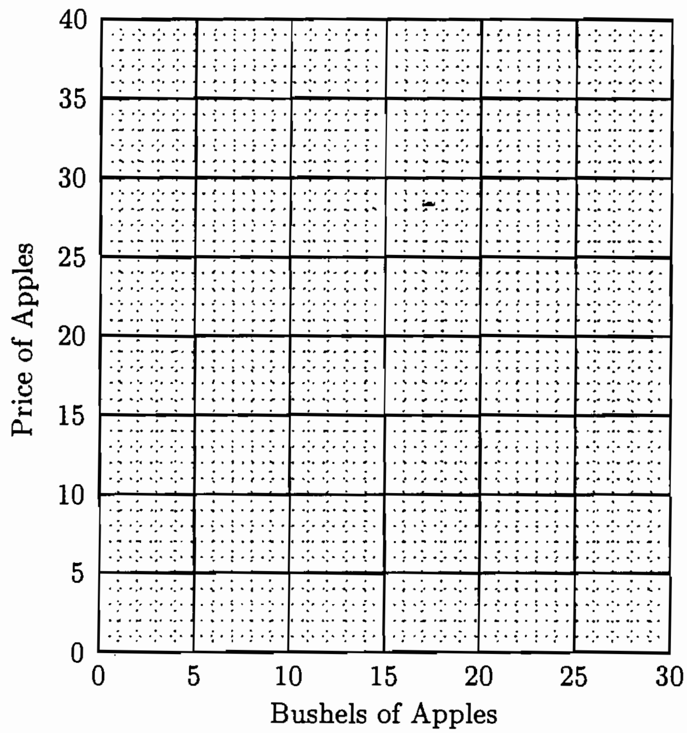
If the price of apples is between \$10 and \$30, all 15 of the high-value demanders can make profits by buying a bushel of apples, but low-value demanders will lose money if they buy apples. So at prices between \$10 and \$30, the total demand for apples is 15 bushels, and we write 15 as the amount demanded in the second line of Table 1.3.

If the price of apples is below \$10, then all of the high-value demanders and all of the low-value demanders can make a profit by buying apples. There are 15 high-value and 15 low-value demanders, so that total demand for apples at any price below \$10 is 30 bushels. Therefore we enter 30 as the amount demanded in the bottom line of Table 1.3.

Drawing Supply and Demand Curves

The supply and demand tables will help you to graph the supply curve and the demand curve. The first step is to draw a pair of axes, with *price of apples* measured on the vertical axis and *quantity of apples* measured on the horizontal axis. This has been done in Figure 1.1.

Figure 1.1: Supply and Demand for Apples



Drawing the Supply Curve

A **supply curve** shows the total number of apples that sellers would be willing to sell at each possible price. You can use the information in the Supply Table 1.2 to draw a supply curve. We suggest that as you read this discussion, you follow through by drawing the lines and points requested in the text. Your graphs will be easier to read if you draw the supply and demand curves in two different colors.

As we see from the Supply Table (Table 1.2), at prices below \$5, the amount of apples supplied is 0. Thus the supply curve must show that at these prices no apples will be supplied. This means that the supply curve includes a vertical line that follows the vertical axis from the origin $(0,0)$ up to the point $(0,5)$ where price is \$5 and quantity is 0.[2] Draw this line segment.

[2]The notation (X,Y) stands for the point on the graph that is located at a horizontal distance of X from the left side of the graph and at a vertical distance of Y from the bottom of the graph.

From the Supply Table, we see that at any price between \$5 and \$25, the total quantity supplied is 20 bushels. Therefore the supply curve includes a vertical line segment drawn from the point (20, 5) up to the point (20, 25). Add this line segment to your graph.

At prices above \$25, we see from the Supply Table that the quantity supplied is 30 bushels. Therefore the supply curve includes a vertical line starting at the point (30, 25) and going straight up to the point (30, one zillion). We don't want you to run out of ink drawing one line, so just draw a line segment from the point (30, 25) to the top of the box.

Your supply curve so far contains three vertical line segments. But we haven't yet answered the question of what happens at a price of exactly \$5 or of exactly \$25. At a price of \$5, all of the high-cost suppliers would lose money if they sold any apples. At this price, the low-cost suppliers won't *make* any money by selling apples, but they won't *lose* any money either. They will be *indifferent* between selling and not selling. Since at a price of \$5, each of the 20 low-cost suppliers would be satisfied with supplying any quantity between 0 and 1 bushel, we can say that at a price of \$5, suppliers in total would be willing to supply any quantity of apples between 0 and 20 units. We show this fact by adding a horizontal segment at a price of \$5 on our supply curve. On the graph, this segment is a line from the point (0, 5) to the point (20, 5).

At a price of \$25, all 20 of the low-cost suppliers will want to supply apples, and the 10 high-cost suppliers would just break even. At this price, each of the 10 high-cost suppliers is willing to supply any amount between zero and one unit. So at a price of \$25, the total quantity supplied can be any amount between 20 and 30 bushels. This implies that the supply curve includes a horizontal segment at a price of \$25. This segment runs from the point (20, 25) to the point (30, 25).

Drawing the Demand Curve

Now that you have drawn a supply curve, it is time to draw a **demand curve.** The demand curve shows the total quantity of apples that demanders would like to buy at each possible price. Like the supply curve, the demand curve consists of vertical and horizontal line segments. You can use the Demand Table (Table 1.3) to draw the demand curve, much as you used the Supply Table to draw the supply curve. You can probably do this without reading more details, but in case you get stuck, you will find detailed hints on how to draw the demand curve on the "Lookup Page," which is found on page 23.

We suggest that you try to draw the supply and demand curves for this example before you peek at the Lookup Page. After you have tried, you can check to see if you got it right.

Finding Equilibrium Price and Quantity

The **competitive equilibrium price** for a good is the price at which the total amount that suppliers want to sell is equal to the total amount that demanders want to buy. The quantity that is supplied and demanded at the competitive equilibrium price is the **competitive equilibrium quantity**. If you have drawn the supply and demand curves on a graph, how can you find the competitive equilibrium price? Before reading the answer that appears below, see if you can figure it out for yourself.

Answer: Remember that the quantity demanded or supplied at any price is found by locating the price on the vertical axis and reading across until you reach the supply or demand curve. If at some price, supply equals demand, it must be that at this price, the supply curve and the demand curve are touching each other. Thus to find the competitive equilibrium price, simply draw the supply and demand curves and find where they cross. If the two curves intersect at a single point, then you can read across to the vertical axis to find the competitive equilibrium price and down to the horizontal axis to find the competitive equilibrium quantity. (Sometimes the supply and demand curves may overlap at more than one point. In this case, there will be more than one competitive equilibrium price and/or quantity.)

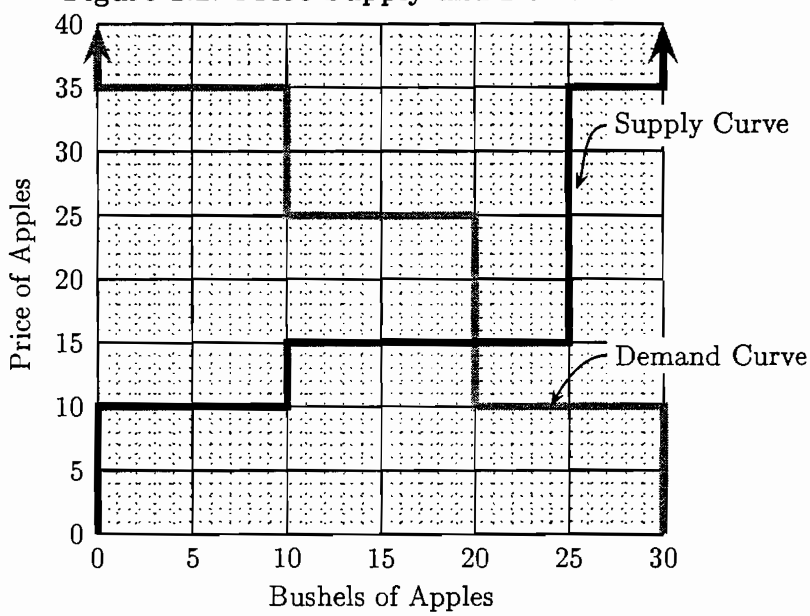
If you look at the supply and demand curves that you drew, you can see that at any price higher than the competitive equilibrium price, suppliers want to sell more apples than demanders want to buy. At any price lower than the equilibrium price, demanders want to buy more apples than suppliers are willing to sell. But at the competitive equilibrium price, suppliers want to sell exactly as many apples as demanders want to buy.

Exercise: Reading Supply and Demand Curves[3]

You have drawn supply and demand curves using the numerical information in a Supply Table and a Demand Table. Now it is time to practice working the other way around—reading numerical information from supply and demand curves.

Figure 1.2 shows supply and demand curves on which you can practice. To make things a little more exciting, let's suppose that there are not two, but *three* different kinds of demanders and also *three* kinds of suppliers.[4]

Figure 1.2: More Supply and Demand



Exercise 1.1 How many bushels of apples will suppliers want to supply at a price of \$40?______ At a price of \$30?______ At a price of \$12?______ At a price of \$5?______

Exercise 1.2 How many bushels of apples will demanders want to

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[3] Answers to these questions can be found on page 24.

[4] If the excitement is too overwhelming, you might want to take a break and read a few pages of a text in accounting or political science to calm yourself down.

buy at a price of $30?______ At a price of $20? ______ At a price of $5? ______ At a price of $40? ______

Exercise 1.3 At a price of $15, suppliers are willing to supply any amount of apples between ______ bushels and ______ bushels.

Exercise 1.4 At a price of $25, demanders are willing to buy any amount of apples between ______ bushels and ______ bushels.

You can also use supply and demand curves to determine the *inverse* relation, namely, the price at which a given quantity would be demanded or supplied. For example, we see from the supply curve that the only price at which suppliers would be willing to supply 5 bushels of apples is $10. If the price were lower, suppliers would not want to supply any apples. If the price were higher than $10, they would want to supply more than 5 bushels. (Of course, at a price of $10, they would also be willing to supply any other number of bushels between 0 and 10.)

Exercise 1.5 Suppliers would be willing to supply exactly 15 bushels of apples at a price of $ ______ and exactly 5 bushels of apples at a price of $ ______ .

Exercise 1.6 Suppliers would be willing to supply exactly 10 bushels of apples at any price between $ ______ and $ ______ .

Exercise 1.7 Demanders would be willing to buy exactly 15 bushels of apples at a price of $ ______ and exactly 5 bushels of apples at a price of $ ______ .

Exercise 1.8 Demanders would be willing to buy exactly 10 bushels of apples at any price between $ ______ and $ ______ .

If, at the current price, the quantity of apples that demanders want to buy is greater than the quantity that suppliers want to sell, we say that there is **excess demand**. If, at the current price, the quantity of apples that suppliers want to sell is greater than the quantity that demanders want to buy, we say that there is **excess supply**.

Exercise 1.9 For each of the following prices, write "S" if there is excess supply and "D" if there is excess demand. \$40 _______ \$30 _______ \$20 _______ \$12 _______ \$5 _______

Exercise 1.10 There is excess supply at prices higher than \$ _______ and there is excess demand at prices lower than \$ _______ .

Exercise 1.11 At a competitive equilibrium price, there is no excess demand and no excess supply. For the supply and demand curves in Figure 1.2, the competitive equilibrium price is \$ _______, and the competitive equilibrium quantity is _______ bushels.

Profits of Buyers and Sellers

Reservation Prices and Consumers' Surplus

In our classroom experiment, if a supplier sells a bushel of apples for a price higher than her Seller Cost she will make a profit, and if she sells for a price lower than her Seller Cost she will lose money. We define a **supplier's reservation price** for a unit of a good to be the lowest price at which she is willing to sell this unit. In this experiment, every supplier's reservation price for a bushel of apples is equal to her Seller Cost.

In this experiment, a demander will make a profit if he buys a bushel of apples for a price lower than his Buyer Value and he will take a loss if he pays more than his Buyer Value. We define a **demander's reservation price** to be the highest price that he would be willing to pay for a unit of the good rather than do without. In this experiment, the most that a demander would be willing to pay for a bushel of apples is his Buyer Value and thus his reservation price is equal to his Buyer Value.[5] We sometimes refer to a supplier's reservation price as her **minimum willingness-to-accept** and to a demander's reservation price as his **maximum willingness-to-pay**.

[5]As we will see in later experiments, suppliers' reservation prices are not always the same as their Seller Costs, and demanders' reservation prices are not always the same as their Buyer Values.

In real-world markets, some goods are used by people who intend to resell them or use them in manufacturing, while other goods are purchased by people who buy them for their own use and enjoyment. Those who demand goods for their own consumption are known as **consumers**. In experimental markets, we motivate demanders to act like real-world consumers by assigning Buyer Values that will be paid to them by the market manager if they buy a unit of the goods. In real-world markets, there is of course no market manager to make such payments. Instead, consumers receive benefits directly from consuming the goods that they buy.

A demander's **consumer's surplus** from purchasing a unit of some good is defined to be the difference between his reservation price and the price he actually has to pay. In this experimental market, where demanders' reservation prices equal their Buyer Values, a buyer gets a consumer's surplus equal to the difference between his Buyer Value and the price that he pays. Another name for this difference is demander's profit. In this book, we use the terms *consumer's surplus* and *demander's profit* interchangeably.

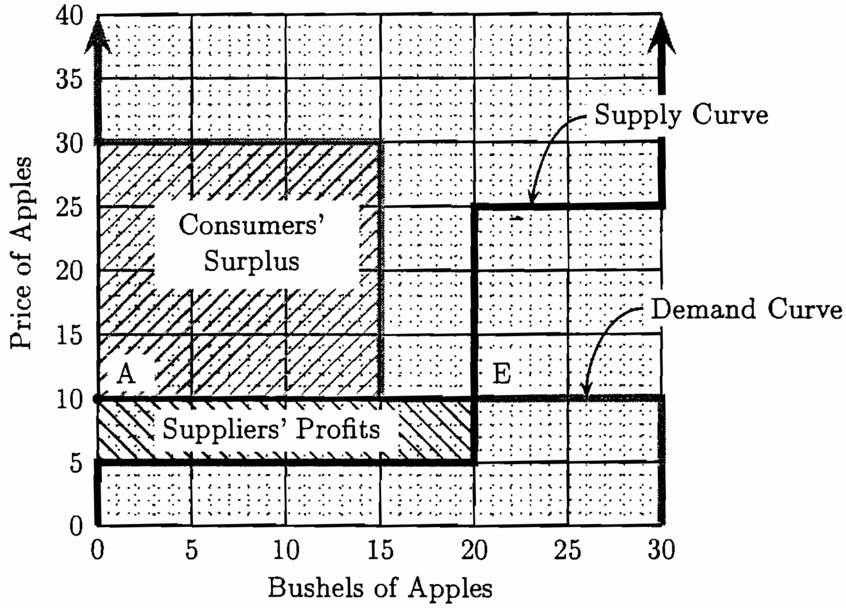
Calculating Profits and Consumers' Surplus

Let us calculate total profits made by suppliers and demanders for a market with the supply and demand curves shown in Figure 1.3. First we calculate the total profit of all *suppliers.* In this example, low-cost suppliers each have costs of $5 per bushel and high-cost suppliers each have costs of $25 per bushel. At the equilibrium price of $10 per bushel, while the low-cost suppliers can make a profit by selling a bushel of apples, the high-cost suppliers would make losses if they produced. So each of the 20 low-cost suppliers will want to supply one bushel, and none of the high-cost suppliers will want to supply any apples.

The only sellers at $10 are the 20 low-cost suppliers. Each of the 20 low-cost suppliers receives $10 for her apples and has to pay her Seller Cost of $5. Thus, her profit from selling apples is $\$10 - \$5 = \$5$. The total profits made by the 20 low-cost suppliers is therefore $20 \times \$5 = \$100$. Since at a price of $10, the high-cost suppliers do not supply any apples at all, they have zero revenue, zero costs, and zero profits. Total profit of all suppliers equals the total profit of low-cost suppliers plus total profit of high-cost suppliers. This is $\$100 + \$0 = \$100$.

Now we calculate total consumers' surplus of all the *demanders* in the market. At the competitive equilibrium price of $10, the high-value demanders, who have Buyer Values of $30, will make a profit by buying apples. The consumer's surplus of each high-value demander is $\$30 - \$10 = \$20$.

Figure 1.3: Profits in the Apple Market



Since there are 15 high-value demanders, the total consumers' surplus of all high-value demanders is 15 × \$20 = \$300. Each of the low-value demanders has a Buyer Value of \$10 for a bushel of apples. Since the price of apples is also \$10, the low-value demanders who buy apples will each have a consumer's surplus of \$10 − \$10 = 0. (They are neither better off nor worse off than the low-value demanders who don't buy any apples.) Since all low-value demanders receive zero profits, whether or not they buy apples, the total amount of consumers' surplus received by low-value demanders is 0. Therefore, the total amount of consumers' surplus made by all demanders is \$300 + 0 = \$300.

We also want to measure the *total profit of all market participants.* This is obtained by adding the total profit of suppliers to the total consumers' surplus of demanders. In the example considered here, total profit of all market participants is \$100 + \$300 = \$400.

Figure 1.3 shows a useful geometric way to find total profits in competitive equilibrium from the graph of the supply and demand curves. First draw a horizontal line from the point E, where the supply and demand curves cross, to the point A, where this horizontal line meets the vertical axis. The area that is *below* the line AE and *above* the supply curve represents the total profits made by suppliers. The area *above* this line and *below* the demand curve represents the total consumers' surplus. This geometric trick works because for each unit sold, the vertical distance from the line AE to the supply curve equals the profit made by the seller of that unit. If we add these profits over all units sold, we have the total profits made by suppliers, which is the area of the region labeled "Suppliers' Profits." Similarly, for each unit sold, the vertical distance between the demand curve and the line AE is the Consumer's Surplus (Demander's Profit) made by the buyer of that unit. Adding these surpluses over all units sold, we have the total consumers' surplus, which is the area of the region labeled "Consumers' Surplus."

Other Implications of Competitive Theory

So far, we have been interested in how well competitive equilibrium works at predicting the outcome in trading environments like our classroom market. If competitive equilibrium turns out to be a good predictor of what happens, then it will be interesting to know more about other implications of the competitive equilibrium theory.

Who Trades in Competitive Equilibrium?

Competitive equilibrium theory makes interesting predictions about which suppliers will sell and which demanders will buy. In competitive equilibrium, it must be that if a supplier can make a profit by selling at the competitive price she will do so, and if she would make a loss, she will not sell. This implies that every supplier whose Seller Cost is lower than the competitive equilibrium price will sell a bushel of apples, and no supplier whose Seller Cost is higher than the competitive equilibrium price will sell any apples. Similarly, in competitive equilibrium, every demander will buy if he can make a profit by buying at the competitive equilibrium price and will not buy if he makes a loss from doing so. Therefore the theory predicts that every demander whose Buyer Value is higher than the competitive equilibrium price will buy a bushel of apples, and every demander whose Buyer Value is lower than the competitive equilibrium price will buy no apples.

Predicting the actions of suppliers or demanders when their Seller Costs or Buyer Values are exactly equal to the competitive price is slightly more complicated. If a supplier's Seller cost equals the price, she is indifferent between selling and not selling. Similarly, if a demander's Buyer Value equals the price, he is indifferent between buying and not buying. In equilibrium, however, we know that the total number of apples sold has to equal the total number of apples bought. This fact gives us enough information to calculate the total number of bushels of apples traded by sellers or buyers who make exactly zero profits by trading. The best way to see how to do this is to look at an example.

Example:

Let us consider a market in which the demand and supply curves are as described by Figure 1.3 on page 19. Let us suppose that each supplier can supply at most one bushel and that each demander can use at most one bushel of apples. There are 20 suppliers with Seller Costs of $5 and 10 suppliers with Seller Costs of $25, and there are 15 demanders with Buyer Values of $30 and 15 demanders with Buyer Values of $10 for a bushel of apples. We see from Figure 1.3 that the competitive equilibrium price is $10. Since the 20 suppliers with Seller Costs of $5 will all make a profit at this price, they will each supply one bushel in competitive equilibrium. Since the 10 suppliers with Seller Costs of $25 would all lose money if they sold, none of them will supply any apples. The 15 demanders with Buyer Values of $30 will all make a profit by buying apples for $10, so we know that in equilibrium they must all be buying apples. But what about the demanders with Buyer Values of $10? Since the competitive equilibrium price of apples is $10, they are just indifferent between buying and not buying. Looking at the demand and supply curves in Figure 1.3, we see that the total number of bushels of apples that are sold in competitive equilibrium must be 20. We know that the 15 high-value demanders will each demand one bushel. This leaves 5 bushels to be consumed in equilibrium by the low-value demanders. This can happen only if 5 of the demanders with Buyer Values of $10 buy apples (and the other 10 do not).

Efficiency and Competitive Equilibrium

Economists are interested in the efficiency of market outcomes. A market outcome is said to be **efficient** if the sum of the profits made by all individuals in the market is as large as possible. A market outcome is said to be **inefficient** if some other possible arrangement of trades will result in higher total profits for all participants. If one set of market institutions leads to an inefficient outcome, then it may be possible to find alternative institutions that result in higher total profits. Higher total profits could, in principle, be redistributed in such a way that *everyone* is better off after the redistribution than they were before the reform.[6]

[6] It might be that although *total* profits with alternative institutions are higher than they were with the original institutions, the direct effect of the change makes some participants worse off than they were before the change. Even if there is enough total gain for the "winners" to compensate the "losers," it is not always possible to determine who the winners and losers will be.

Experimental economists define the **market efficiency** of an experimental market outcome to be the actual total profits of market participants expressed as a percentage of the highest possible amount of profits that could be achieved in the market. If the total profits actually made by market participants are equal to the maximum possible amount, then market efficiency is said to be 100%. If the total profits actually made are only 80 percent of the maximum possible amount, then market efficiency is said to be 80 percent, and so on.

Among all possible arrangements of traders, it turns out that if the profits of buyers and sellers depend only on the trades that they make themselves, the market efficiency of competitive equilibrium is 100%. We state this important result as follows:

Proposition 1.1 *In markets where the profits of buyers and sellers depend only on the trades that they themselves make, competitive equilibrium is efficient. That is, the sum of the profits of buyers and sellers in competitive equilibrium is at least as large as it would be with any other arrangement of trades.*

You already know nearly enough to complete a proof of this proposition. A rigorous, general proof requires a slightly more intricate argument than is appropriate for this course, and is probably best left for an intermediate economic theory course. But the following sketch of an argument can be expanded to provide a rigorous proof.

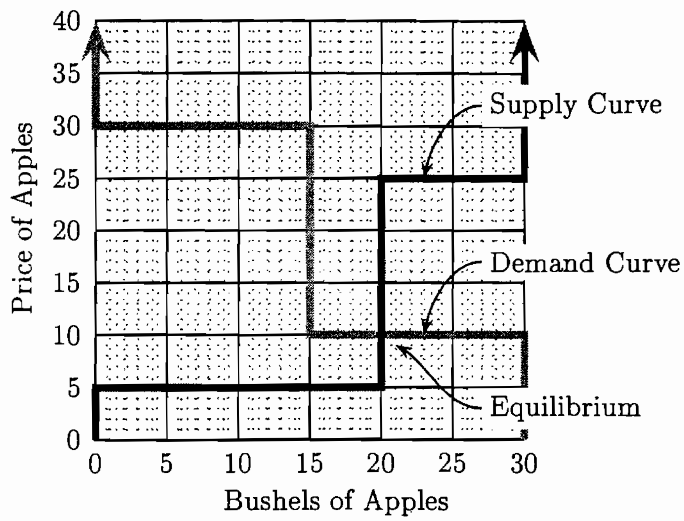
The total amount of profits made by buyers and sellers is equal to the sum of the Buyer Values of those who buy a unit of the good *minus* the sum of the Seller Costs of those who sell a unit of the good. Recall from the warm-up exercises that (regardless of the price) the total profit made by the buyer and seller in any trade is equal to the buyer's Buyer Value minus the seller's Seller Cost. Therefore total profits made by any arrangement of trades is completely determined by who makes trades and who does not. In competitive equilibrium, every demander who buys a unit of the good has a Buyer Value that is at least as high as the competitive equilibrium price, which in turn is at least as high as the Seller Cost of every supplier who sells. Moreover every demander who does not trade has a Buyer Value that is no larger than the competitive equilibrium price, and every supplier who does not trade has a Seller Cost that is no smaller than the competitive equilibrium price. Using these facts one can show that you cannot increase total profits above the competitive equilibrium level either by having more or by having fewer people trading, nor by exchanging some of the individuals trading for some of those who are not trading.

Lookup Page for Supply and Demand Curves

Here are the hints that we promised on how to draw a demand curve.

The highest Buyer Value for apples is 30, so we know that at prices above 30, nobody will want to buy apples. Therefore the demand curve includes a vertical line extending from the point (0, 30) to the top of the box. At prices greater than 10 but less than 30, the demanders with Buyer Values of 30 will want to buy apples, and the demanders with Buyer Values of 10 will not want to buy. There are 15 demanders with Buyer Values of 30, so that 15 units will be demanded at any price between 10 and 30. This means that the demand curve includes a vertical segment running from (15, 10) to (15, 30). At prices below 10, every demander wants to buy one bushel. There are 30 demanders in all, so total demand will be 30 bushels. The demand curve, therefore, includes a vertical segment running from (30, 0) to (30, 10).

Figure 1.4: Supply and Demand–Example 1



At a price of exactly 30, the 15 high-value demanders are indifferent between buying or not. Total demand could be any amount between 0 and 15. Therefore the demand curve includes a horizontal segment running from (0, 30) to (15, 30). At a price of exactly 10, the 15 high-value demanders will all want to buy one unit. The 15 low-value demanders will be indifferent between buying and not buying, so at a price of 10, demand can be any amount between 15 and 30. Therefore the demand curve includes a horizontal segment running from (15, 10) to (30, 10).

Answers to Warm-up Exercises

W 1.1: $15, $5, $20; **W 1.2**: $39, $20; **W 1.3**: $21, $20; Notice that here, regardless of the trading price, the *total* of buyer's profit and seller's profit is always $20. In general, the *sum* of the profits of the buyer and the seller depend only on their Buyer Values and Seller Costs and not on the trading price.

Answers to Exercises

Ex. 1.1: 30, 25, 10, 0; **Ex. 1.2**: 10, 20, 30, 0; **Ex. 1.3**: 10, 25; **Ex. 1.4**: 10, 20; **Ex. 1.5**: $15, $10; **Ex. 1.6**: $10, $15; **Ex. 1.7**: $25, $35; **Ex. 1.8**: $25, $35; **Ex. 1.9**: S, S, S, D, D; **Ex. 1.10**: $15, $15; **Ex. 1.11**: $15, 20.

Lab Notes for Experiment 1

Recording Transactions and Profits

In order to study and interpret the results of this experiment, you will need a set of "lab notes" that record the relevant information about what happened in the experiment. In particular, you will need a record of the transactions made in the last round of each session. This information can be copied into Tables 1.4 and 1.5.[7] The first three columns record *Sale Price*, supplier's *Seller Cost*, and demander's *Buyer Value.*

To complete Tables 1.4 and 1.5, you need to calculate and record **seller's profit**, **buyer's profit**, and **total profit** for each transaction. If your class has no more than 25–30 students, there will be only about 10 transactions per round, so it won't take you long to do these calculations by hand or with a calculator. For larger classes, we suggest that you use a computer spreadsheet. If you work with a spreadsheet, you may print out a copy of the spreadsheet rather than copy the numbers into these tables.

Recall that for any transaction, the seller's profit is $P - C$, where P is the price and C is her Seller Cost. The buyer's profit is $V - P$, where V is his Buyer Value and P is the price. Total profit in a transaction is the sum of the seller's profit and the buyer's profit in that transaction. When you have calculated the information in Tables 1.4 and 1.5, you can use this information to fill in the tables for Problem 1.1 of your homework.

Recording Market Fundamentals

At the end of the experiment, your instructor will announce the distribution of suppliers' Seller Costs and demanders' Buyer Values for all the participants in the experiment, including those who did not trade as well as those who did trade. (You will not be able to recover all of this information simply from the transaction sheets, because although these sheets tell you the types of the people who *did* trade, they give you no information about those who did not trade.) You should copy this information into Tables 1.6 and 1.7. You will need this information to draw supply and demand curves for the market and to make predictions using supply and demand theory.

[7] If your class is fairly small, you can copy this information directly from the blackboard at the end of the last round of each session. In large classes, your instructor may post this information for you on a class website or distribute it by other means.

Table 1.4: Transactions in the Last Round of Session 1

Transaction	Price	Seller Cost	Buyer Value	Seller's Profit	Buyer's Profit	Total Profit
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						

Table 1.5: Transactions in the Last Round of Session 2

Transaction	Price	Seller Cost	Buyer Value	Seller's Profit	Buyer's Profit	Total Profit
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						

Table 1.6: Distribution of Types in Session 1

Type of Agent	Number of Agents	Value	Cost
Low-Cost Supplier			
High-Cost Supplier			
High-Value Demander			
Low-Value Demander			

Table 1.7: Distribution of Types in Session 2

Type of Agent	Number of Agents	Value	Cost
Low-Cost Supplier			
High-Cost Supplier			
High-Value Demander			
Low-Value Demander			

Predictions of the Theory

The way that scientists evaluate a theory is to see how well it predicts outcomes in controlled experiments or in real-world situations that approximate the conditions postulated by the theory. Supply and demand theory makes detailed predictions about what will happen in each session of the Apple Market experiment. Given the distribution of types of buyers and sellers in the market, the theory predicts the price at which apples will be sold and the number of bushels of apples traded. It also predicts the total amount of profits made by suppliers and demanders and it predicts which types will trade and which will not.

You are now in a position to evaluate supply and demand theory by comparing its predictions with the outcomes in your classroom market. In the discussion section of this chapter, you learned how to draw supply and demand curves for a market given the distribution of Buyer Values and Seller Costs. For your homework, you need to draw supply and demand curves for the distribution of Buyer Values and Seller Costs found in your classroom experiment. When you have drawn these curves, you will be able to find the equilibrium prices, quantities, and profits predicted by the competitive theory.

NAME ____________________ SECTION______

Homework for Experiment 1

Problem 1.1 Use the information in Tables 1.4 and 1.5 to complete Table 1.8. Find the **mean** (average) price by adding all the prices posted during the round and dividing by the number of transactions. Find the **number of transactions** by counting the number of transactions recorded in 1.4 (or 1.5). Find total profits of sellers and of buyers by adding the corresponding columns in these tables. Find total profits of all traders by adding total profits of sellers and total profits of buyers.

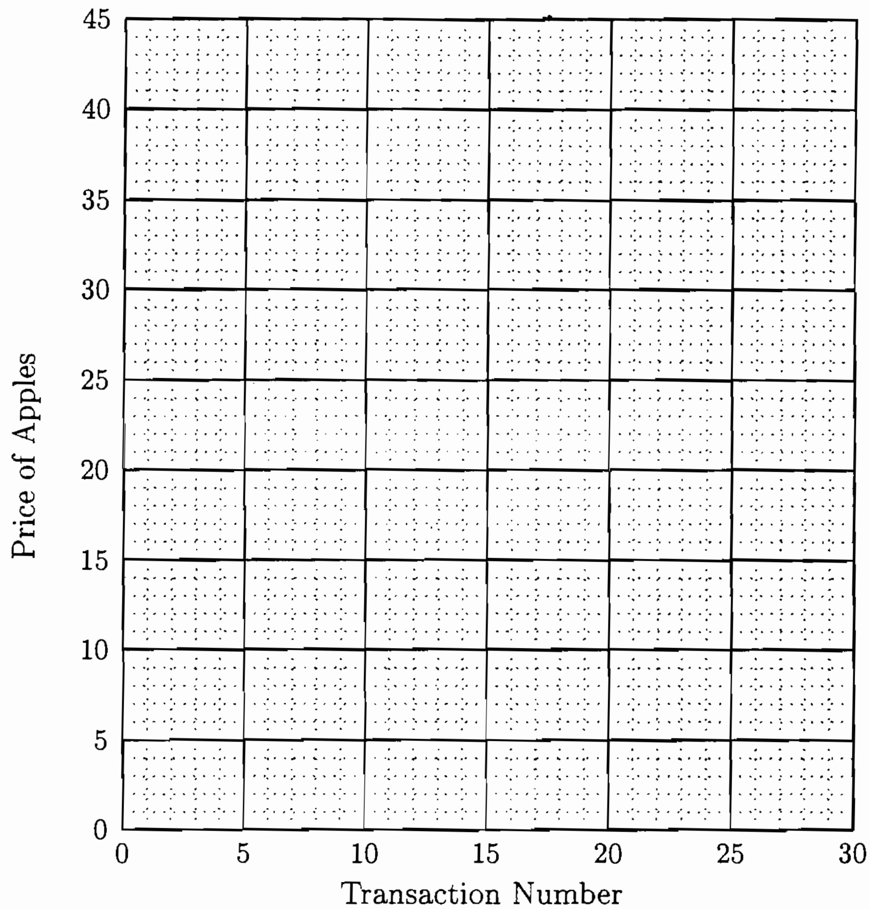
Table 1.8: Summary of Results in Sessions 1 and 2

	Session 1	Session 2
Mean Price		
Number of Transactions		
Total Profits of All Sellers		
Total Profits of All Buyers		
Total Profits of All Traders		

Problem 1.2 When you are looking for logical patterns in a mass of numerical information, it is often useful to draw a graph. One way to present the results of this experiment is to plot a **time series** of prices, showing the transaction prices in the order in which they were recorded. In Figure 1.5, plot the time series of prices in the last round of Session 1 in red ink and the time series of prices in the last round of Session 2 in blue ink. To plot these paths, use the numbers entered in Tables 1.4 and 1.5. To plot prices in Session 1, mark the point $(1, P_1)$, where P_1 is the price in the first transaction, then plot the point $(2, P_2)$, where P_2 is the price in the second

trade, and so on, plotting in sequence the price of each trade in the round. Finally, use red ink to draw line segments that "connect the dots" that you have plotted. After you have plotted the time series for Session 1, use blue ink to plot a similar series for Session 2.

Figure 1.5: Time Paths of Prices in Session 1 and 2



Problem 1.3 Complete the Supply and Demand Tables 1.9, 1.10, 1.11, and 1.12 for Sessions 1 and 2 of your classroom market. These tables will be used to draw supply and demand curves for each session. The information needed to complete these tables is found in Tables 1.6 and 1.7. (See pages 10 and 11 for detailed instructions on how to construct Supply and Demand Tables.)

Problem 1.4 In Figure 1.6, use the information from the Supply and

Table 1.9: Supply Table: Session 1

Price Range	Amount Supplied
$P < \$10$	
$\$10 < P < \$30$	
$P > \$30$	

Table 1.10: Demand Table: Session 1

Price Range	Amount Demanded
$P > \$40$	
$\$20 < P < \$40$	
$P < \$20$	

Table 1.11: Supply Table: Session 2

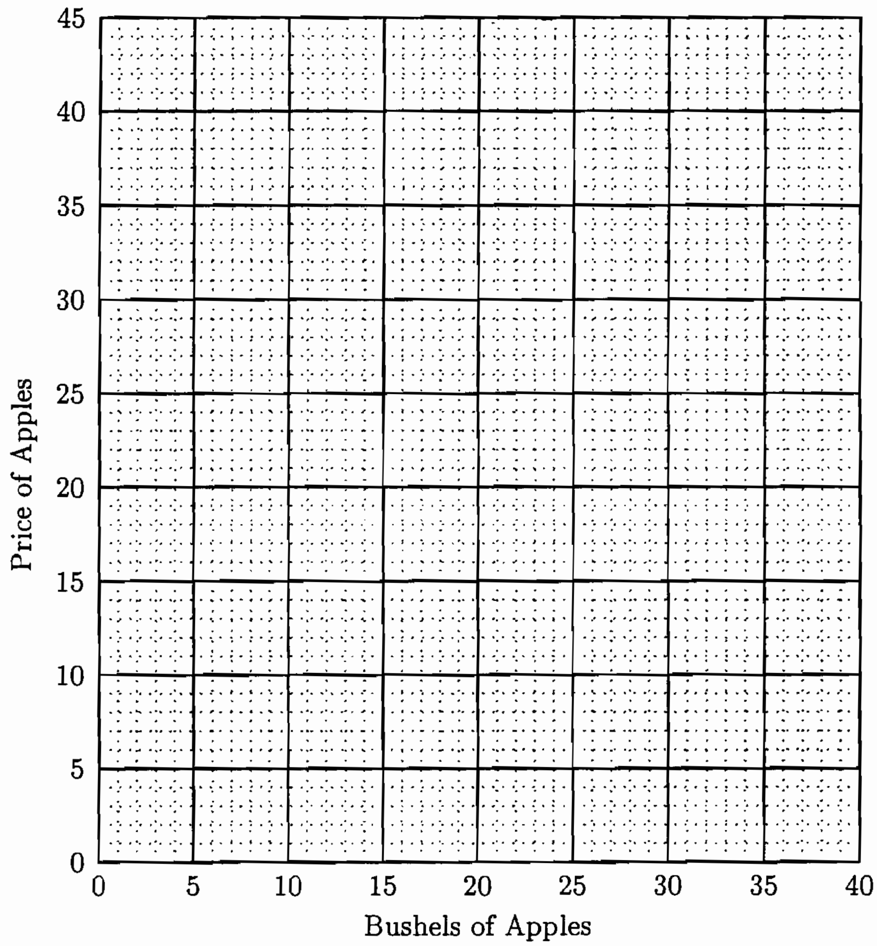
Price Range	Amount Supplied
$P < \$10$	
$\$10 < P < \$30$	
$P > \$30$	

Table 1.12: Demand Table: Session 2

Price Range	Amount Demanded
$P > \$40$	
$\$20 < P < \$40$	
$P < \$20$	

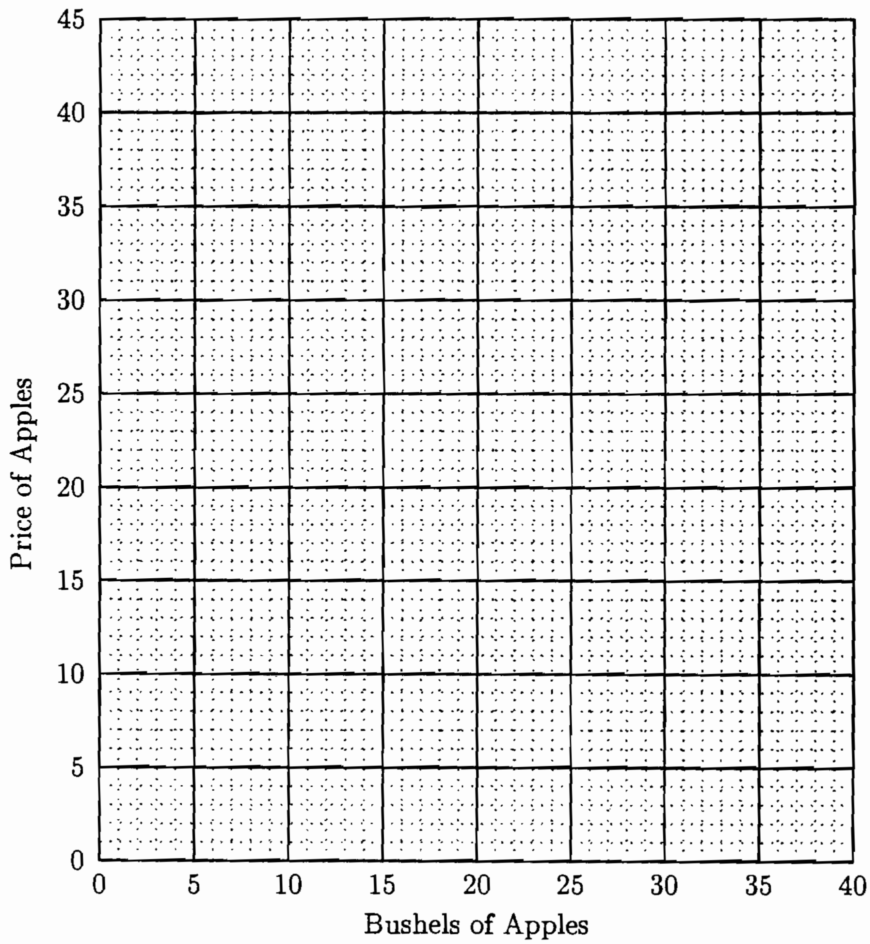
Demand Tables 1.9 and 1.10 to draw a (red) supply curve and a (green) demand curve for the market in Session 1. (See page 11 for detailed instructions on how to draw supply and demand curves.) Mark the intersection of the supply and demand curves with a black dot and label it *CE*.

Figure 1.6: Supply and Demand for Apples, Session 1



Problem 1.5 In Figure 1.7, use the information from the Supply and Demand Tables 1.11 and 1.12 to draw a (red) supply curve and a (green) demand curve for the market in Session 2. Mark the intersection of the supply and demand curves with a black dot and label it CE.

Figure 1.7: Supply and Demand for Apples, Session 2



Problem 1.6 Complete Tables 1.13 and 1.14 to compare the experimental results from your classroom experiment with the predictions made by supply and demand theory.

Table 1.13: Predicted and Actual Outcomes–Sess. 1

	Experimental Outcome	Competitive Prediction
Mean Price		
Number of Transactions		
Total Profits of All Sellers		
Total Profits of All Buyers		
Total Profits of All Traders		
Market Efficiency		

Hints:

- Remember that the *predictions* of the theory and the actual outcomes of the experiment are two different things. The predictions of a theory are almost never *exactly* the same as the experimental outcomes. A theory typically predicts outcomes only approximately.
- Note that the information about experimental outcomes can be copied directly from Table 1.8
- The mean price and number of transactions predicted by competitive equilibrium theory can be found from the points in Figures 1.6 and 1.7 that you labeled CE, where your supply and demand curves crossed. (Note that since in competitive equilibrium all transactions take place at the same price, the mean price is equal to the competitive equilibrium price.)
- A thorough discussion of how to calculate the competitive predictions of the profits of sellers and the profits of buyers (consumers' surplus) starts on page 17.

Table 1.14: Predicted and Actual Outcomes–Sess. 2

	Experimental Outcome	Competitive Prediction
Mean Price		
Number of Transactions		
Total Profits of All Sellers		
Total Profits of All Buyers		
Total Profits of All Traders		
Market Efficiency		

- Market efficiency is defined on page 22. From Proposition 1.1 on page 22, it follows that the highest total amount of profit for a market like the one in this experiment is achieved in competitive equilibrium. This tells you that the competitive prediction of market efficiency is 100 percent. It also tells you that the efficiency of your experimental outcome can be obtained by expressing total profits of all traders in the market experiment as a percentage of the predicted total profits in competitive equilibrium.

Problem 1.7 Not only does competitive equilibrium theory predict prices, quantities, and profits, it also makes predictions about which traders will trade and which will not. Complete Tables 1.15 and 1.16 to compare the experimental outcomes with competitive predictions. **Hint:** You can determine the number of persons of each type who actually traded in each session by looking at the transaction tables 1.4 and 1.5 in your Lab Notes. A detailed discussion of how to find the number of persons of each type who trade in competitive equilibrium can be found on page 20.

Problem 1.8 Consider a market in which the distributions of Buyer Values and Seller Costs are as recorded in Table 1.6. Suppose that you are appointed as a *middleman* for the market. As the middleman, you can arrange the market by assigning trading partners–one supplier to one demander. Suppliers and demanders are not allowed to trade with anybody except the trading partner that you assign to them. You will receive a *com-*

Table 1.15: Who Trades?—Session 1

	Experimental Outcome	Competitive Prediction
Number of Low-Cost Sellers		
Number of High-Cost Sellers		
Number of High-Value Buyers		
Number of Low-Value Buyers		

Table 1.16: Who Trades?—Session 2

	Experimental Outcome	Competitive Prediction
Number of Low-Cost Sellers		
Number of High-Cost Sellers		
Number of High-Value Buyers		
Number of Low-Value Buyers		

mision of $1 from the buyer and $1 from the seller for every trade that takes place. If a pair of trading partners that you have assigned can both make a profit after paying your commission, they will trade. If they cannot both make a profit after paying your commission, they will not trade. You always choose to assign trading partners in such a way as to maximize your total income from commissions.

Part a) What is the largest number of mutually profitable trades that you can arrange, and how much income in commissions will you make?________

________________ **Hint:** Try matching high-cost suppliers with high-value demanders and letting them trade at higher prices than the prices at which low-cost suppliers trade with low-value demanders.

Part b) Suppose that for the market in the previous problem, you are again a middleman, but instead of getting a commission of a fixed amount of money per transaction, you get to keep all of the profits of buyers and sellers. How would you arrange transactions so as to maximize your own profits? **Hint:** Recall Proposition 1.1 on page 22.

Part c) Suppose that for the market in the previous problem, you are a middleman who is paid a certain fraction, say 10%, of the total profits of buyers and sellers. How would you arrange transactions so as to maximize your own profits?
