PRESCRIPTED

Driving Question	Total Time
How should pharmaceutical companies decide what to develop?	120 minutes

Real-World Takeaways

- Different medications have different market sizes, and customers are more price-sensitive with some drugs than others
- A pharmaceutical company's revenue depends on the size of the market and how much customers are willing to pay; these companies will often set the price to maximize revenue
- Developing a new drug can cost billions of dollars. This means that drug companies will often prioritize drugs that are highly profitable (e.g. allergy medications) over ones that are more socially valuable (e.g. an Ebola vaccine)
- Governments and foundations may have a role in incentivizing companies to develop low-profit, high-impact drugs

Math Objectives

- Given a linear graph, find and interpret the meaning of the y-intercept, x-intercept, slope, and equation
- Evaluate a linear function for various values of x
- Write a quadratic equation as the product of two linear expressions
- Use the graph of a parabola to find and interpret the meaning of the vertex
- Describe the effect a subsidy has on a parabola, namely: it shifts the y-intercept from $0 to the subsidy amount

Lesson at a Glance			
Preview		Students watch commercials for prescription drugs and consider what types of medications pharmaceutical companies tend to advertise	5 minutes
Act One	1	Interpret demand curves for two medications: flu shots and allergy pills	25 minutes
	2	Evaluate demand equations for both products at two prices: $10 and $50. For each price, determine the number of customers who will buy the product and also the total revenue	25 minutes
Act Two	3	Write quadratic functions to model total revenue for each drug and find the profit maximizing price	35 minutes
	4	Discuss the factors companies should consider when deciding which new drugs to develop	15 minutes
	5	Explain why an Ebola vaccine didn't exist for so long, and suggest ways to encourage drug companies to develop important drugs like it in the future	15 minutes

P   Students watch TV commercials for some leading medications, including Mucinex (congestion), Nasonex (nasal allergies), and Lipitor (cholesterol). Students list which other medications they've seen advertised on television, then discuss whether the drugs tend to be for serious medical conditions or for less serious ones.

Discussion Questions

1. *In addition to these, what are some other medications you've seen advertised on TV? How many can you list?*
2. *In general, do the drugs that are advertised on TV tend to be for serious medical conditions or less serious ones?*
3. *Why do you think pharmaceutical companies spend so much money on ads for medications like allergy pills?*
4. *What are the most serious diseases and viruses you can think of? Have you seen commercials for drugs for them?*

Key Takeaway(s)

- Many (most?) of the pharmaceutical commercials are for medical conditions that aren't life-threatening.
- Pharmaceutical companies want to make money, and medications like Mucinex and Nasonex are very popular.

1. The lines below model the possible relationship between the price and **demand** for two medications: an annual flu shot and a year's worth of allergy pills. Describe the demand for each medication as thoroughly as you can.

Customers (millions)

$0 $20 $40 $60 $80 $100 $120 $140 $160 $180 $200 $220
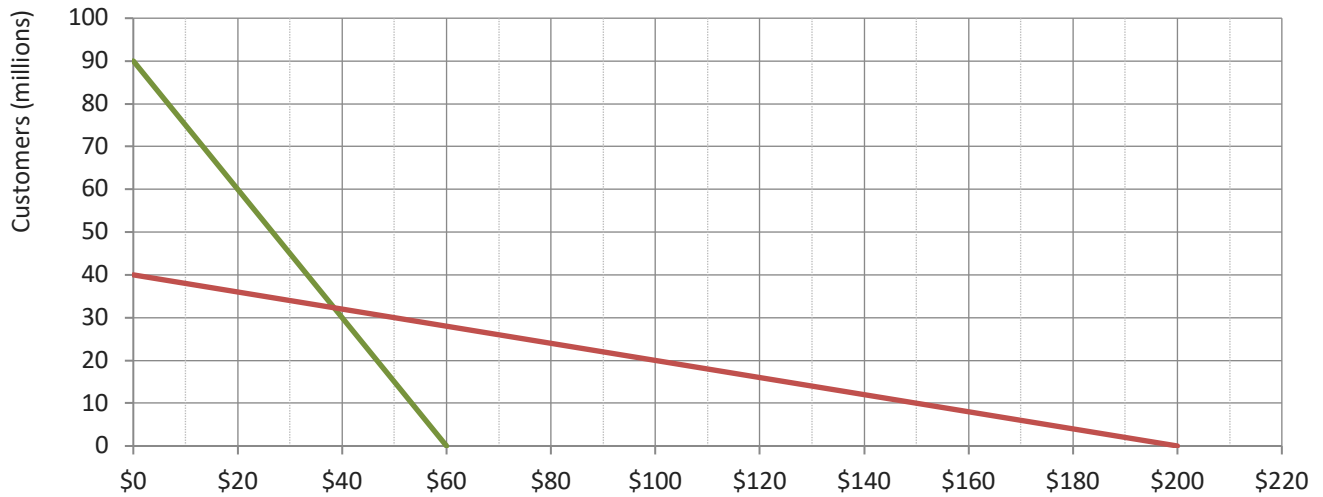
Flu Shot

- When shot is free, 90 million people will get it
- Once price hits $60, nobody will get shot anymore
- Raising price by $60 results in 90 million fewer customers. This suggests that for every $1 the price goes up, the no. of customers goes down by 1.5 million

Demand = 90,000,000 – 1,500,000p
(where p = price in dollars)

Allergy Pills

- When pills are free, 40 million people will take them
- Once price hits $200, nobody will get pills anymore
- Raising price by $200 results in 40 million fewer customers. This suggests that for every $1 the price goes up, the no. of customers goes down by 200,000

Demand = 40,000,000 – 200,000p
(where p = price in dollars)

Teaching Tip

Consider having students work in small groups, then share their findings as the class. As you write their observations on the board, there's a good chance the class will come up with every observation above (including the equation).

Key Insights & Guiding Questions

At a price of $0, more people will get the flu shot than the allergy pills. This means the market is larger for the shot.
What's the maximum number of people willing to take each drug? Why might the market for the flu shot be bigger?

For each medication, there's a price at which nobody is willing to buy it anymore.
What's the most anyone would be willing to spend on each medication? Where on the graph do you see this?

Customers' sensitivity to price can be found by calculating the slope: the change in customers for each additional $1. This price sensitivity is likely related to multiple factors, including the likelihood of getting sick and the duration.
For which drug do people respond more to a price change? When the price increases by $1, how does demand change? Why do you think people might be more sensitive to price changes with the flu shot than with allergy pills?

The demand for each drug can be modeled by a linear function, which includes the market size and change per dollar.
For each drug, how would you predict the demand for a given price? Can you write an equation to model the demand?

2 At prices of $10 and $50, determine how many people would buy each medication. How much **revenue** would the company earn in each scenario, and do you think it's a good idea to charge as much as possible? Explain.

	Price = $10		Price = $50	
	Customers	Revenue	Customers	Revenue
Flu Shot	90,000,000 − 1,500,000p 90,000,000 − 1,500,000(10) **75 million customers**	75 million × $10 **$750 million**	90,000,000 − 1,500,000p 90,000,000 − 1,500,000(50) 15 million customers	15 million × $50 **$750 million**
Allergy Pills	40,000,000 − 200,000p 40,000,000 − 200,000(10) **38 million customers**	38 million × $10 **$380 million**	40,000,000 − 200,000p 40,000,000 − 200,000(50) 30 million customers	30 million × $50 **$1.5 billion**

I'm not sure if it's always a good idea for companies to raise the price of drugs. In the case of the allergy pills, increasing the price from $10 to $50 causes revenue to increase from $380 million to $1.5 billion. Even though the company loses 8 million customers — or roughly one-fifth — it makes around five times as much revenue. Here, raising the price is clearly good for business. This isn't the case with the flu shot, though. When the price of the shot increases from $10 to $50, the revenue stays the same. Even though the new price of the medication is five times higher, one-fifth as many people bought it (15 million vs. 75 million); the decline in demand perfectly cancels out the increase in the price.

That said, I don't think revenue should be the only factor a pharmaceutical company takes into consideration when setting the price. Even though the company makes the same amount on the flu shot at $10 and $50, I still think $10 is better. The flu can be dangerous. Since more people buy the shot at $10 — and since people who get the shot are less likely to infect others — I think the lower price point is better for society as a whole.


Key Insights & Guiding Questions

We can use a linear equation to find the demand at $p. For each drug, increasing the price results in fewer customers.
How will you determine how many people will purchase each drug at $10 and $50?

The revenue can be found by multiplying the price of a drug by the number of people who buy it.
At $10, how will you determine how much the pharmaceutical company will earn from each drug? At $50?

In some cases, increasing the price of a drug will result in more revenue. But this isn't always true, since increasing the price also causes fewer people to buy the medication.
Does increasing the price necessarily result in more revenue? Why might this be?

Companies will often choose the price that maximizes revenue. However, they may consider other factors, as well.
If you were the CEO of the pharmaceutical company, how would you decide how much to charge for each drug? If you were a doctor or state governor, how much would you want the company to charge?

Deeper Understanding Questions

- *If the company raised the prices even more, what do you expect would happen to the flu and allergy revenues?*
  Students may assume that the flu revenue will stay constant at $750 million and that allergy revenue will continue to increase. However, we know from the previous question that nobody is willing to buy the flu shot at $60 or the allergy pills at $200, so the revenue would necessarily be $0 at these prices.

3 For each medication write and graph an equation for revenue. If the company wanted to maximize its revenue, what price should it charge for each medication and how much would it earn?
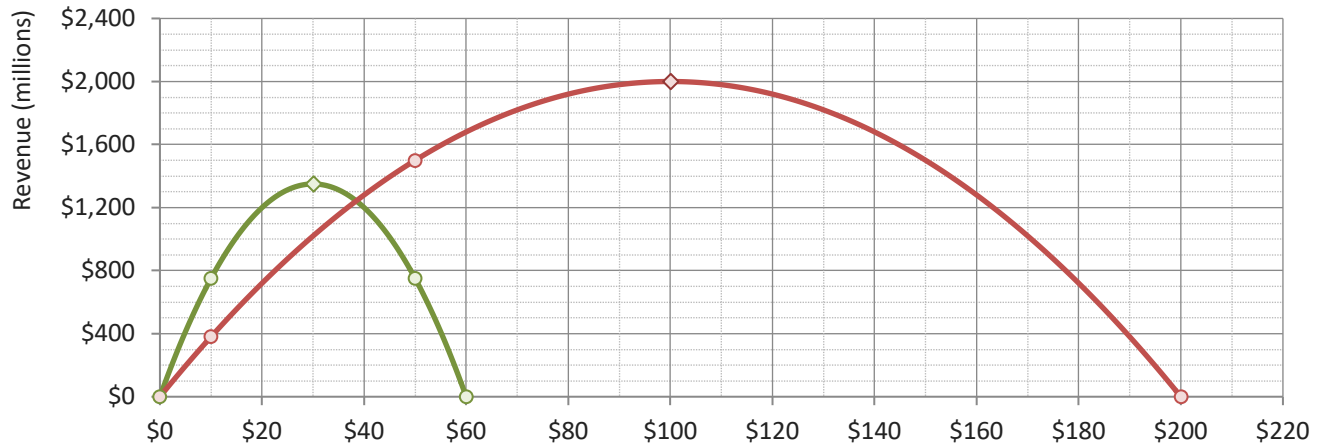
	Revenue Equation	Optimal Price	Revenue
Flu Shot	Revenue = Demand × Price $R_F = (90{,}000{,}000 - 1{,}500{,}000p) \times p$ $R_F = 90{,}000{,}000p - 1{,}500{,}000p^2$	vertex is halfway btw. price = $0 and $60 optimal price: $30	Revenue at $30: $R_F(30) = \$1.35$ billion
Allergy Pills	Revenue = Demand × Price $R_A = (40{,}000{,}000 - 200{,}000p) \times p$ $R_A = 40{,}000{,}000p - 200{,}000p^2$	vertex is halfway btw. price = $0 and $200 optimal price: $100	Revenue at $100: $R_A(100) = \$2$ billion

Key Insights & Guiding Questions

Before we have the revenue functions, we can plot the points we already know. These will help outline the graphs.
Are there any revenues we already know and can plot? For each medication, how many points can you come up with?

To find a specific revenue, we multiply the specific number of customers by the specific price. To create a general model for revenue, we multiply the demand function by the price, *p*.
Earlier, how did we find the revenues at $10 and $50? How can we come up with a general revenue mode for price, p?

As the price increases from $0, the revenue also increases...until it reaches a maximum and begins to come down. For each drug, the revenue-maximizing price is exactly halfway between $0 and the "no more customers" price.
For each medication, what price that corresponds to the maximum revenue? What do you notice about these prices?

Though the market is smaller for allergy pills than for the flu shot, the company can make much more revenue from the pills. Since allergy customers are less sensitive to price changes, the company can charge more and make more.
Which drug do you think the pharmaceutical company prefers, and why can it earn so much more from allergy pills?

Deeper Understanding Questions

- *How does the slope of the demand line affect the shape of the revenue parabola?*
  The steeper the demand line – i.e. the lower the price where demand = 0 – the narrower the revenue parabola.

4 On average, pharmaceutical companies spend $1.4 billion (and up to $11 billion) to develop a new medication. When companies decide which drugs to develop, what factors do you think they should consider and why?

Responses may vary. Sample response:

Pharmaceutical companies exist to develop medications, but they're also in the business of making money. When deciding which new medications to develop, I think companies should take into account a number of factors, including:

- *What is the size of the market, i.e. how many people may be willing to buy the drug?*
- *How sensitive are would-be customers to price changes?*
- *How much can the company invest, and how long will it take to recoup the investment?*
- *Do there exist similar products already? If not, how long will the company be able to sell its drug until there are competitors?*
- *If the company doesn't create the medication, will anyone else? If not, how will this affect patients/society?*

All of these factors help to determine how much revenue the company will earn. The larger the market and the less sensitive customers are to price changes, and the more unique the drug is, the more revenue the pharmaceutical company can make. However, I don't think revenue is the only factor companies should consider when deciding which new medications to develop. I also think they should consider how important the medication is. For instance, a company may be able to make a lot of money from a new allergy medication, but that seems a lot less important than a flu shot. Even if a company doesn't expect to make much on a flu vaccine, it would be very bad for society if there didn't exist once.

Teaching Tip

Like before, consider having students work in small groups to come up with as many factors as possible. To help put them in the company's frame of mind, you might say, "Imagine you're the CEO of a major pharmaceutical company. What would *you* take into consideration when deciding what to invest in?" When students come back together as a class to share their thoughts, they'll likely come up with many more considerations than those above.

Key Insights & Guiding Questions

There are lots of factors that influence a pharmaceutical company's decision whether or not to develop a new drug. Many of these may be related to how much money the company expects to make (size of market, ability of customers to pay, competition), but some companies might also take into consideration the importance of the drug to society.
If you were the CEO of a pharmaceutical company, what would you take into account when deciding what to develop?

5 In 2014, an outbreak of the Ebola virus killed more than 10,000 people in Africa and one in the United States, in part because there didn't yet exist a vaccine. Listen to the *Marketplace* radio clip. In situations like this, how might companies be incentivized to develop much-needed drugs, even if they're not as profitable as others?

Responses may vary. Sample response:

According to the radio clip, one of the main reasons there wasn't an Ebola vaccine in 2014 was because there weren't that many potential customers around the world…and the ones that did exist were from parts of the world that are relatively poor. Since the pharmaceutical companies didn't expect to earn much from the vaccine, they had little incentive to invest the billions of dollars it would have likely taken to create it.

In situations like this, the government and philanthropies like the Gates Foundation could provide money to pharmaceutical companies to help pay for research and development. The government could also tax less "socially important" drugs like allergy pills, then create a pool of money that pharmaceutical companies could use to create drugs like an Ebola vaccine.

Teaching Tip

Students may conclude that because pharmaceutical companies decided not to invest in an Ebola vaccine, they're to blame for the Ebola deaths. Whatever we may think of the profit motive in healthcare, it's important that students understand the situation from the companies' perspective: They're private businesses, not charities, and have a responsibility to their shareholders to provide a return on any investment they make.

It's also important for students to realize they have a role to play in influencing which medications get developed. The federal government provides billions of dollars in subsidies and grants to pharmaceutical companies to support research and development. While students may be tempted to focus on individual companies, it's helpful to step back and remember that these companies are pieces in a much larger puzzle. In other words: *Don't hate the player. Fix the game.*

Key Insights & Guiding Questions

Just because a drug is important does not mean a pharmaceutical company will necessarily develop it. If the market is too small or patients can't afford the drug, the company might conclude that it won't be able to make its money back.
According to the radio clip, even though lots of people needed the Ebola vaccine, why didn't companies develop it?

When private companies are reluctant to invest in much-needed medications, governments and foundations can provide grants, subsidies, and tax breaks to help incentivize research and development. Alternatively, the government can also tax lower-priority drugs, and use those funds to support higher-priority ones.
What role could the government play in helping drug companies develop more socially-impactful medications?

Providing a subsidy effectively raises the company's revenue for every price. Graphically, this means shifting the parabola up by the subsidy amount, resulting in a positive y-intercept.
How will a government subsidy affect the company's revenue graph, and why?