1. Show, using indifference curves and budget constraints, that
   a. all goods can be normal, but
   b. not all goods can be inferior.

   1. a. As shown in the graph, it is possible with an increase in income for the consumer to choose more of both good \( X \) and good \( Y \).

   b. As shown in the graph, if the consumer chooses less of good \( X \) in response to an increase in income, then this implies that more of good \( Y \) must be chosen. So, the existence of an inferior good means that the other must be normal.

2. Joelle consumes food and clothing. For incomes near her current income, her income expansion path is negatively sloped. Assume that food is measured along the horizontal axis and clothing is measured along the vertical axis. Indicate whether each of the following statements is true or false, and provide a brief explanation why. (You may want to use a graph in your explanation.)
   a. At current income levels, food must be an inferior good.
   b. At current income levels, clothing must be an inferior good.
   c. At current income levels, food and clothing must be inferior goods.
   d. At current income levels, either food or clothing must be an inferior good.

   2. a. False. A negatively sloped income expansion path implies choosing more of the good on the horizontal axis as income increases.
   b. True. A negatively sloped income expansion path implies choosing less of the \( Y \)-axis good as income increases. If clothing is measured along the vertical axis, then it would be an inferior good.
   c. False. Consuming less of one good when income increases implies consuming more of the other. Therefore, at least one good must be normal.
   d. True. If the income expansion path slopes downward, less of the \( Y \)-axis good is consumed when income increases.
3. Suppose that, holding prices constant, Alice has preferences over the number of books she purchases, illustrated in the chart at the right.
   a. Draw a smooth approximation of Alice’s Engel curve for books, indicating the ranges over which books are inferior goods and over which they are normal goods.
   b. A luxury good is a good that has an income elasticity greater than 1. Give the ranges in which books are luxury goods for Alice.

<table>
<thead>
<tr>
<th>Income (thousands of dollars)</th>
<th>Optimal number of books purchased</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>6</td>
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<tr>
<td>15</td>
<td>20</td>
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<td>20</td>
<td>25</td>
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<td>26</td>
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<td>30</td>
<td>10</td>
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<td>35</td>
<td>9</td>
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<tr>
<td>40</td>
<td>8</td>
</tr>
<tr>
<td>45</td>
<td>7</td>
</tr>
<tr>
<td>50</td>
<td>6</td>
</tr>
</tbody>
</table>

3. a. For the income ranging from $25,000 to $50,000, books are an inferior good. For the income ranging from $5,000 to $25,000, books are a normal good.
   b. Income elasticity exceeds 1 when income changes from $10,000 to $15,000.

4. Kim’s utility function is given by $U = XY$. For this utility function, $MU_x = Y$ and $MU_y = X$.
   a. If good X costs $6 and good Y costs $3, what share of Kim’s utility-maximizing bundle is made up of good X? Of good Y?
   b. If the price of good Y rises to $4, what happens to the shares of X and Y in Kim’s utility-maximizing bundle?

4. a. At the utility-maximizing point:

$$\frac{MU_x}{MU_y} = \frac{P_x}{P_y}$$

$$\frac{Y}{X} = \frac{6}{3} = 2$$

Kim will choose twice as much of good Y as good X. Two-thirds of her optimal bundle will consist of good Y. One-third will consist of good X.
b. At the utility-maximizing point:
\[
\frac{MU_x}{MU_y} = \frac{P_x}{P_y} \\
\frac{Y}{X} = \frac{6}{4} = 1.5
\]
Kim will choose 1.5 as much of good Y as good X. Her optimal bundle will consist of \( \frac{3}{2} \) of good X and \( \frac{1}{2} \) of good Y.

5. Consider the graph at the right, which illustrates Tyler’s preferences for DVD rentals and in-theater movie tickets. Suppose that DVD rentals always cost $1, and that Tyler’s income is $100 per week.

a. If the price of a movie ticket is $10, draw Tyler’s budget line. Be very careful to draw to scale. How many movies does he see in the theater?
b. Begin to draw Tyler’s demand curve for movies by creating a new set of axes, with price on the vertical axis and the quantity of movies on the horizontal axis. Plot a point that shows how many movies Tyler demands when the price of movies is $10.
c. The movie theater changes the price of tickets to $12.50. Modify the graph provided to reflect this price change. Then, add a point to your demand curve graph to show how many movies Tyler demands at a price of $12.50.
d. Tyler’s mother gives him a discount card that allows him to purchase movie tickets for $7.50 each. Modify the graph provided to reflect this price change. Then, add a point to your demand curve graph to show how many movies Tyler demands at a price of $7.50.
e. Connect the dots in the graph you created to complete Tyler’s demand curve for movie tickets.

5. a. When the price of a movie ticket is $10, Tyler sees 6 movies in the theater.

b–e. *6. Carmen’s preferences are such that she is always indifferent between watching 2 movies or seeing 1 basketball game.

a. What must Carmen’s indifference curves look like?
b. Suppose that Carmen has an income of $90. If a movie costs $10 and a basketball game costs $18, what will Carmen’s optimal consumption bundle be?*
6. a. Carmen’s indifference curves are straight, parallel lines. For her, watching a movie and seeing a basketball game are perfect substitutes. Carmen’s utility function can be described as \( U = X + 2Y \), where \( X \) denotes the basketball games and \( Y \) denotes the movies.

b. The optimal consumption bundle is to buy 5 basketball games in order to reach the highest feasible indifference curve \( U_4 \) given the budget constraint.

7. Armen lives in Washington State, where grapes are grown. Armen’s twin Allen lives in New York, where grapes must be trucked in from Washington at a fixed cost of $0.20 per pound of grapes. Armen and Allen have identical tastes, but Armen tends to purchase lower-quality grapes and Allen tends to purchase higher-quality grapes. Use indifference curve analysis to explain this oddity.

7. Lower-quality grapes and higher-quality grapes are perfect substitutes. Suppose the budget line for Armen is \( BC_1 \) and for Allen is \( BC_2 \). Both have identical indifference curves. Yet, the different budget constraints (Allen’s budget constraint is flatter due to the transportation costs incurred) may explain the oddity as shown on the graph. This example is an application of the Alchian–Allen effect, which states that when the prices of two substitute goods, such as high and low grades of a product, are both increased by a fixed per-unit amount (such as transportation costs), consumption will shift toward the higher-grade product. The intuition is that since transportation costs do not depend on the quality of grapes, adding that fixed transport cost changes the relative price of grapes. If high-quality grapes cost 20 cents in Washington and lower-quality grapes 10 cents, then \( P_h / P_l = 2 \). If shipping costs 10 cents, then in New York, high-quality grapes cost 30 cents and lower-quality grapes cost 20 cents, so \( P_h / P_l = 1.5 \). Thus, customers in New York will, because of this change in relative prices and corresponding substitution effect, buy more high-quality grapes and fewer lower-quality grapes.

8. Mitch cares only about how much he can write. Because a pen will write 7 miles of text and a pencil will write 35 miles of text, Mitch considers them perfect 5-to-1 substitutes. If the price of pens is given by \( P_{\text{pen}} \) and the price of pencils is given by \( P_{\text{pencil}} \), and if Mitch’s income is given by \( Y \), use indifference curve analysis to derive the demand curve for pencils.

8. The budget line for Mitch is

\[
I = (P_{\text{pen}} \times Q_{\text{pen}}) + (P_{\text{pencil}} \times Q_{\text{pencil}})
\]

The utility is

\[
U = Q_{\text{pen}} + (5 \times Q_{\text{pencil}})
\]
Mitch will only buy pencils if the absolute value of the slope of the budget line is less in magnitude than 5. The slope denotes the price ratio of pencils to pens. As long as pencils cost no more than 5 times the price of pens, Mitch will buy only pencils.

![Graph showing the price of pencils and the quantity of pencils.]

<table>
<thead>
<tr>
<th>Price ($/pencil)</th>
<th>Quantity of pencils</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

9. Consider the following three graphs, which illustrate the preferences of three consumers (Bob, Carol, and Ted) regarding two goods, apples and peaches. Each consumer has an income of $30, and each consumer pays $2 for apples and $3 for peaches.

(a) Bob

(b) Carol

(c) Ted

a. Suppose that the price of peaches falls to $2. Draw a new budget line for each consumer and find the new optimal bundle of apples and peaches each would buy. How does the new quantity of peaches compare to the original quantity? Indicate the change in the first column of the table below (an increase of 1 unit might be denoted as +1).

b. For each consumer, determine the substitution effect of the price change by drawing a hypothetical budget line with the same slope as your new budget line, but just tangent to the consumer’s original indifference curve. How much of a change in peach consumption does the substitution effect account for? Indicate that change in the first column of the table on the right.

c. Now add the income effect. Compare each consumer’s peach consumption in (b) to his or her final peach consumption in (a). Indicate the difference in column 3 of the table on the right. Double-check your work to ensure that the last two columns add up to the number in the first column.

d. Do Bob, Carol, and Ted consider peaches normal, inferior, or income-inelastic?

<table>
<thead>
<tr>
<th>Total Effect of Price Change</th>
<th>Substitution Effect of Price Change</th>
<th>Income Effect of Price Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bob</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ted</td>
<td></td>
<td></td>
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</tbody>
</table>
9. a. When the price of peaches falls to $2, Bob consumes 9 peaches and 6 apples.

(b) Bob

When the price of peaches falls to $2, Carol consumes 6 peaches and 9 apples.

(b) Carol

When the price of peaches falls to $2, Ted consumes 6 peaches and 9 apples.

(c) Ted

b. For Bob, the substitution effect is $6 - 5 = 1$. For Carol, the substitution effect is $7 - 5 = 2$. For Ted, the substitution effect is $6 - 5 = 1$. 
c. Based on diagrams in (b), the income effect for Bob is $9 - 6 = 3$, for Carol $6 - 7 = -1$, and for Ted $6 - 6 = 0$.

<table>
<thead>
<tr>
<th></th>
<th>Total Effect of Price Change</th>
<th>Substitution Effect of Price Change</th>
<th>Income Effect of Price Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bob</td>
<td>+4</td>
<td>+1</td>
<td>+3</td>
</tr>
<tr>
<td>Carol</td>
<td>+1</td>
<td>+2</td>
<td>-1</td>
</tr>
<tr>
<td>Ted</td>
<td>+1</td>
<td>+1</td>
<td>0</td>
</tr>
</tbody>
</table>

d. Bob considers peaches a normal good. Carol considers peaches an inferior good, and Ted considers them to be an income-inelastic good.

10. Suppose that Sonya faces an increase in the price of pasta, as depicted below, moving her from an optimum bundle of rice and pasta at $A$ to an optimal bundle at $B$.

a. Trace a copy of this diagram. Graphically depict the substitution and income effect.

b. Which effect is strongest? How can you tell?

b. The two effects seem to be equivalent in magnitude for pasta with a decrease of 2 cups of pasta for each effect. As far as rice, the substitution effect dominates the income effect; in particular, the substitution effect leads to a 2-cup increase in rice consumption, whereas the income effect causes rice consumption to fall by 1 cup.

11. Brady, who has ordinary-shaped indifference curves, buys 16 ounces of salt each year. Even when the price of salt doubles, Brady continues to purchase exactly 16 ounces.

a. Use indifference curves and budget constraints to depict Brady’s behavior graphically. Put salt on the horizontal axis and a composite good on the vertical axis.
b. True or False (and explain): Salt is neither inferior nor normal to Brady.

c. What is Brady’s price elasticity of demand for salt?

d. What is Brady’s income elasticity of demand for salt?

e. What can we say about the substitution and income effects of a change in the price of salt?

11. a. False. The substitution effect is always negative. To remain at the same optimal bundle of 16 ounces, the income effect has to be positive. Thus, salt has to be an inferior good.

c. The price elasticity of demand for salt is zero, as the change in price has no impact on the quantity demanded. The demand curve is perfectly inelastic.

d. Salt is an inferior good; therefore, the income elasticity of demand for salt is negative.

e. The income and substitution effects have the same magnitude but opposite signs. Hence, the total effect is zero.

12. Explain intuitively why any normal good cannot possibly be a Giffen good. (You may wish to illustrate your answer with a budget line/indifference curve graph.)

12. A Giffen good arises when an income effect moves opposite to the substitution effect and is strong enough to outweigh it. For normal goods, the income effect and substitution effect move in the same direction.

13. During the Irish potato famine of the mid-1800s, potato blight caused a massive reduction in the supply of potatoes. The price of potatoes soared to historically unprecedented levels. Use this evidence to explain why (or why not!) potatoes were a Giffen good in 1800s Ireland.

13. This situation had the necessary ingredients to give rise to a Giffen good: a dramatic price increase for an inferior good that was a significant part of the typical consumer’s budget. Given that households would purchase a significant number of potatoes under any circumstances, it is conceivable that the higher potato price meant that no income was left over for more expensive dietary alternatives, such as cheese, meat, fruit, and other vegetables. Even at the elevated price, potatoes were a relatively inexpensive source of nutrition.

*14. Consider the diagram at the right, which illustrates Gaston’s preferences for red beans and rice. Gaston has an income of $20. Rice costs $2 per serving.

a. Derive Gaston’s demand for red beans. Use prices of $2 and $4 in your analysis. Graph your results, and connect the points you plotted to yield Gaston’s demand for red beans.

b. Suppose that the price of rice increases to $3. Again, derive Gaston’s demand for red beans using the same prices you used in part (a).

c. Does Gaston’s demand for red beans increase or decrease as a result of the increase in the price of rice?

d. Does your answer to (c) indicate that red beans and rice are substitutes or complements?
14. a. Gaston’s demand for red beans

<table>
<thead>
<tr>
<th>Price ($/serving)</th>
<th>Quantity of red beans</th>
</tr>
</thead>
<tbody>
<tr>
<td>$4</td>
<td>0</td>
</tr>
<tr>
<td>$2</td>
<td>3</td>
</tr>
<tr>
<td>$1</td>
<td>6</td>
</tr>
</tbody>
</table>

b.

<table>
<thead>
<tr>
<th>Price ($/serving)</th>
<th>Quantity of red beans</th>
</tr>
</thead>
<tbody>
<tr>
<td>$4</td>
<td>0</td>
</tr>
<tr>
<td>$2</td>
<td>2</td>
</tr>
<tr>
<td>$1</td>
<td>5</td>
</tr>
</tbody>
</table>

c. When the price of rice increases to $3, the demand for red beans decreases.
d. The changes in prices and quantities are consistent with the definition of complements.

15. Consider Liu’s indifference curve indicated in the graph at the right:
a. True or False (and explain): Peanuts and Crackerjack are clearly complements.
b. True or False (and explain): Peanuts and Crackerjack are clearly both normal goods.
15. a. True. After a certain point, if Liu has more peanuts without also having more Crackerjacks, his utility does not increase. Liu would like to consume both goods together.
   
b. False. In order to determine whether these are normal goods, we need to know what happens to the shape of Liu’s indifference curves at higher levels of utility.

16. True or False: If pizza and calzones are substitutes, then the substitution effect of a price change will be in a different direction than if pizza and calzones are complements. Explain, using a diagram.

Assume a decrease in the price of calzones.

**Case 1:** Let pizza and calzones be perfect substitutes. The initial optimal equilibrium given the budget constraint $BC_1$ is $A$. The initial budget constraint rotates from $BC_1$ to $BC_2$ reaching higher utility curve $U_2$, where the optimal consumption occurs at point $B$. The substitution effect of both goods is shown.

**Case 2:** Now, suppose pizza and calzones are perfect complements. As shown, there is no substitution effect in this case. The entire effect can be attributed to the income effect.

**Case 3:** Let pizza and calzones be substitutes or complements, but not perfect substitutes or perfect complements. With ordinary, convex indifference curves, the substitution effect of a price decrease is positive, regardless of whether the goods are substitutes or complements.

17. You may have noticed that the market demand curve is always flatter than any individual demand curve. Is market price elasticity of demand also always lower than individual price elasticity of demand? Why or why not?
17. The market demand curve is as flat as or flatter because the market quantity demanded is found by taking the horizontal sum of all individual demand curves. Nevertheless, it does not necessarily imply that the elasticity of the market demand curve is higher than that of individual demand curves (though this is often the case). This is because the elasticity does not just depend on the slope, but also on the level of quantity demanded. The percentage change in prices (the denominator in the elasticity equation) will be the same for both individuals and the market. While the change in quantity will be smaller for individuals, the level of quantity demanded will be lower, too. If the level is small enough, the percentage change in quantity demanded for the individual can be large enough to make individual demand as or more elastic than market demand.

18. Three students have different demands for doughnuts. André’s demand is given by \( Q = 5 - P \); Carlene’s demand is given by \( Q = 6 - 2P \); Cooper’s demand is given by \( Q = 4 - 0.5P \).
   a. Derive the market demand curve for doughnuts algebraically.
   b. Graph the market demand curve for doughnuts. Pay special attention to any kinks in the market demand!

18. a. Adding all 3 individual demand curves together, we get
   \[
   Q = (5 - P) + (6 - 2P) + (4 - 0.5P) = 15 - 3.5P
   \]
   However, André enters the market at prices below 5; Carlene at prices below 3; and Cooper at prices below 8.

19. Suppose that Grover consumes two goods, cookies and milk. Grover’s income expansion path is shown in the diagram below. Use the information in the diagram to explain whether each of the statements below is true or false. Provide an explanation for each answer.
   a. At low levels of income, both cookies and milk are normal goods for Grover.
   b. As Grover’s income grows, eventually cookies become an inferior good.
   c. Draw, intuitively, the Engel curve for Grover’s consumption of milk at various incomes.
   d. Draw, intuitively, the Engel curve for Grover’s consumption of cookies at various incomes.
19. a. True. At low levels of income, the consumption of both goods increases with income.
   b. False. Cookies are normal goods across all income levels, whereas milk becomes an inferior good at higher income levels.
   c. 

20. At a price of $3 each, Yoshi (a typical New Yorker) drinks 200 44-ounce sodas each year. Concerned about burgeoning obesity, the mayor of New York proposes a $0.50 tax on such drinks. He then proposes compensating consumers for the price increase by mailing each resident a check for $100.
   a. What will happen to Yoshi’s consumption of soda? Show, using an indifference curve diagram with soda on the horizontal axis and a composite good (price = $1) on the vertical axis.
   b. Will Yoshi be better off, worse off, or indifferent to the change? Explain, using your diagram.
   c. In terms of revenue, will the government be better off, worse off, or indifferent to the proposal? Explain.

*20. The implication of the optimal bundle is that Yoshi’s income is at least $600. In addition, assuming well-behaved indifference curves implies that Yoshi’s income is greater than $600. As a result of the tax and the rebate, the intercepts in the two axes change. The intercept of the horizontal axis, after the tax and the rebate, lies to the left of 1/3. The intercept of the vertical axis, after the tax and the rebate, lies above 1/3. The graph is indicated on the right. As shown, Yoshi’s consumption of soda will decrease and his consumption of the composite good will increase.
   b. Yoshi will be better off as his optimal bundle lies on a higher indifference curve than before.
   c. Since Yoshi cuts back on soda, the government raises less than $100 in revenue. At the same time, the government spends $100 subsidizing Yoshi. The government is therefore worse off.