Economic Analysis for Managerial
Decisions-Firms and Markets
Fall 1998

PROBLEM SET

Supply and Demand Analysis

1. Consider the following demand and supply curves:
   \[ Q^d = 5800 - 6P \quad \text{and} \quad Q^s = 4P + 120 \]
   a. Graph the supply and demand curves.
   b. What are the equilibrium quantity and equilibrium price?
   c. What happens in this market if a price floor of $600 is placed on this good?
   d. If a price ceiling of $500 instead of a price floor were placed on this good, how
      would the market be affected?

Relationship between Sales Revenue and Demand Characteristics

2. The following table presents hypothetical data for the market demand for a good.
   Complete the table.

<table>
<thead>
<tr>
<th>Price</th>
<th>Quantity Demanded</th>
<th>Average Revenue</th>
<th>Total Revenue</th>
<th>Marginal Revenue</th>
<th>Arc Price Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>$50</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$40</td>
<td>2</td>
<td></td>
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<td></td>
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<tr>
<td>$30</td>
<td>3</td>
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<tr>
<td>$20</td>
<td>4</td>
<td></td>
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<td></td>
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<tr>
<td>$13</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$8</td>
<td>6</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

3. Given: The demand equation is \( P = 81 - 9Q \).
   a. What is the equation for \( MR \)?
   b. At what output is \( MR = 0 \)?
   c. At what output is \( TR \) maximum?
   d. Determine the price elasticity of demand at the output where \( TR \) is maximum.
4. Suppose that the demand equation for a good is \( Q = 20 - 3P \). What is the price elasticity of demand at a price of $1? At a price of $4?

5. If the demand equation for an item is \( Q = 16 + 9P - 2P^2 \), calculate the price elasticity of demand at a price $4; at a price of $3.

6. If the demand equation for an item is \( P = 1000 + 3Q - 4Q^2 \),
   a. determine price elasticity of demand at \( Q = 10 \) units.
   b. determine the equations for \( TR \) and \( MR \).

7. Given that the relationship between product A and product B is \( Q_A = 80P_B + 0.5P_B^2 \) where \( Q_A \) = units of product A demanded by consumers each day and \( P_B \) = selling price of product B.
   a. Determine the cross-elasticity coefficient for the two products when the price of product B = $10.
   b. Are products A and B complements, substitutes, or independent, and how "strong" is the relationship?

8. Given the price levels now prevailing for steel products, would you expect that the price elasticity of demand for the output of USX Corporation is higher or lower than the price elasticity of demand for the output of the steel industry as a whole? Why?

9. A minor league baseball team is in the process of determining its ticket pricing policy. Past data suggest the following ticket sales elasticities: ticket price, -0.6; refreshment price, -0.2; and local population, 0.7.
   a. If the local population increases from 60,000 to 61,500, what will be the impact on ticket sales? What if refreshment prices rise 40 percent on average?
   b. Currently a typical fan pays an average ticket price of $5 and consumes $4 worth of refreshments at the game. Management is thinking of raising the average ticket price to $5.50. Compute the percentage changes in (1) tickets sold, (2) ticket revenue, and (3) total revenue from admissions and refreshment sales. (If it aids your thinking, assume current sales are 5,000 tickets per game. However, you can answer the questions without knowing the current level of sales.)

10. "The demand for automobiles must be less elastic than the demand for stereos because a $50 reduction in price of cars does not affect the number sold nearly as much as a $50 reduction in the price of stereos." Is this statement correct? Explain.
Production Theory, Technology and Optimal Choice of Inputs

11. Given: The production function \( Q = 12X \), where \( Q \) = units of output per period of time and \( X \) = units of variable input.

   a. Determine the equations for MP and AP.

   b. Assuming 5 units of fixed input are presently being employed in the production process represented by the production function above, determine \( AP \) when 10 units of variable input are combined with the 5 units of fixed input.

   c. Graphically illustrate the production function and the corresponding MP and AP functions.

   d. How would you describe the important properties of this production function?

12. Production managers for the Cosmic Paper Corporation estimate that their production process is currently characterized by the following short-run production function: \( Q = 72X + 15X^2 - X^3 \), where \( Q \) = tons of paper products per production period.

   a. Determine the equations for MP and AP.

   b. What is MP when 7 units of variable input are employed?

   c. By how much does output rise when the usage of variable input is increased from 7 to 8 units per production period?

   d. At what rate of usage of variable input is the point of diminishing marginal productivity encountered?

   e. What is the maximum output capability per production period? What rate of usage of variable input is required to reach the maximum output level?

   f. Graphically illustrate this production function and the corresponding MP and AP functions. Indicate on your graph the output ranges where output is increasing at an increasing rate and where output is increasing at a decreasing rate. Also indicate the output where the point of diminishing average productivity of the variable input is encountered.

13. Determine the optimum resource combination of labor and capital when

   a. \( Q = 140L + 160C - 5L^2 - 2C^2 \)

      \( P_L = $12 \)

      \( P_C = $24 \)

      \( T_C = $732 \)
b. \( Q = 6LC \)
\[
\begin{align*}
P_L &= $5 \\
P_C &= $10 \\
T_C &= $180 
\end{align*}
\]

14. Consider the production function \( Q' = 10L^{1.5}K^{2.5} \) for \( L \) and \( K \) in the range 0 to 10 units. Does this production function exhibit diminishing marginal productivity of each input? Does it exhibit decreasing returns to scale? Explain.

15. A 200-pound steer can be sustained on a diet calling for various proportions of grass and grain. These combinations are:

<table>
<thead>
<tr>
<th>Pounds of Grass</th>
<th>Pounds of Grain</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>80</td>
</tr>
<tr>
<td>56</td>
<td>70</td>
</tr>
<tr>
<td>60</td>
<td>65</td>
</tr>
<tr>
<td>68</td>
<td>60</td>
</tr>
<tr>
<td>80</td>
<td>54</td>
</tr>
<tr>
<td>88</td>
<td>52</td>
</tr>
</tbody>
</table>

a. Plot the isoquant corresponding to the inputs necessary to sustain a 200-pound steer. Comment on its shape.

b. The rancher's cost of grass is $.10 per pound; the cost of grain is $.07 per pound. He prefers a feed mix of 68 pounds of grass and 60 pounds of grain. Is this a least-cost mix? If not, what is? Explain?

c. The rancher believes there are constant returns to scale in fattening cattle. At current feed prices, what input quantities should he choose if he wants to raise the steer's weight to 250 pounds?
The Theory of Costs

16. Complete the following table. Assume that units of fixed input cost $10 each and that units of variable input cost $20 each.

<table>
<thead>
<tr>
<th>Units of Fixed Input</th>
<th>Units of Variable Input</th>
<th>Units of Output</th>
<th>Marginal Product of Variable Input</th>
<th>Average Product of Variable Input</th>
<th>TFC</th>
<th>TVC</th>
<th>TC</th>
<th>AFC</th>
<th>ATC</th>
<th>MC</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
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<tr>
<td>100</td>
<td>20</td>
<td>600</td>
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<td>2000</td>
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<tr>
<td>100</td>
<td>80</td>
<td>2200</td>
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<td>100</td>
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<td>2300</td>
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</tbody>
</table>
17. Given TC = 2000 + 15Q - 6Q² + Q³, where Q = units of output:
   a. How much is TFC at an output of 2000 units? At 5000 units?
   b. How much is AFC at an output of 2000 units? At 5000 units?
   c. How much is AVC at an output of 20 units?
   d. How much is MC at an output of 20 units?
   e. How much is ATC at an output of 20 units?
   f. At approximately what output rate is the point of diminishing marginal productivity encountered?
   g. At approximately what output rate does diminishing average productivity begin?

18. Given the production function Q=15X, where X = units of variable input and Q = units of output. Units of variable input cost $30 each and units of fixed input cost $100 each. Ten units of fixed input are available.
   a. Determine AFC at an output of 400 units.
   b. Determine AVC when 10 units of variable input are combined with the 10 available units of fixed input.
   c. How much is MC at an output of 300 units?

19. Given the following cost information:
   a. AFC for 5 units of output is $2000.
   b. AVC for 4 units of output is $850.
   c. TC rises by $1240 when the sixth unit of output is produced.
   d. ATC for 5 units of output is $2880.
   e. It costs $1000 more to produce 1 unit of output than to produce nothing.
   f. TC for 8 units by output is $19,040.
   g. TVC increases by $1535 when the seventh unit of output is produced.
   h. AFC plus AVC for 3 units of output is $4185.
   i. ATC falls by $5100 when output rises from 1 to 2 units.

Using this information, complete the following table:

<table>
<thead>
<tr>
<th>Output</th>
<th>TFC</th>
<th>TVC</th>
<th>TC</th>
<th>AFC</th>
<th>AVC</th>
<th>ATC</th>
<th>MC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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<td>6</td>
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<td>7</td>
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</tbody>
</table>
20. a. Suppose a firm's short-run average cost curve is U shaped. What does this imply about the marginal productivity of the variable input?
   
b. Suppose a firm's long-run average cost curve is flat. What does this imply about returns to scale in the firm? What does this mean for the firm's long-run marginal cost?

21. A firm is planning to build one of two types of plant. The short-run cost of a type A plant is $C_A = 80\%Q_A + 5Q_A^2$. Plant B's short-run cost is $C_B = 50\%Q_B^2$.
   
a. If an output of 8 units is planned, which plant should be built? How large an output is needed to justify building plant A?
   
b. Suppose the firm already has built both plants. If a total planned output is sufficiently large, the firm should use both facilities. Explain why. Suppose planned production is 22 units. How should the firm divide production between the plants to minimize total cost? (Hint: Confirm that the firm should divide production to ensure that $MC_A = MC_B$.)

22. a. A firm's total revenue can be determined by adding the values of MR for each unit sold. True or false? Explain.
   
b. A firm's total cost can be determined by adding the values of MC for each unit produced. True or false? Explain.
   
c. A firm's total profit can be determined by adding the values of Mp for each unit produced and sold. True or false? Explain.

23. Assume in a perfectly competitive industry that market supply and demand forces combine to produce a short-run equilibrium price of $70. Suppose further that a firm in this industry has weekly total cost function expressed by the equation $TC=200+25Q-6Q^2+(1/3)Q^3$. Determine the perfectly competitive firm's profit-maximizing output rate and the amount of its short-run profits or losses.

24. Using the unit cost and unit revenue curves, graphically illustrate the short-run profit-maximizing price and output for a perfectly competitive firm which has a production function that exhibits decreasing marginal productivity of the variable input over its entire range of output capability. (Hint: Determine the shape of the ATC and MC curves that correspond to a production function characterized by diminishing marginal productivity of the variable input and then locate the price and output at which MR=MC). Indicate on your graph the area that represents the firm's total profits.

25. The Green Company produces chemical in a perfectly competitive market. The current market price is $40; the firm's total cost is $C = 100\%4Q + 5Q^2$.
   
a. Determine the firm's profit-maximizing output. More generally, write down the equation for the firm's supply curve in terms of price P.
   
b. Complying with more stringent environmental regulations increases the firm's fixed cost from 100 to 144. Would this affect the firm's output? Its supply curve?
   
c. How would the increase in fixed costs affect the market's long-run equilibrium price? The number of firms? (Assume that green's costs are typical in the
market.)

**Tariffs and Quotas**

26. Assume that US demand for steel is estimated to be \( Q_D = 184 - 20P \) and US industry supply is: \( Q_S = 124 + 4P \).
   a. Find the competitive market price and output.
   b. Assume that the world price of steel is $2. Assuming free trade calculate US demand supply and imports.
   c. Assume the government imposes a 25 cent tariff. Calculate tax revenue.
   d. Assume the government instead imposes a quota of 6. Calculate the profits to the owner of the import license.
   e. Assume an increase in demand to \( Q_D = 200 - 20P \). Compare the equilibrium price and output assuming first a tariff of $.25 and, second a quota of 6 tons. Also, calculate tax revenues and profits to the importer.

**The Model of Monopoly**

27. A television station is considering selling promotional videos. It can have the videos produced by one of two suppliers. Supplier A will charge the station a set-up charge of $1,200 plus $2 for each cassette; supplier B has no set-up charge and will charge $4 per cassette. The station estimates its demand for the cassettes to be given by \( Q' = 1,600 - 200P \), where \( P \) is the price in dollars and \( Q \) is the number of cassettes.
   (The associated price equation is \( P' = 8 & Q/200 \).)
   a. Suppose the station plans to give away the video. How many cassettes should it order? From which supplier?
   b. Suppose the station seeks to maximize its profit from sales of the cassettes. What price should it charge? How many cassettes should it order from which supplier? (Hint: Solve two separate problems, one with supplier A and one with supplier B, and then compare profits. In each case, apply the \( MR' MC \) rule.)

28. Under the terms of the current contractual agreement, Burger Queen (BQ) is entitled to 20 percent of the revenue earned by each of its franchises. BQ’s best-selling item is the Slopper (it slops out of the bun). BQ supplies the ingredients for the Slopper (bun, mystery meat, etc.) at cost to the franchise. The franchise's average cost per Slopper (including ingredients, labor cost, and so on) is $.80. At a particular franchise restaurant, weekly demand for Sloppers is given by \( P' = 3.00 & Q/800 \).
   a. If BQ sets the price and weekly sales quantity of Sloppers, what quantity and price would it set? How much does BQ receive? What is the franchise's net profit?
   b. Suppose the franchise owner sets the price and sales quantity. What price and quantity will the owner set? (Hint: Remember that the owner keeps only $.80 of each extra dollar of revenue earned.) How does the total profit earned
by the two parties compare to their total profit in part a?
c. Now, suppose BQ and an individual franchise owner enter into an agreement in which BQ is entitled to a share of the franchise’s profit. Will profit sharing remove the conflict between BQ and the franchise operator? Under profit sharing, what will be the price and quantity of Sloppers? (Does the exact split of the profit affect your answer? Explain briefly.) What is the parties' total profit?
d. Profit sharing is not widely practiced in the franchise business. What do you think are its disadvantages relative to revenue sharing?

29. a. Determine the maximum profit and the corresponding price and quantity for a monopolist whose demand functions are \( P=20-0.5q \) and total costs are \( C=30+5q \).
b. Assume an increase in oil prices increases the cost per unit by 3 dollars. What are the implications for the price output and profit of the firm. Is raising the price by 3 optimal?
c. Assume an increase in property taxes of 20. Determine the price, output and profits of the firm.
d. Assume a 20% tax on the profits of the firm. Determine price, output and profits.
e. Assume a 20% sales tax. Calculate the price output and profit of the firm.

**Special Pricing Issues**

30. The American Cracker Corporation has three plants for producing soda crackers. The marginal cost functions of the three plants and the firm's estimated demand-AR schedule are as follows:

<table>
<thead>
<tr>
<th>Daily Output In Cartons</th>
<th>Marginal Cost of Plant 1</th>
<th>Marginal Cost of Plant 2</th>
<th>Marginal Cost of Plant 3</th>
<th>Price of Cartons of Soda Crackers</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$0.14</td>
<td>$0.13</td>
<td>$0.10</td>
<td>$0.50</td>
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<tr>
<td>---</td>
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<td>---</td>
</tr>
<tr>
<td>1</td>
<td>$0.14</td>
<td>$0.13</td>
<td>$0.10</td>
<td>$0.48</td>
</tr>
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<td>2</td>
<td>$0.16</td>
<td>$0.14</td>
<td>$0.13</td>
<td>$0.46</td>
</tr>
<tr>
<td>3</td>
<td>$0.18</td>
<td>$0.15</td>
<td>$0.16</td>
<td>$0.44</td>
</tr>
<tr>
<td>4</td>
<td>$0.20</td>
<td>$0.16</td>
<td>$0.18</td>
<td>$0.42</td>
</tr>
<tr>
<td>5</td>
<td>Capacity</td>
<td>Capacity</td>
<td>Capacity</td>
<td>$0.40</td>
</tr>
<tr>
<td>6</td>
<td>$0.38</td>
<td></td>
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<tr>
<td>7</td>
<td>$0.36</td>
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<tr>
<td>8</td>
<td>$0.34</td>
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<tr>
<td>9</td>
<td>$0.32</td>
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<tr>
<td>10</td>
<td>$0.30</td>
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<td></td>
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<tr>
<td>11</td>
<td>$0.28</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>$0.26</td>
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</tbody>
</table>

Determine the most profitable price and output for the American Cracker Corporation. Then determine the optimal allocation of output among the firm's three plants.
31. The Morgan Chair Company manufacturers rocking chairs and sells them under conditions of monopolistic competition. The owner of the company has estimated its demand function as \( P' = 1625 - 6Q \), where \( P \) is in dollars and \( Q \) is in dozens of chairs sold per month. The company believes its monthly expenses vary with output according to the equation \( TC' = 25,000 + 25Q + 2Q^2 + 1/3Q^3 \).
   a. Determine the firm's short-run profit-maximizing price and output rate.
   b. How much profit will the firm earn at this price and output rate?
   c. Suppose the Morgan Chair Company's total fixed costs rise by 10%. Calculate the impact upon the firm's price, output, and profits. How do you account for these results?

32. Within Europe, the market for air travel is highly regulated. Entry of new airlines is severely restricted, and air fares are set by regulation. Partly as a result, European air fares are higher than US fares for routes of comparable distance. Suppose that for a given European air route (say, London to Rome), annual air travel demand is estimated to be \( Q' = 1,500 - 3P \) (or, equivalently, \( P' = 500 - Q/3 \)), where \( Q \) is the number of trips in thousands and \( P \) is the one-way fare in dollars. (For example, 600 thousands annual trips are taken when the fare is $300.) In addition, the long-run average (one-way) cost per passenger along this route is estimated to be $200.
   a. Some economist have suggested there is an implicit cartel among European air carriers whereby the airlines charge monopoly fares under the shield of regulation. Given the preceding facts, find the profit maximizing fare and the annual number of passenger trips.
   b. Suppose the European market were deregulated so that these routes became perfectly competitive. Find the competitive price and quantity of trips.

33. Suppose that over the short run (say, the next five years), demand for OPEC oil is given by \( Q' = 52.5 - 1.25P \) or, equivalently, \( P' = 42 + 8Q \). (Here \( Q \) is measured in thousands of barrels per day.) OPEC's average cost per barrel is $10.
   a. What is OPEC's optimal level of production? What is the prevailing price of oil at this level?
   b. Many experts contend that maximizing short-run profit is counterproductive for OPEC in the long run because high prices induce buyers to conserve energy and/or seek supplies elsewhere. Suppose the demand curve just described will remain unchanged only if oil prices stabilize at $20 per barrel or below. If the oil price exceeds this threshold, long-run demand (over a second five-year period) will be curtailed to \( Q' = 60 - 2P \) (or \( P' = 30 + 5Q \)). OPEC seeks to maximize its total profit over the next decade. What is its optimal output and price policy? (Assume all values are present values.)
34. Firm A and B are battling for market share in two separate markets. Market I is worth $30 million in revenue; market II is worth $18 million. Firm A must decide how to allocate its three salespersons between the markets; firm B has only two salespersons to allocate. Each firm's revenue share in each market is proportional to the number of salespeople the firm assigns there. For example, if firm A puts two salespersons and firm B puts one salesperson in market I, A's revenue from this market is \[ \frac{2}{(2+1)} \times 30 = \frac{2}{3} \times 30 = 20 \] million and B's revenue is the remaining $10 million. (The firms split a market equally if neither assigns a salesperson to it.) Each firm is solely interested in maximizing the total revenue it obtains from the two markets.

a. Compute the complete payoff table. (Firm A has four possible allocations: 3-0, 2-1, 1-2, and 0-3. Firm B has three allocations: 2-0, 1-1, 0-2.) Is this a constant-sum game?

b. Does either firm have a dominant strategy (or dominated strategies)? What is the predicted outcome?

35. One way to lower the rate of auto accidents is strict enforcement of motor vehicle laws (speeding, drunk driving, and so on). However, maximum enforcement is very costly. The payoff table below lists the payoffs of a typical motorist and a town government. The motorist can obey or disobey the motor vehicle laws, which the town can enforce or not.

<table>
<thead>
<tr>
<th>Motorist</th>
<th>Town Enforce</th>
<th>Don't Enforce</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obey</td>
<td>0,-15</td>
<td>0,0</td>
</tr>
<tr>
<td>Disobey</td>
<td>-20,-20</td>
<td>5,-10</td>
</tr>
</tbody>
</table>

a. What is the town's optimal strategy? What is the typical motorist's behavior in response?

b. What if the town could commit to a strict enforcement policy and motorists believed that this policy would be used? Would the town wish to do so?

c. Now suppose the town could commit to enforcing the law part of the time. (The typical motorist cannot predict exactly when the town's traffic police will be monitoring the roadways.) What is the town's optimal degree (i.e., percentage) of enforcement? Explain.

36. From 1989 to 1991 the Trump Shuttle and the Pan Am Shuttle battled for market share on the Boston/New York and Washington DC/New York routes. In addition to service quality and dependability (claimed or real), the airlines competed over price via periodic fare changes. The hypothetical payoff table below lists each airline's estimated profit (expressed on a per-seat basis) for various combinations
of one-way fares.

<table>
<thead>
<tr>
<th>Trump Shuttle Fares</th>
<th>Pan Am Shuttle Fares</th>
</tr>
</thead>
<tbody>
<tr>
<td>$139</td>
<td>$34, $38</td>
</tr>
<tr>
<td>$119</td>
<td>$42, $20</td>
</tr>
<tr>
<td>$99</td>
<td>$35, $7</td>
</tr>
<tr>
<td>$139</td>
<td>$15, $42</td>
</tr>
<tr>
<td>$119</td>
<td>$22, $22</td>
</tr>
<tr>
<td>$99</td>
<td>$27, $9</td>
</tr>
<tr>
<td></td>
<td>$6, $32</td>
</tr>
<tr>
<td></td>
<td>$10, $25</td>
</tr>
<tr>
<td></td>
<td>$18, $16</td>
</tr>
</tbody>
</table>

a. Suppose that the two airlines will select their fares independently and "once and for all." (The airline's fare cannot be changed.) What fares should the airlines set?

b. Suppose instead that the airlines will set fares over the next 18 months. In any month, each airline is free to change its fare if it wishes. What pattern of fares would you predict for the airlines over the 18 months?

37. Waxy Products, Inc., has discovered a new way to produce a "plastic wax" which, when once applied to hardwood floors, creates a permanent, waterproof, scuffproof, shiny surface absolutely guaranteed under any conditions to last for 12 months. Waxy Products, realizing the vast market potential for its plastic wax, has employed a market research team to estimate the demand function for plastic wax in both national and international markets. The market research team reports that its estimate of plastic wax demand in the domestic market is \( P_D = 100 - 5Q_D \) and that its estimate of demand in the international market is \( P_F = 60 - 5Q_F \), where \( P \) is in dollars and \( Q \) is daily sales in cases. Waxy Products estimates that the short-run production function for plastic wax is \( Q = 10X \), where \( X \) = units of variable input; units of variable input cost $200 each. The president of Waxy Products, not knowing very much about price policy, asks you to assist him in maximizing his firm's profits. Calculate for him the specific price and output levels that will maximize profits from the sale of plastic wax.

38. A private garage operator has identified two distinct market segments: short-term parkers and all-day parkers with respective demand curves of \( P_S = 3Q_S/200 \) and \( P_c = 2Q_c/200 \). Here \( P \) is the average hourly rate and \( Q \) is the number of cars parked at this price. The garage owner is considering charging different prices (on a per-hour basis) for short-term parking and all-day parking. The capacity of the garage is 600 cars, and the cost associated with adding extra cars in the garage (up to this limit) is negligible.

a. Given these facts, what is the owner's appropriate objective? How can he ensure that members of each market segment effectively pay a different hourly price?

b. What price should he charge for each type of parker? How many of each type (i.e., cars) will use the garage at these prices? Will the garage be full?
c. Answer the questions in part a assuming the garage has a capacity of only 400 cars.