P2.2  A. Fill in the missing data for price (P), total revenue (TR), marginal revenue (MR), total cost (TC), marginal cost (MC), profit (π), and marginal profit (Mπ) in the following table:

<table>
<thead>
<tr>
<th>Q</th>
<th>P</th>
<th>TR=P×Q</th>
<th>MR=ΔTR</th>
<th>TC</th>
<th>MC=ΔTC</th>
<th>π=TR-TC</th>
<th>Mπ=Δπ</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$160</td>
<td>$0</td>
<td>$---</td>
<td>$0</td>
<td>$---</td>
<td>$0</td>
<td>$---</td>
</tr>
<tr>
<td>1</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>25</td>
<td>25</td>
<td>125</td>
<td>125</td>
</tr>
<tr>
<td>2</td>
<td>140</td>
<td>280</td>
<td>130</td>
<td>55</td>
<td>30</td>
<td>225</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>130</td>
<td>390</td>
<td>110</td>
<td>90</td>
<td>35</td>
<td>300</td>
<td>75</td>
</tr>
<tr>
<td>4</td>
<td>120</td>
<td>480</td>
<td>90</td>
<td>130</td>
<td>40</td>
<td>350</td>
<td>50</td>
</tr>
<tr>
<td>5</td>
<td>110</td>
<td>550</td>
<td>70</td>
<td>175</td>
<td>45</td>
<td>375</td>
<td>25</td>
</tr>
<tr>
<td>6</td>
<td>100</td>
<td>600</td>
<td>50</td>
<td>230</td>
<td>55</td>
<td>370</td>
<td>-5</td>
</tr>
<tr>
<td>7</td>
<td>90</td>
<td>630</td>
<td>30</td>
<td>290</td>
<td>60</td>
<td>340</td>
<td>-30</td>
</tr>
</tbody>
</table>

B. At what output level is profit maximized?

C. At what output level is revenue maximized?

D. Discuss any differences in your answers to Parts B and C.

P2.2 SOLUTION

A.
Profit increases so long as \( MR > MC \) and \( M\pi > 0 \). In this problem, profit is maximized at \( Q = 5 \) where \( \pi = \$375 \) (and \( TR = \$550 \)).

Total Revenue increases so long as \( MR > 0 \). In this problem, revenue is maximized at \( Q = 8 \) where \( TR = \$640 \) (and \( \pi = \$285 \)).

Given a downward sloping demand curve and \( MC > 0 \), as is typically the case, profits will be maximized at an output level that is less than the revenue-maximizing level. Revenue maximization requires lower prices and greater output than would be true with profit maximization.

The potential long-run advantage of a revenue-maximizing strategy is that it might generate rapid market expansion and long-run benefits in terms of customer loyalty and future unit-cost reductions. The cost is, of course, measured in terms of lost profits in the short-run (here the loss is $90 in profits).

P2.3 Marginal Analysis. Characterize each of the following statements as true or false, and explain your answer.

A. If marginal revenue is less than average revenue, the demand curve will be downward sloping.
B. Profits will be maximized when total revenue equals total cost.

C. Given a downward-sloping demand curve and positive marginal costs, profit-maximizing firms will always sell less output at higher prices than will revenue-maximizing firms.

D. Marginal cost must be falling for average cost to decline as output expands.

E. Marginal profit is the difference between marginal revenue and marginal cost and will always equal zero at the profit-maximizing activity level.

P2.3 SOLUTION

A. True. The demand curve is the average-revenue curve. Since average revenue is falling along a downward sloping demand curve, marginal revenue is less than average revenue.

B. False. Profits are maximized when marginal revenue equals marginal cost. Profits equal zero at the breakeven point where total revenue equals total cost.

C. True. Profit maximization involves setting marginal revenue equal to marginal cost. Revenue maximization involves setting marginal revenue equal to zero. Given a downward-sloping demand curve and positive marginal costs, revenue-maximizing firms will charge lower prices and offer greater quantities of output than will profit maximizers.

D. False. Average cost will fall as output expands so long as marginal cost is simply less than average cost. If this condition is met, average cost will decline whether marginal costs are falling, rising, or constant.
E. True. Marginal profit equals marginal revenue minus marginal cost and will equal zero at the profit-maximizing activity level.

P2.4 Marginal Analysis: Tables. Sarah Berra is a regional sales representative for Dental Laboratories, Inc. Berra sells alloy products created from gold, silver, platinum, and other precious metals to several dental laboratories in Maine, New Hampshire, and Vermont. Berra’s goal is to maximize her total monthly commission income, which is figured at 10% of gross sales. In reviewing her monthly experience over the past year, Berra found the following relations between days spent in each state and monthly sales generated:

<table>
<thead>
<tr>
<th></th>
<th>Maine</th>
<th>New Hampshire</th>
<th>Vermont</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days</td>
<td>Gross Sales</td>
<td>Days</td>
<td>Gross Sales</td>
</tr>
<tr>
<td>0</td>
<td>$4,000</td>
<td>0</td>
<td>$0</td>
</tr>
<tr>
<td>1</td>
<td>10,000</td>
<td>1</td>
<td>3,500</td>
</tr>
<tr>
<td>2</td>
<td>15,000</td>
<td>2</td>
<td>6,500</td>
</tr>
<tr>
<td>3</td>
<td>19,000</td>
<td>3</td>
<td>9,000</td>
</tr>
<tr>
<td>4</td>
<td>22,000</td>
<td>4</td>
<td>10,500</td>
</tr>
<tr>
<td>5</td>
<td>24,000</td>
<td>5</td>
<td>11,500</td>
</tr>
<tr>
<td>6</td>
<td>25,000</td>
<td>6</td>
<td>12,000</td>
</tr>
<tr>
<td>7</td>
<td>25,000</td>
<td>7</td>
<td>12,500</td>
</tr>
</tbody>
</table>

A. Construct a table showing Berra’s marginal sales per day in each state.

B. If administrative duties limit Berra to only ten selling days per month, how should she spend them?

C. Calculate Berra’s maximum monthly commission income.
### P2.4 SOLUTION

#### A.

<table>
<thead>
<tr>
<th></th>
<th>Maine</th>
<th></th>
<th>New Hampshire</th>
<th></th>
<th>Vermont</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Days</td>
<td>Marginal Sales</td>
<td>Days</td>
<td>Marginal Sales</td>
<td>Days</td>
<td>Marginal Sales</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>--</td>
<td>0</td>
<td>--</td>
<td>0</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>$6,000</td>
<td>1</td>
<td>$3,500</td>
<td>1</td>
<td>$2,500</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>5,000</td>
<td>2</td>
<td>3,000</td>
<td>2</td>
<td>2,000</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>4,000</td>
<td>3</td>
<td>2,500</td>
<td>3</td>
<td>1,500</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>3,000</td>
<td>4</td>
<td>1,500</td>
<td>4</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>2,000</td>
<td>5</td>
<td>1,000</td>
<td>5</td>
<td>500</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1,000</td>
<td>6</td>
<td>500</td>
<td>6</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>7</td>
<td>500</td>
<td>7</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

#### B.

The maximum commission income is earned by allocating selling days on the basis of obtaining the largest marginal sales for each additional day of selling activity. Using the data in Part A, we see that five days should be spent in Maine, three days in New Hampshire, and two days should be spent in Vermont.

#### C.

Given this time allocation, Berra's maximum commission income is
Harcourt Brace & Company

State | Sales
--- | ---
Maine (5 days) | $24,000
New Hampshire (3 days) | 9,000
Vermont (2 days) | 7,000
Total | $40,000
× Commission rate | × 0.1
$ 4,000 per month

P2.5 **Marginal Analysis: Tables.** Climate Control Devices, Inc., estimates that sales of defective thermostats cost the firm an average of $25 each for replacement or repair. An independent engineering consultant has recommended hiring quality control inspectors so that defective thermostats can be identified and corrected before shipping. The following schedule shows the expected relation between the number of quality control inspectors and the thermostat failure rate, defined in terms of the percentage of total shipments that prove to be defective.

<table>
<thead>
<tr>
<th>Number of Quality Control Inspectors</th>
<th>Thermostat Failure Rate (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5.0</td>
</tr>
<tr>
<td>1</td>
<td>4.0</td>
</tr>
<tr>
<td>2</td>
<td>3.2</td>
</tr>
<tr>
<td>3</td>
<td>2.6</td>
</tr>
<tr>
<td>4</td>
<td>2.2</td>
</tr>
<tr>
<td>5</td>
<td>2.0</td>
</tr>
</tbody>
</table>

The firm expects to ship 250,000 thermostats during the coming year, and quality control inspectors each command a salary of $30,000 per year.
A. Construct a table showing the marginal failure reduction (in units) and the dollar value of these reductions for each inspector hired.

B. How many inspectors should the firm hire?

C. How many inspectors would be hired if additional indirect costs (lost customer goodwill and so on) were to average 30% of direct replacement or repair costs?

P2.5 SOLUTION

<table>
<thead>
<tr>
<th>Inspectors</th>
<th>Failure Rate</th>
<th>Failures (=250,000×(2))</th>
<th>Marginal Failure Reduction (4)</th>
<th>Marginal Value (=$25×(4))</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.050</td>
<td>12,500</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>1</td>
<td>0.040</td>
<td>10,000</td>
<td>2,500</td>
<td>$62,500</td>
</tr>
<tr>
<td>2</td>
<td>0.032</td>
<td>8,000</td>
<td>2,000</td>
<td>50,000</td>
</tr>
<tr>
<td>3</td>
<td>0.026</td>
<td>6,500</td>
<td>1,500</td>
<td>37,500</td>
</tr>
<tr>
<td>4</td>
<td>0.022</td>
<td>5,500</td>
<td>1,000</td>
<td>25,000</td>
</tr>
<tr>
<td>5</td>
<td>0.020</td>
<td>5,000</td>
<td>500</td>
<td>12,500</td>
</tr>
</tbody>
</table>

B. I = 3. With a $30,000 inspector salary, the firm will enjoy a net marginal return of $7,500 (= $37,500 - $30,000) from hiring a third inspector. Hiring a fourth inspector would result in a marginal loss of $5,000 (= $25,000 - $30,000).

C. I = 4. If additional indirect costs total 30% of direct replacement costs, the marginal value of inspectors (column 5) would rise by 30%. Under these circumstances, the marginal value of a fourth inspector would rise from $25,000 to $32,500 (= 1.3 x 25,000), and
hiring four inspectors could be justified since doing so would increase profits by $2,500 (= $32,500 - $30,000).

**P2.6 Profit Maximization: Equations.** Rochester Instruments, Inc., operates in the highly competitive electronics industry. Prices for its RII-X control switches are stable at $50 each. This means that $P = MR = $50 in this market. Engineering estimates indicate that relevant total and marginal cost relations for the RII-X model are:

\[ TC = 78,000 + 18Q + 0.002Q^2 \]
\[ MC = 18 + 0.004Q. \]

**A. Calculate the output level that will maximize RII-X profit.**

**B. Calculate this maximum profit.**

**P2.6 SOLUTION**

**A.** To find the profit-maximizing level of output, set $MR = MC$ and solve for $Q$:

\[ MR = MC \]
\[ $50 = 18 + 0.004Q \]
\[ 0.004Q = 32 \]
\[ Q = 8,000 \]

(Note: Profits are decreasing for $Q > 8,000$.)

**B.** The total revenue function for Rochester is:

\[ TR = P \times Q = 50Q \]
Then, total profit is:
π = TR - TC
= $50Q - $78,000 - $18Q - $0.002Q^2
= $0.002Q^2 + $32Q - $78,000
= $0.002(8,000^2) + $32(8,000) - $78,000
= $50,000

P2.7 Profit Maximization: Equations. 21st Century Insurance offers mail-order automobile insurance to preferred-risk drivers in the Los Angeles area. The company is the low-cost provider of insurance in this market but doesn’t believe its $750 annual premium can be raised for competitive reasons. Its rates are expected to remain stable during coming periods; hence, P = MR = $750. Total and marginal cost relations for the company are as follows:

\[ TC = 2,500,000 + 500Q + 0.005Q^2 \]
\[ MC = 500 + 0.01Q. \]

A. Calculate the profit-maximizing activity level.

B. Calculate the company's optimal profit and return-on-sales levels.

P2.7 SOLUTION

A. Set MR = MC and solve for Q to find the profit-maximizing activity level:

\[ MR = MC \]
\[ $750 = 500 + 0.01Q \]
0.01Q = $250
Q = 25,000

B. The total revenue function for 21st Century Insurance is:

\[ TR = P \times Q = 750Q \]

Then, total profit is:

\[ \pi = TR - TC \]

\[ = 750Q - 2,500,000 - 500Q - 0.005Q^2 \]

\[ = 750(25,000) - 2,500,000 - 500(25,000) - 0.005(25,000^2) \]

\[ = 625,000 \]

\[ \text{TR} = 750(25,000) \]

\[ = 18.75 \text{ million} \]

Return on Sales = \[ \frac{\pi}{\text{TR}} \]

\[ = \frac{625,000}{18,750,000} \]

\[ = 0.033 \text{ or } 3.3\% \]

P2.9 Revenue Maximization. Desktop Publishing Software, Inc., develops and markets software packages for business computers. Although sales have grown rapidly during recent years, the company’s management fears that a recent onslaught of new
competitors may severely retard future growth opportunities. Therefore, it believes that the time has come to "get big or get out."

The marketing and accounting departments have provided management with the following monthly demand and cost information:

\[ P = 1000 - Q \]
\[ TC = 50000 + 100Q \]
\[ MR = 1000 - 2Q \]
\[ MC = 100 \]

A. Calculate monthly quantity, price, and profit at the short-run revenue-maximizing output level.

B. Calculate these same values for the short-run profit-maximizing level of output.

C. When would short-run revenue maximization lead to long-run profit maximization?

P2.9 SOLUTION

A. To find the revenue-maximizing output level, set MR = 0 and solve for Q. Thus,

\[ MR = 1000 - 2Q = 0 \]
\[ 2Q = 1000 \]
\[ Q = 500 \]

At Q = 500,

\[ P = 1000 - 1(500) \]
\[ = 500 \]
\[ \pi = TR - TC \]
\[ = ($1,000 - $1Q)Q - $50,000 - $100Q \]
\[ = -$50,000 + $900Q - $1Q^2 \]
\[ = -$50,000 + $900(500) - $1(500^2) \]
\[ = $150,000 \]

(Note: This is a maximum since revenue is decreasing beyond this point.)

B. To find the profit-maximizing output level set \( MR = MC \), or \( M\pi = 0 \), and solve for \( Q \).

Since,

\[ MR = MC \]
\[ 1,000 - 2Q = 100 \]
\[ 2Q = 900 \]
\[ Q = 450 \]

At \( Q = 450 \),

\[ P = $1,000 - $1(450) \]
\[ = $550 \]
\[ \pi = -$50,000 + $900(450) - $1(450^2) \]
\[ = $152,500 \]

(Note: This is a profit maximum since profit is decreasing beyond this point.)
C. In pursuing a short-run revenue rather than a profit-maximizing strategy, Desktop Publishing can expect to gain a number of important advantages, including: enhanced product awareness among consumers, increased customer loyalty, potential economies of scale in marketing and promotion, and possible limitations in competitor entry and growth. To be consistent with long-run profit maximization, these advantages of short-run revenue maximization must be at least worth the sacrifice of $2,500 per outlet in monthly profits.

P2.10 **Average Cost Minimization.** Giant Screen TV, Inc., is a San Diego-based importer and distributor of 60-inch screen, high-resolution televisions for individual and commercial customers. Revenue and cost relations are as follows:

\[
TR = 1,800Q - 0.006Q^2, \\
MR = 1,800 - 0.012Q, \\
TC = 12,100,000 + 800Q + 0.004Q^2, \\
MC = 800 + 0.008Q.
\]

A. Calculate output, marginal cost, average cost, price, and profit at the average cost-minimizing activity level.

B. Calculate these values at the profit-maximizing activity level.

C. Compare and discuss your answers to Parts A and B.

P2.10 **SOLUTION**
A. To find the average cost-minimizing level of output, set MC = AC and solve for Q.

Since,

\[ AC = \frac{TC}{Q} \]

\[ = \frac{($12,100,000 + $800Q + $0.004Q^2)}{Q} \]

\[ = $12,100,000Q^{-1} + $800 + $0.004Q \]

Therefore,

\[ MC = AC \]

\[ $800 + $0.008Q = $12,100,000Q^{-1} + $800 + $0.004Q \]

\[ 0.004Q = 12,100,000 / Q \]

\[ Q^2 = 12,100,000 / 0.004 \]

\[ Q = [12,100,000 / 0.004]^{.5} \]

\[ = 55,000 \]

And,

\[ MC = $800 + $0.008(55,000) \]

\[ MC = $1,240 \]

\[ AC = 12,100,000 / 55,000 + 800 + 0.004(55,000) \]

\[ AC = $1,240 \]

\[ P = TR/Q \]
= \frac{(1,800Q - 0.006Q^2)}{Q} \\
= 1,800 - 0.006Q \\
= 1,800 - 0.006(55,000) \\
= 1,470 \\

\pi = P \times Q - TC \\
= 1,470(55,000) - 12,100,000 - 800(55,000) - 0.004(55,000^2) \\
= 12,650,000 \\

(Note: Average cost is rising for Q > 55,000.) 

B. To find the profit-maximizing level of output, set MR = MC and solve for Q (this is also where M\pi = 0): 

MR = MC \\
$1,800 - 0.012Q = 800 + 0.008Q \\
0.02Q = 1,000 \\
Q = 50,000 \\

And MC = 800 + 0.008(50,000) \\
= 1,200 \\

AC = 12,100,000 / 50,000 + 800 + 0.004(50,000) \\
AC = 1,242 \\
P = 1,800 - 0.006(60,000)
\[ \pi = TR - TC \]
\[ = $1,800Q - $0.006Q^2 - $12,100,000 - $800Q - $0.004Q^2 \]
\[ = -$0.01Q^2 + $1,000Q - $12,100,000 \]
\[ = -$0.01(50,000^2) + $1,000(50,000) - $12,100,000 \]
\[ = $12,900,000 \]

(Note: Profit is falling for \( Q > 50,000 \).)

C. Average cost is minimized when \( MC = AC = $1,240 \). Given \( P = $1,470 \), a $230 profit per unit of output is earned when \( Q = 55,000 \). Total profit \( \pi = $12.65 \) million.

Profit is maximized when \( Q = 50,000 \) since \( MR = MC = $1,200 \) at that activity level. Since \( MC = $1,200 < AC = $1,242 \), average cost is falling. Given \( P = $1,500 \) and \( AC = $1,242 \), a $258 profit per unit of output is earned when \( Q = 50,000 \). Total profit \( \pi = $12.9 \) million.

Total profit is higher at the \( Q = 50,000 \) activity level because the modest $2 (= $1,242 - $1,240) decline in average cost is more than offset by the $30 (= $1,500 - $1,470) price cut necessary to expand sales from \( Q = 50,000 \) to \( Q = 55,000 \) units.