Chapter 3: MARGINAL ANALYSIS FOR OPTIMAL DECISIONS

Multiple Choice

3-1 A firm will maximize profit by producing that level of output at which
   a. the additional revenue from the last unit sold exceeds the additional cost of the last unit
      by the largest amount.
   b. the additional revenue from the last unit sold equals the additional cost of the last unit.
   c. total revenue exceeds total cost by the largest amount.
   d. total revenue equals total cost.
   e. both b and c

Answer: e
Difficulty: 02 Medium
Topic: Concepts and Terminology
AACSB: Reflective Thinking
Blooms: Understand
Learning Objective: 03-01

3-2 The function a decision maker seeks to maximize or minimize is the ________ function.
   a. optimal
   b. decision-making
   c. objective
   d. marginal
   e. none of the above

Answer: c
Difficulty: 01 Easy
Topic: Concepts and Terminology
AACSB: Reflective Thinking
Blooms: Remember
Learning Objective: 03-01

3-3 Choice variables
   a. determine the value of the objective function
   b. determine the constraint
   c. can only take on integer values
   d. cannot be continuous
   e. both c and d

Answer: a
Difficulty: 01 Easy
Topic: Concepts and Terminology
AACSB: Reflective Thinking
Blooms: Remember
Learning Objective: 03-01

3-4 For an unconstrained maximization problem
   a. the decision maker seeks to maximize net benefits.
   b. the decision maker seeks to maximize total benefits.
   c. the decision maker does not take cost into account because there is no constraint.
   d. the decision maker does not take the objective function into account because there is no
      constraint.
   e. none of the above
Answer: a
Difficulty: 02 Medium
Topic: Concepts and Terminology
AACSB: Reflective Thinking
Blooms: Understand
Learning Objective: 03-01

3-5 When marginal cost is greater than marginal benefit at the current activity level, the decision maker can increase net benefit by decreasing the activity because
a. total benefit will rise by more than total cost will rise.
b. marginal cost is rising faster than marginal benefit is falling.
c. net benefit is upward sloping at this point.
d. total cost will fall by more than total benefit will fall.
Answer: d
Difficulty: 02 Medium
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03

3-6 For a constrained minimization problem, the decision maker
a. is constrained by the specific amount of total benefits.
b. is constrained by the choice set of values for the activities.
c. seeks to minimize the cost of achieving a specific goal.
d. all of the above
Answer: d
Difficulty: 02 Medium
Topic: Unconstrained Maximization
AACSB: Reflective Thinking
Blooms: Understand
Learning Objective: 03-02

3-7 A continuous choice variable
a. must be continuously varied to attain the goal.
b. can take on only special values between two end points.
c. is in unconstrained but not constrained problems.
d. all of the above
Answer: e
Difficulty: 02 Medium
Topic: Concepts and Terminology
AACSB: Reflective Thinking
Blooms: Remember
Learning Objective: 03-01

3-8 An agency is having problems with personal phone calls made during working hours. Each minute of a personal call costs the agency $0.50 in wasted wages. The agency hires operators to
monitor calls in order to attain the optimal number of personal calls (minimize total cost of personal calls).

<table>
<thead>
<tr>
<th>Number of Operators</th>
<th>Total minutes of personal calls (per hour)</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>600</td>
</tr>
<tr>
<td>1</td>
<td>480</td>
</tr>
<tr>
<td>2</td>
<td>410</td>
</tr>
<tr>
<td>3</td>
<td>370</td>
</tr>
<tr>
<td>4</td>
<td>350</td>
</tr>
</tbody>
</table>

Based on the above information, if operators receive $25 an hour, how many operators should the agency hire?

a. 0  
b. 1  
c. 2  
d. 3  
e. 4  
Answer: c

Difficulty: 02 Medium  
Topic: Unconstrained Maximization  
AACSB: Analytic  
Blooms: Apply  
Learning Objective: 03-02

3-9 An agency is having problems with personal phone calls made during working hours. Each minute of a personal call costs the agency $0.50 in wasted wages. The agency hires operators to monitor calls in order to attain the optimal number of personal calls (minimize total cost of personal calls).

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<td>3</td>
<td>370</td>
</tr>
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<td>4</td>
<td>350</td>
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</table>

Based on the above information, if operators receive $25 an hour, what is the minimum possible total cost of personal calls (per hour)?

a. $460  
b. $255  
c. $120  
d. $85  
e. none of the above  
Answer: b

Difficulty: 03 Hard  
Topic: Unconstrained Maximization  
AACSB: Analytic  
Blooms: Apply  
Learning Objective: 03-02

Chapter 3: MARGINAL ANALYSIS FOR OPTIMAL DECISION MAKING

© 2016 by McGraw-Hill Education. This is proprietary material solely for authorized instructor use. Not authorized for sale or distribution in any manner. This document may not be copied, scanned, duplicated, forwarded, distributed, or posted on a website, in whole or part.
An agency is having problems with personal phone calls made during working hours. Each minute of a personal call costs the agency $0.50 in wasted wages. The agency hires operators to monitor calls in order to attain the optimal number of personal calls (minimize total cost of personal calls).

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<td>370</td>
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<tr>
<td>4</td>
<td>350</td>
</tr>
</tbody>
</table>

Based on the above information, what is the most the agency would be willing to pay the first operator?

a. $480  
b. $300  
c. $240  
d. $120  
e. none of the above

Answer: e

Difficulty: 03 Hard  
Topic: Unconstrained Maximization  
AACSBA: Analytic  
Blooms: Apply  
Learning Objective: 03-02
Refer to the figure below, which shows marginal benefits (MB) and marginal cost (MC) of activity A:

![Figure showing marginal benefit and cost](image)

If the decision maker is choosing 200 units of activity A,

a. this level maximizes net benefits.
b. the activity could be reduced by one unit and net benefits will increase by $10.
c. the activity could be increased by one unit and net benefits will increase by $10.
d. the activity could be increased by one unit and net benefits will increase by $25.
e. the activity could be reduced by one unit and net benefits will increase by $15.

Answer: c
Difficulty: 02 Medium
Topic: Unconstrained Maximization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-02
Refer to the figure below, which shows marginal benefits ($MB$) and marginal cost ($MC$) of activity $A$:

If the decision maker is choosing 400 units of activity $A$,

a. this level maximizes net benefits.

b. the activity could be reduced by one unit and net benefits will increase by $10.

c. the activity could be reduced by one unit and net benefits will rise by $25.

d. the activity could be increased by one unit and net benefits will increase by $15.

e. the activity could be reduced by one unit and net benefits would decrease by $10.

Answer: b

Difficulty: 02 Medium

Topic: Unconstrained Maximization

AACSB: Analytic

Blooms: Apply

Learning Objective: 03-02
Refer to the figure below, which shows marginal benefits ($MB$) and marginal cost ($MC$) of activity $A$:

If the decision maker is choosing 300 units of activity $A$,

a. this level maximizes net benefits.

b. if the activity is increased by one unit, net benefits will increase by $20.

c. if the activity is decreased by one unit, net benefits will decrease by $20.

d. both $b$ and $c$

e. all of the above

Answer: a

Difficulty: 01 Easy

Topic: Unconstrained Maximization

AACSB: Analytic

Blooms: Apply

Learning Objective: 03-02
3-14 A manager in charge of new product development can hire engineers and market researchers. The annual salary of an engineer is $40,000 while a market researcher receives $20,000. The marginal contribution of engineers and market researchers are:

<table>
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<tr>
<th>Worker</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>240</td>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>80</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>200</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>70</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>160</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>60</td>
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<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt;</td>
<td>100</td>
<td>4&lt;sup&gt;th&lt;/sup&gt;</td>
<td>50</td>
</tr>
<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt;</td>
<td>40</td>
<td>5&lt;sup&gt;th&lt;/sup&gt;</td>
<td>40</td>
</tr>
</tbody>
</table>

Based on the above information, how should a manager with an annual budget of $140,000, allocate this budget in order to maximize the number of new products developed?

a. Hire one engineer and five market researchers
b. Hire two engineers and three market researchers
c. Hire three engineers and one market researcher
d. Hire four engineers and four market researchers

Answer: c

Difficulty: 03 Hard
Topic: Unconstrained Maximization
AACSB: Analytic
Blooms: Analyze
Learning Objective: 03-02

3-15 A manager in charge of new product development can hire engineers and market researchers. The annual salary of an engineer is $40,000 while a market researcher receives $20,000. The marginal contribution of engineers and market researchers are:

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<td>4&lt;sup&gt;th&lt;/sup&gt;</td>
<td>100</td>
<td>4&lt;sup&gt;th&lt;/sup&gt;</td>
<td>50</td>
</tr>
<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt;</td>
<td>40</td>
<td>5&lt;sup&gt;th&lt;/sup&gt;</td>
<td>40</td>
</tr>
</tbody>
</table>

Based on the above information, if the manager has an annual budget of $140,000 and currently is hiring two engineers and three market researchers, then

a. the last dollar spent on an engineer yielded more new products than the last dollar spent on a market researcher.
b. the last dollar spent on a market researcher yielded more new products than the last dollar spent on an engineer.

c. he is making the correct decision because engineers make more than market researchers.

d. he is making the correct decision because the last market researcher hired was more productive than the last engineer hired.

Answer: a

3-16 A manager in charge of new product development can hire engineers and market researchers. The annual salary of an engineer is $40,000 while a market researcher receives $20,000. The marginal contribution of engineers and market researchers are:

<table>
<thead>
<tr>
<th>Workers</th>
<th>Additional New Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineers ($E$)</td>
<td>Market Researchers ($R$)</td>
</tr>
<tr>
<td>1$^{st}$</td>
<td>240</td>
</tr>
<tr>
<td>2$^{nd}$</td>
<td>200</td>
</tr>
<tr>
<td>3$^{rd}$</td>
<td>160</td>
</tr>
<tr>
<td>4$^{th}$</td>
<td>100</td>
</tr>
<tr>
<td>5$^{th}$</td>
<td>40</td>
</tr>
</tbody>
</table>

Based on the above information, how should a manager with an annual budget of $240,000, allocate this budget in order to maximize the number of new products developed?

a. Hire three engineers and four market researchers.

b. Hire three engineers and five market researchers.

c. Hire five engineers and two market researchers.

d. Hire four engineers and four market researchers.

Answer: d

3-17 The decision rule for constrained optimization is to select the level for each activity at which

a. marginal benefit equals marginal cost for each activity.

b. total benefit equals total cost for each activity.

c. marginal benefit per dollar of marginal cost is equal across all activities.

d. total benefit per dollar of total cost is equal across all activities.

Answer: c
A student taking economics, statistics, and finance has decided to spend 9 hours per week studying. The objective is to maximize the average grade, which means maximizing the total grade in the three courses. The table shows the student's estimate of the relation between time spent studying each course and the grade for each course.

<table>
<thead>
<tr>
<th>Hours of Study</th>
<th>Economics</th>
<th>Statistics</th>
<th>Finance</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>50</td>
<td>42</td>
<td>56</td>
</tr>
<tr>
<td>1</td>
<td>62</td>
<td>54</td>
<td>68</td>
</tr>
<tr>
<td>2</td>
<td>71</td>
<td>64</td>
<td>76</td>
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<tr>
<td>3</td>
<td>79</td>
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<td>6</td>
<td>90</td>
<td>87</td>
<td>93</td>
</tr>
<tr>
<td>7</td>
<td>92</td>
<td>89</td>
<td>95</td>
</tr>
</tbody>
</table>

Based on the above information, how should the student allocate her time?

a. 3 hours economics, 4 hours statistics, 2 hours finance
b. 3 hours economics, 3 hours statistics, 3 hours finance
c. 4 hours economics, 3 hours statistics, 2 hours finance
d. 3 hours economics, 2 hours statistics, 4 hours finance

Answer: a

Difficulty: 03 Hard
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03
Based on the above information, what is the maximum AVERAGE grade the student can earn if she studies 9 hours per week?

a. 80  
b. 80.3  
c. 82  
d. 78.3  
Answer: d  
Difficulty: 03 Hard  
Topic: Constrained Optimization  
AACSB: Analytic  
Blooms: Apply  
Learning Objective: 03-03

3-20 Use the following marginal benefit and marginal cost functions for activity A:

\[ MB = 100 - 5A \]
\[ MC = 20 + 3A \]

The optimal level of A is

a. 40  
b. 30  
c. 20  
d. 10  
e. 0  
Answer: d  
Difficulty: 01 Easy  
Topic: Unconstrained Maximization  
AACSB: Analytic  
Blooms: Apply  
Learning Objective: 03-02

3-21 Use the following marginal benefit and marginal cost functions for activity A:

\[ MB = 100 - 5A \]
\[ MC = 20 + 3A \]

The fifth unit of activity A will
a. increase net benefits by 75.
b. reduce net benefits by 35.
c. increase net benefits by 40.
d. decrease net benefits by 40.
e. reduce net benefits by 75.
Answer: c
Difficulty: 03 Hard
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03

3-22 In order to minimize the net cost of pollution reduction, the level of pollution reduction (the amount of a pollutant not released into the environment) should be the level at which
a. the marginal benefit of reducing pollution exceeds the marginal cost of reducing pollution by the greatest possible amount.
b. the total benefit of reducing pollution equals the total cost of reducing pollution.
c. the marginal benefit of reducing pollution equals the marginal cost of reducing pollution.
d. the total cost of reducing pollution is minimized and the total benefits of reducing pollution are maximized.
Answer: c
Difficulty: 01 Easy
Topic: Unconstrained Maximization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-02

3-23 When the choice variable is a continuous variable, the decision rule for an unconstrained maximization problem is:

a. If $MB > MC$, increase the activity.
b. If $MB < MC$, decrease the activity.
c. Choose the activity so that $MB = MC$.
d. all of the above

e. none of the above
Answer: d
Difficulty: 01 Easy
Topic: Unconstrained Maximization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-02

3-24 If profits depend on both how much is produced (output) and on the level of advertising, then a profit-maximizing firm should choose the levels of output and advertising at which
a. the marginal revenue of output equals the marginal cost of output.
b. the addition to total revenue of the last unit of advertising equals the addition to total cost of the last unit of advertising.
c. total revenue equals total cost for both output and advertising.
d. both a and b

e. both b and c
Answer: d
Difficulty: 01 Easy
3-25 Gigi consumes only Perrier and cheese. In order to maximize her happiness subject to limited income, Gigi should purchase the amounts of Perrier and cheese at which

a. the addition to happiness of the last bottle of Perrier is the same as the addition to happiness of the last pound of cheese.
b. the addition to happiness per dollar spent on Perrier is the same as the addition to happiness per dollar spent on cheese.
c. she spends all her income.
d. both b and c
e. both a and c

Answer: d

Difficulty: 01 Easy

Topic: Unconstrained Maximization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-02

3-26 A firm is deciding whether or not to close down its plant and modernize by installing new technology. Which of the following should management ignore when making the decision?

a. How much the present plant cost
b. Cost of lost sales while the plant is closed
c. Added cost of the labor needed for the new plant
d. All of the above

Answer: a

Difficulty: 01 Easy

Topic: Unconstrained Maximization
AACSB: Reflective Thinking
Blooms: Understand
Learning Objective: 03-02

3-27 In making a decision about whether to increase its advertising budget the firm management should not consider

a. the added revenue from increased sales.
b. the added cost of producing more goods for sale.
c. interest payments on the firm’s loan.
d. the cost of the increased advertising.
e. none of the above

Answer: c

Difficulty: 01 Easy

Topic: Unconstrained Maximization
AACSB: Reflective Thinking
Blooms: Understand
Learning Objective: 03-02

3-28 Which of the following statements represents bad decision making?

a. I’ve already spent 3 years in the college so I can’t drop out and go to work now.
b. I’ve already paid for the ticket so I might as well stay to the end.
c. I’ve put in so much time on this paper, I can’t quit now.
Chapter 3: MARGINAL ANALYSIS FOR OPTIMAL DECISION MAKING

A firm can maximize profit (net benefit) by choosing to produce that level of output at which:

a. the difference between the additional revenue from the last unit sold and the additional cost of that unit is maximized.
b. the additional revenue from the last unit sold equals the additional cost of that unit.
c. the additional revenue from the last unit sold is just a little more than the additional cost of that unit.
d. total revenue equals total cost.

Answer: b

A clinic uses doctors and nurses optimally and is servicing the maximum number of patients given a limited annual payroll. The last doctor hired treated 1,600 extra patients in a year, while the last nurse hired treated 1,000 extra patients in a year. If doctors make $40,000 a year, what do nurses make?

a. $25,000 a year
b. $20,000 a year
c. $15,000 a year
d. $10,000 a year

Answer: a

A clinic uses doctors and nurses optimally and is servicing the maximum number of patients given a limited annual payroll. The last doctor hired treated 1,600 extra patients in a year, while the last nurse hired treated 1,000 extra patients in a year. If doctors make $80,000 a year and nurses make $40,000 a year, then

a. the clinic could serve more patients by hiring more doctors and fewer nurses.
b. the clinic could serve more patients by hiring fewer doctors and more nurses.
c. the clinic is making the correct decision because doctors are more productive than nurses.
d. the clinic is not making the correct decision because the additional patients per dollar spent on doctors is greater than the additional patients per dollar spent on nurses.
e. both a and d.

Answer: b
A clinic uses doctors and nurses optimally and is servicing the maximum number of patients given a limited annual payroll. The last doctor hired treated 1,600 extra patients in a year, while the last nurse hired treated 1,000 extra patients in a year. If doctors make $50,000 a year and nurses make $40,000 a year, then

a. the clinic could serve more patients by hiring more doctors and fewer nurses.
b. the clinic could serve more patients by hiring fewer doctors and more nurses.
c. the clinic is making the correct decision.
d. the clinic is not making the correct decision because the additional patients per dollar spent on doctors is greater than the additional patients per dollar spent on nurses.
e. a and d

Answer: e

Difficulty: 02 Medium
Topic: Unconstrained Maximization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-02

In order to minimize the NET costs associated with crime,
a. steps must be taken to eliminate all crime.
b. crime should be reduced to the level at which the total benefit from crime equals the total cost of crime prevention.
c. crime should be reduced to the level at which the marginal cost from crime equals the marginal cost of crime prevention.
d. no crime should be eliminated.

Answer: c

Difficulty: 02 Medium
Topic: Unconstrained Maximization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-02
The optimization rule for unconstrained optimization is to select that level of activity at which
a. marginal benefit equals marginal cost.
b. total benefit is less than total cost.
c. total benefit is equal to total cost.
d. marginal benefit exceeds marginal cost.
Answer: a
Difficulty: 01 Easy
Topic: Unconstrained Maximization
AACSB: Reflective Thinking
Blooms: Understand
Learning Objective: 03-02

Whenever the additional revenue from the last unit of output exceeds the additional cost of that
unit, a profit-maximizing firm should
a. do nothing, the firm is making profits.
b. produce less in order to increase profits.
c. produce more in order to increase profits.
d. think about investing in another industry.
Answer: c
Difficulty: 01 Easy
Topic: Unconstrained Maximization
AACSB: Reflective Thinking
Blooms: Understand
Learning Objective: 03-02

A toy manufacturer is experiencing quality problems on its assembly line. Every defective toy
that leaves the factory costs the firm $20. The firm has decided to hire quality inspectors to catch
defective toys before they leave the factory.

<table>
<thead>
<tr>
<th>Number of Inspectors</th>
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<tr>
<td>0</td>
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<td>1</td>
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<td>0</td>
</tr>
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</table>

Given the above information, if each inspector is paid $100 a day, how many inspectors should
the firm hire to minimize the total cost of defective toys?
a. 3
b. 4
c. 5
d. 6
Answer: a
A toy manufacturer is experiencing quality problems on its assembly line. Every defective toy that leaves the factory costs the firm $20. The firm has decided to hire quality inspectors to catch defective toys before they leave the factory.

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</tbody>
</table>

Given the above information, if the cost of each defective toy rises to $50, while inspectors are paid $150 a day, how many inspectors should the firm hire?

a. 3  
b. 4  
c. 5  
d. 6  
Answer: c  
Difficulty: 03 Hard  
Topic: Unconstrained Maximization  
AACSB: Analytic  
Blooms: Apply  
Learning Objective: 03-02

Gonzo consumes only two things—coke and hot dogs. We can define the addition to "happiness" of consuming an additional coke as the marginal utility of coke and that for hot dogs as the marginal utility of hot dogs. The prices of coke and hot dogs are fixed and Gonzo has a limited budget. To maximize "happiness" subject to his limited budget, Gonzo should purchase coke and hot dogs so that

a. the marginal utility of coke is the same as the marginal utility of hot dogs.  
b. he spends the same amount on coke as on hot dogs.  
c. the addition to happiness of the last coke is the same as the addition to happiness of the last hot dog.  
d. the addition to happiness per dollar spent on coke is the same as the addition to happiness per dollar spent on hot dogs.  
Answer: d  
Difficulty: 02 Medium
A manager in charge of new product development can hire engineers and market researchers. The annual salary of an engineer is $30,000 and that of a market researcher is $20,000. The marginal contribution of engineers and market researchers are

<table>
<thead>
<tr>
<th>Worker</th>
<th>Engineers ($E$)</th>
<th>Market Researchers ($R$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Additional New Products</td>
<td>Additional New Products</td>
</tr>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>50</td>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
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<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
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<td>4&lt;sup&gt;th&lt;/sup&gt;</td>
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<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt;</td>
<td>8</td>
<td>5&lt;sup&gt;th&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Given the above information, if the manager has an annual budget of $120,000, how should this budget be allocated in order to maximize the number of new products developed?

a. Hire two engineers and one market researcher.
b. Hire two engineers and three market researchers.
c. Hire three engineers and two market researchers.
d. Hire three engineers and four market researchers.

Answer: b

Difficulty: 02 Medium

Topic: Constrained Optimization

AACSB: Analytic

Blooms: Apply

Learning Objective: 03-03
3-41 A manager in charge of new product development can hire engineers and market researchers. The annual salary of an engineer is $30,000 and that of a market researcher is $20,000. The marginal contribution of engineers and market researchers are

<table>
<thead>
<tr>
<th></th>
<th>Engineers (E)</th>
<th>Market Researchers (R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worker</td>
<td>Additional New Products</td>
<td>Worker</td>
</tr>
<tr>
<td>1\textsuperscript{st}</td>
<td>50</td>
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<tr>
<td>5\textsuperscript{th}</td>
<td>8</td>
<td>5\textsuperscript{th}</td>
</tr>
</tbody>
</table>

Given the above information, if the manager currently has two engineers and one market researcher, what must be true?

a. He is making the correct decision because \( MP_e = MP_r \).
b. He is not making the correct decision because \( MP_e / P_e > MP_r / P_r \).
c. Fewer new products will be developed if he hires fewer engineers and more market researchers.
d. More new products will be developed if he hires fewer engineers and more market researchers.

Answer: d

Difficulty: 03 Hard
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03

3-42 A clinic uses doctors and nurses to serve the maximum number of patients given a limited annual payroll. The clinic currently has 10 doctors and 30 nurses. The last doctor hired can serve 300 additional patients, while the last nurse hired can serve 200 additional patients. If doctors make $60,000 a year and nurses make $20,000 a year, the clinic

a. is making the correct hiring decision because doctors are more productive than nurses.
b. is making the correct hiring decision because doctors are paid more than nurses.
c. could serve more patients with the same payroll by hiring more doctors and fewer nurses.
d. could serve more patients with the same payroll by hiring more nurses and fewer doctors.

Answer: d

Difficulty: 02 Medium
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03
The optimal level of pollution reduction is that level at which
a. the total benefits of pollution reduction exceed the total cost of pollution reduction by the largest amount.
b. the total benefits of pollution reduction equal the total cost of pollution reduction.
c. the marginal benefit of pollution reduction exceeds the marginal cost of pollution reduction by the largest amount.
d. the additional benefit of the last unit of pollution reduction equals the additional cost of the last unit of pollution reduction.
e. both a and d

Answer: e

A Blue Ribbon Committee has decided that acid rain should be reduced and is trying to determine the optimal level of reduction. There are benefits from reducing acid rain (more wildlife and forests, better health, etc.), but there are also costs. The committee estimates that the marginal benefit of each unit of reduction is $1,400 − 5R, where R is units of reduction, and the marginal cost is 2R. If the committee wants to maximize the net benefit from reducing acid rain, what is the optimal level of pollution reduction?

a. $10
b. $20
c. $100
d. $200

Answer: d

A Blue Ribbon Committee has decided that acid rain should be reduced and is trying to determine the optimal level of reduction. There are benefits from reducing acid rain (more wildlife and forests, better health, etc.), but there are also costs. The committee estimates that the marginal benefit of each unit of reduction is $700 − 5R, where R is units of reduction, and the marginal cost is 2R. If the committee wants to maximize the net benefit from reducing acid rain, what is the optimal level of pollution reduction?

a. 10
b. 20
c. 100
d. 200

Answer: c
If profits depend on both how much is produced (output) and the level of quality, then a profit-maximizing firm should choose the levels of output and quality at which

a. The marginal revenue of output exceeds the marginal cost of output by the largest amount.
b. The marginal revenue of quality exceeds the marginal cost of quality by the largest amount.
c. The difference between the addition to total revenue and the addition to total cost of the last units of output and quality is the greatest.
d. both a and b

e. none of the above

Answer: e

Difficulty: 02 Medium

Topic: Constrained Optimization

AACS: Analytic

Blooms: Apply

Learning Objective: 03-03

A manager in charge of new product development can hire engineers and market researchers. The annual salary of an engineer is $40,000, while a market researcher receives $20,000. The marginal contributions of engineers and market researchers are:

<table>
<thead>
<tr>
<th>Engineers (E)</th>
<th>Market Researchers (R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worker</td>
<td>Additional New Products</td>
</tr>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>50</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>40</td>
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<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
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<td>20</td>
</tr>
<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt;</td>
<td>10</td>
</tr>
</tbody>
</table>

Based on the above information, how should the manager with an annual budget of $160,000, allocate this budget in order to maximize the number of new products developed?

a. Hire 2 engineers and 1 market researcher.
b. Hire 3 engineers and 2 market researchers.
c. Hire 4 engineers and 3 market researchers.
d. Hire 4 engineers and 1 market researcher.

Answer: b

Difficulty: 03 Hard

Topic: Constrained Optimization

AACS: Analytic

Blooms: Apply

Learning Objective: 03-03
A manager in charge of new product development can hire engineers and market researchers. The annual salary of an engineer is $40,000, while a market researcher receives $20,000. The marginal contributions of engineers and market researchers are:

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<td>5\text{th}</td>
<td>10</td>
<td>5\text{th}</td>
<td>2</td>
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</tbody>
</table>

Based on the above information, if the manager currently hires four engineers and one market researcher, what must be true?

a. She is making the correct decision because $MP_E = MP_R$.

b. More new products would be developed if she hires more engineers and fewer market researchers.

c. More new products would be developed if she hires fewer engineers and more market researchers.

d. She is not making the correct decision because engineers are more productive than market researchers at all levels of output.

Answer: c

A radio manufacturer is experiencing theft problems at its warehouse and has decided to hire security guards to reduce the thefts. The firm wants to minimize the net cost of warehouse thefts.

<table>
<thead>
<tr>
<th>Number of Security Guards</th>
<th>Number of Radios Stolen Per Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>1</td>
<td>30</td>
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<tr>
<td>2</td>
<td>20</td>
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<td>14</td>
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<td>4</td>
<td>8</td>
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<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

Chapter 3: MARGINAL ANALYSIS FOR OPTIMAL DECISION MAKING

© 2016 by McGraw-Hill Education. This is proprietary material solely for authorized instructor use. Not authorized for sale or distribution in any manner. This document may not be copied, scanned, duplicated, forwarded, distributed, or posted on a website, in whole or part.
Given the above info, if each security guard is paid $200 a week and the cost of a stolen radio is $25, how many security guards should the firm hire?

a. 1  
b. 2  
c. 3  
d. 4  
e. 5

Answer: b  
Difficulty: 02 Medium  
Topic: Constrained Optimization  
AACSB: Analytic  
Blooms: Apply  
Learning Objective: 03-03

3-50  A radio manufacturer is experiencing theft problems at its warehouse and has decided to hire security guards to reduce the thefts. The firm wants to minimize the net cost of warehouse thefts.

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<td>20</td>
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<td>3</td>
<td>14</td>
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<tr>
<td>4</td>
<td>8</td>
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<tr>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

Given the above info, if the cost of a stolen radio is $25, what is the MOST the firm would be willing to pay to hire the first security guard?

a. $200  
b. $250  
c. $500  
d. $750

Answer: c  
Difficulty: 02 Medium  
Topic: Constrained Optimization  
AACSB: Analytic  
Blooms: Apply  
Learning Objective: 03-03
3-51 A radio manufacturer is experiencing theft problems at its warehouse and has decided to hire security guards to reduce the thefts. The firm wants to minimize the net cost of warehouse thefts.

<table>
<thead>
<tr>
<th>Number of Security Guards</th>
<th>Number of Radios Stolen Per Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>1</td>
<td>30</td>
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<tr>
<td>2</td>
<td>20</td>
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<tr>
<td>3</td>
<td>14</td>
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<tr>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

Given the above info, if each security guard is paid $200 a week and the cost of a stolen radio is $50, how many security guards should the firm hire?

a. 1  
b. 2  
c. 3  
d. 4  
e. 5  

Answer: d

Difficulty: 02 Medium
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03

3-52 A radio manufacturer is experiencing theft problems at its warehouse and has decided to hire security guards to reduce the thefts. The firm wants to minimize the net cost of warehouse thefts.

<table>
<thead>
<tr>
<th>Number of Security Guards</th>
<th>Number of Radios Stolen Per Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>1</td>
<td>30</td>
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<tr>
<td>2</td>
<td>20</td>
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<tr>
<td>3</td>
<td>14</td>
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<td>4</td>
<td>8</td>
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<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

Given the above info, in order to minimize the NET cost of theft, a firm should choose the level of theft prevention at which
a. theft is eliminated.
b. the marginal benefit of theft equals the marginal cost of the theft.
c. the total benefit of theft prevention equals the total cost of the theft prevention.
d. the marginal benefit of theft prevention equals the marginal cost of preventing theft.
e. the total cost of theft prevention equals the total cost of preventing theft.

Answer: d

Difficulty: 01 Easy

Topic: Concepts and Terminology

AACSB: Reflective Thinking

Blooms: Understand

Learning Objective: 03-01

3-53 The manager of the customer service department at a bank can hire employees with a high school degree (HS) who earn $10,000 annually or employees with a bachelor's degree (B) who earn $20,000. The manager wants to maximize the number of customers served given a fixed payroll.

<table>
<thead>
<tr>
<th>Worker</th>
<th>Number of Additional Customers Served</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High School Degree</td>
</tr>
<tr>
<td>1st</td>
<td>80</td>
</tr>
<tr>
<td>2nd</td>
<td>60</td>
</tr>
<tr>
<td>3rd</td>
<td>50</td>
</tr>
<tr>
<td>4th</td>
<td>40</td>
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<tr>
<td>5th</td>
<td>35</td>
</tr>
<tr>
<td>6th</td>
<td>30</td>
</tr>
</tbody>
</table>

Given the above info, if the manager has a payroll of $80,000, how should the budget be allocated in order to maximize the number of customers served?

a. Hire two HS and three B.
b. Hire four HS and two B.
c. Hire one HS and two B.
d. Hire three HS and one B.

Answer: b

Difficulty: 02 Medium

Topic: Constrained Optimization

AACSB: Analytic

Blooms: Apply

Learning Objective: 03-03
The manager of the customer service department at a bank can hire employees with a high school degree (HS) who earn $10,000 annually or employees with a bachelor's degree (B) who earn $20,000. The manager wants to maximize the number of customers served given a fixed payroll.

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
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<td>80</td>
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<tr>
<td>2nd</td>
<td>60</td>
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<td>3rd</td>
<td>50</td>
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<td>4th</td>
<td>40</td>
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<td>5th</td>
<td>35</td>
</tr>
<tr>
<td>6th</td>
<td>30</td>
</tr>
</tbody>
</table>

Given the above info, if the manager currently has three HS and three B, what must be true?

- a. More customers could be served if the manager hires fewer HS and more B.
- b. More customers could be served if the manager hires more HS and fewer B.
- c. The manager is making the correct decision because the marginal contributions are proportionate.
- d. The manager is not making the correct decision because bachelor’s degree holders are more productive at all levels of customer served.

Answer: b

Difficulty: 02 Medium

Topic: Constrained Optimization

AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03

The manager of the customer service department at a bank can hire employees with a high school degree (HS) who earn $10,000 annually or employees with a bachelor's degree (B) who earn $20,000. The manager wants to maximize the number of customers served given a fixed payroll.

<table>
<thead>
<tr>
<th>Worker</th>
<th>Number of Additional Customers Served</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>5th</td>
<td>35</td>
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<td>6th</td>
<td>30</td>
</tr>
</tbody>
</table>

Given the above info, if the manager's payroll is $120,000, what should be done to maximize the number of customers served?
a. Hire six HS and three B.
b. Hire five HS and five B.
c. Hire four HS and four B.
d. Hire two HS and five B.

Answer: a

Difficulty: 02 Medium

Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03

3-56 A government agency is having problems with personal telephone calls made during working hours. Because each minute of a personal call costs the agency $0.50 in wasted wages, it has decided to hire operators to monitor calls. The agency wants to hire the number of operators that will minimize the total cost of personal calls.

<table>
<thead>
<tr>
<th>Number of operators</th>
<th>Minutes of personal calls(per week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3900</td>
</tr>
<tr>
<td>1</td>
<td>2300</td>
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<td>3</td>
<td>600</td>
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<tr>
<td>4</td>
<td>100</td>
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<td>5</td>
<td>0</td>
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</tbody>
</table>

Based on the above information, if operators receive $300 a week, how many operators should the agency hire?

a. 0
b. 1
c. 3
d. 5

Answer: c

Difficulty: 02 Medium

Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03
A government agency is having problems with personal telephone calls made during working hours. Because each minute of a personal call costs the agency $0.50 in wasted wages, it has decided to hire operators to monitor calls. The agency wants to hire the number of operators that will minimize the total cost of personal calls.

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<td>600</td>
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<tr>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>

Based on the above information, what is the most the agency would be willing to pay the fifth operator?

a. $100  
   b. $200  
   c. $400  
   d. $500  
   e. none of the above

Answer: e

Difficulty: 02 Medium
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03

A government agency is having problems with personal telephone calls made during working hours. Because each minute of a personal call costs the agency $0.50 in wasted wages, it has decided to hire operators to monitor calls. The agency wants to hire the number of operators that will minimize the total cost of personal calls.

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<td>4</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>
Based on the above information, if operators receive $400 a week, what is the lowest possible total cost of personal calls?

a. $650
b. $800
c. $1450
d. $1500

Answer: c

Difficulty: 02 Medium
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03

3-59 The optimal level of any activity is that level for which
a. total benefit exceeds total cost by the greatest amount.
b. marginal benefit exceeds marginal cost by the greatest possible amount.
c. both \( a \) and \( b \)
d. none of the above

Answer: a

Difficulty: 02 Medium
Topic: Constrained Optimization
AACSB: Reflective Thinking
Blooms: Understand
Learning Objective: 03-03

3-60 Dr. X, an assistant professor at a large state university, is trying to decide how to allocate the 50 hours a week she spends working among the various activities expected of an assistant professor. The professor wants to maximize her raise next year and the table shows estimates of how time spent in each activity will contribute to her raise:

<table>
<thead>
<tr>
<th>Hours Per Week</th>
<th>Total Amount of Raise From:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Research</td>
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<tr>
<td>14</td>
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<tr>
<td>19</td>
<td>850</td>
</tr>
<tr>
<td>20</td>
<td>900</td>
</tr>
<tr>
<td>21</td>
<td>905</td>
</tr>
</tbody>
</table>

Given the above information, how should she allocate her time?

a. 20 hours research, 15 hours teaching, 15 hours service
b. 17 hours research, 17 hours teaching, 16 hours service
3-61 Dr. X, an assistant professor at a large state university, is trying to decide how to allocate the 50 hours a week she spends working among the various activities expected of an assistant professor. The professor wants to maximize her raise next year and the table shows estimates of how time spent in each activity will contribute to her raise:

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<td>400</td>
</tr>
<tr>
<td>16</td>
<td>550</td>
</tr>
<tr>
<td>17</td>
<td>675</td>
</tr>
<tr>
<td>18</td>
<td>775</td>
</tr>
<tr>
<td>19</td>
<td>850</td>
</tr>
<tr>
<td>20</td>
<td>900</td>
</tr>
<tr>
<td>21</td>
<td>905</td>
</tr>
</tbody>
</table>

Given the above information, what is Dr. X's maximum possible raise if she works 50 hours?

- a. $1495
- b. $1600
- c. $1845
- d. $1860

Answer: b

Difficulty: 03 Hard
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03

3-62 Dr. X, an assistant professor at a large state university, is trying to decide how to allocate the 50 hours a week she spends working among the various activities expected of an assistant professor. The professor wants to maximize her raise next year and the table shows estimates of how time spent in each activity will contribute to her raise:

<table>
<thead>
<tr>
<th>Hours Per Week</th>
<th>Total Amount of Raise From:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Research</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Chapter 3: MARGINAL ANALYSIS FOR OPTIMAL DECISION MAKING

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Given the above information, if she decides that she will work 54 hours a week instead, how should she allocate her time?

a. 18 hours research, 18 hours teaching, 18 hours service
b. 21 hours research, 19 hours teaching, 17 hours service
c. 20 hours research, 17 hours teaching, 17 hours service
d. 20 hours research, 18 hours teaching, 16 hours service

Answer: d

Difficulty: 03 Hard
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03

A dentist’s office, which wants to serve the maximum number of patients given a fixed payroll, currently has two dentists and four dental hygienists. Dentists earn $60,000 a year and hygienists earn $15,000 a year. If the office is hiring the optimal combination of dentists and hygienists, and the last dentist hired served 120 additional patients, how many patients will the last hygienist hired add?

a. 30
b. 60
c. 120
d. 240

Answer: a

Difficulty: 02 Medium
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03

A publishing house is using 400 printers and 200 printing presses to produce books. The printers’ wage rate is $20 and the price of a printing press is $100. The last printer added 20 books to total output, while the last press added 50 books to total output. In order to maximize the number of books published with a budget of $28,000, the publishing house

a. should continue to use 400 printers and 200 presses.
b. should use more printers and fewer presses because printers cost less than presses.
c. should use more printers and fewer presses because the last dollar spent on a printer yielded more output than the last dollar spent on a press.
d. should use more presses and fewer printers because the marginal output of the last press was more than the marginal output of the last printer.
e. should use more presses and fewer printers because the last dollar spent on a press yielded more output than the last dollar spent on a printer.

Answer: c

Difficulty: 02 Medium
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03

3-65 A housecleaning company receives $25 for each house cleaned. The table below gives the relation between the number of workers and the number of houses that can be cleaned per week.

<table>
<thead>
<tr>
<th>Number of Workers</th>
<th>Houses Cleaned</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>5</td>
<td>35</td>
</tr>
</tbody>
</table>

Based on the above info, the marginal revenue from the fourth worker is
a. $6.
b. $30.
c. $150.
d. $750
e. none of the above

Answer: c

Difficulty: 02 Medium
Topic: Unconstrained Maximization
AACSB: Reflective Thinking
Blooms: Understand
Learning Objective: 03-02

3-66 A housecleaning company receives $25 for each house cleaned. The table below gives the relation between the number of workers and the number of houses that can be cleaned per week.

<table>
<thead>
<tr>
<th>Number of Workers</th>
<th>Houses Cleaned</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>5</td>
<td>35</td>
</tr>
</tbody>
</table>

Chapter 3: MARGINAL ANALYSIS FOR OPTIMAL DECISION MAKING
Based on the above info, if the company want to maximize profit and hires three workers, the wage rate of a housecleaner can be no more than
a. $175.
b. $200.
c. $225.
d. $600.
e. none of the above
Answer: a
Difficulty: 03 Hard
Topic: Unconstrained Maximization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-02

3-67 A housecleaning company receives $25 for each house cleaned. The table below gives the relation between the number of workers and the number of houses that can be cleaned per week.

<table>
<thead>
<tr>
<th>Number of Workers</th>
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</thead>
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<tr>
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<td>17</td>
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<tr>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>5</td>
<td>35</td>
</tr>
</tbody>
</table>

Based on the above info, if the wage rate of a housecleaner is $130, what is the maximum amount of profit the company can earn?
a. $ 20 
b. $150 
c. $230 
d. $750 
e. none of the above
Answer: c
Difficulty: 02 Medium
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03

3-68 A restaurant currently has two cooks and ten waiters. Cooks earn $10 an hour and waiters earn $5 an hour. The last cook added 40 meals served to total output, while the last waiter added 25 meals served to total output. In order to maximize the number of meals served with a fixed budget, the manager should
a. continue to use two cooks and ten waiters because output is being maximized.
b. should use more cooks and fewer waiters because cooks are more productive than waiters.
c. should use more cooks and fewer waiters because productivity per dollar is higher for cooks than for waiters.
d. should use more waiters and fewer cooks because waiters are paid less than cooks.
e. should use more waiters and fewer cooks because productivity per dollar is higher for waiters than for cooks.
Randolph is taking three courses this semester: economics, statistics, and finance. He has decided to spend 20 hours per week studying (in addition to attending all his classes) and his objective is to maximize his average grade, which means maximizing the total of his grades in the three courses. The table shows Randolph's estimate of the relation between time spent studying and his grade for each course.

<table>
<thead>
<tr>
<th>Hours of study</th>
<th>Economics</th>
<th>Statistics</th>
<th>Finance</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>63</td>
<td>54</td>
<td>68</td>
</tr>
<tr>
<td>5</td>
<td>72</td>
<td>64</td>
<td>76</td>
</tr>
<tr>
<td>6</td>
<td>79</td>
<td>72</td>
<td>82</td>
</tr>
<tr>
<td>7</td>
<td>85</td>
<td>78</td>
<td>87</td>
</tr>
<tr>
<td>8</td>
<td>88</td>
<td>83</td>
<td>90</td>
</tr>
<tr>
<td>9</td>
<td>90</td>
<td>87</td>
<td>93</td>
</tr>
<tr>
<td>10</td>
<td>92</td>
<td>89</td>
<td>95</td>
</tr>
</tbody>
</table>

Based on the above info, how should Randolph allocate his time?

a. 7 hours economics, 7 hours statistics, 6 hours finance  
b. 6 hours economics, 6 hours statistics, 8 hours finance  
c. 7 hours economics, 6 hours statistics, 5 hours finance  
d. 6 hours economics, 5 hours statistics, 7 hours finance

Answer: a
Based on the above info, what is the maximum AVERAGE grade Randolph can earn if he studies 20 hours per week?

- a. 80
- b. 80.3
- c. 82
- d. 81.7

Answer: d

Difficulty: 03 Hard
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03

3-71 A package delivery service uses vans and employees to deliver the maximum number of packages given a fixed budget. The last van added 600 packages to total output, while the last employee added 500 packages. If vans cost $400 per week and employees earn $300 per week, the firm

- a. could deliver more packages with the same budget by using more employees and fewer vans.
- b. could deliver more packages with the same budget by using more vans and fewer employees.
- c. should use more vans and fewer employees because the last dollar spent on vans added more to total output than the last dollar spent on employees.
- d. is delivering the maximum number of packages given the fixed budget.
- e. both b and c

Answer: e

Difficulty: 02 Medium
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03

3-72 A grocery store hires cashiers and baggers. Cashiers earn $8 an hour; baggers earn $4 an hour. The manager, who wants to maximize the number of customers served given a fixed payroll, expects the following productivity from cashiers and baggers:

<table>
<thead>
<tr>
<th>Number of employees</th>
<th>Total number of customers served</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cashiers</td>
</tr>
<tr>
<td>1</td>
<td>240</td>
</tr>
<tr>
<td>2</td>
<td>440</td>
</tr>
<tr>
<td>3</td>
<td>600</td>
</tr>
<tr>
<td>4</td>
<td>712</td>
</tr>
<tr>
<td>5</td>
<td>776</td>
</tr>
</tbody>
</table>
Given the above information, with a payroll of $32 (per hour), how should the manager allocate this budget?

a. Hire three cashiers and two baggers
b. Hire two cashiers and four baggers
c. Hire two cashiers and three baggers
d. Hire four cashiers and one bagger

Answer: b

Difficulty: 02 Medium
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03

A grocery store hires cashiers and baggers. Cashiers earn $8 an hour; baggers earn $4 an hour. The manager, who wants to maximize the number of customers served given a fixed payroll, expects the following productivity from cashiers and baggers:

<table>
<thead>
<tr>
<th>Number of employees</th>
<th>Total number of customers served</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cashiers</td>
</tr>
<tr>
<td>1</td>
<td>240</td>
</tr>
<tr>
<td>2</td>
<td>440</td>
</tr>
<tr>
<td>3</td>
<td>600</td>
</tr>
<tr>
<td>4</td>
<td>712</td>
</tr>
<tr>
<td>5</td>
<td>776</td>
</tr>
</tbody>
</table>

Given the above information, what is the maximum possible number of customers that can be served with a payroll of $32?

a. 1208
b. 936
c. 864
d. 312
e. none of the above

Answer: b

Difficulty: 02 Medium
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03

If the marginal benefits of increasing study time are less than the marginal costs, then

a. study time should be decreased to zero.
b. study time should be decreased.
c. no conclusion about the relative merits of more or less study time is possible.
d. there is too little study time.
e. study time should be increased.

Answer: b

Difficulty: 01 Easy
Topic: Concepts and Terminology
AACSB: Reflective Thinking
Blooms: Understand
Learning Objective: 03-01
A restaurant hires cooks and waiters. Cooks earn $10 an hour; waiters earn $5 an hour. The manager, who wants to maximize the number of meals served given a fixed payroll of $45 per hour, expects the following from cooks and waiters:

<table>
<thead>
<tr>
<th>Number of employees</th>
<th>Total number of meals served</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cooks</td>
</tr>
<tr>
<td>1</td>
<td>200</td>
</tr>
<tr>
<td>2</td>
<td>380</td>
</tr>
<tr>
<td>3</td>
<td>540</td>
</tr>
<tr>
<td>4</td>
<td>660</td>
</tr>
<tr>
<td>5</td>
<td>740</td>
</tr>
</tbody>
</table>

Given the above information, the manager should hire
a. 2 cooks and 4 waiters.
b. 2 cooks and 5 waiters.
c. 3 cooks and 2 waiters.
d. 3 cooks and 4 waiters.
e. none of the above
Answer: e
Difficulty: 02 Medium
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03
Given the above information, and given the fixed payroll, the maximum number of meals that can be served is
a. 240.
b. 670.
c. 850.
d. 1,130.
e. none of the above
Answer: c
Difficulty: 02 Medium
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03

A restaurant hires cooks and waiters. Cooks earn $10 an hour; waiters earn $5 an hour. The manager, who wants to maximize the number of meals served given a fixed payroll of $45 per hour, expects the following from cooks and waiters:

<table>
<thead>
<tr>
<th>Number of employees</th>
<th>Total number of meals served</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cooks</td>
</tr>
<tr>
<td>1</td>
<td>200</td>
</tr>
<tr>
<td>2</td>
<td>380</td>
</tr>
<tr>
<td>3</td>
<td>540</td>
</tr>
<tr>
<td>4</td>
<td>660</td>
</tr>
<tr>
<td>5</td>
<td>740</td>
</tr>
</tbody>
</table>

Given the above information, at the optimal choice, the last dollar spent on hiring waiters yielded
a. 6 additional meals.
b. 16 additional meals.
c. 80 additional meals.
d. 60 additional meals.
e. none of the above
Answer: a
Difficulty: 02 Medium
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03
A metal refining plant emits sulfur dioxide into the air and has decided to install air scrubbers to reduce the amount of pollution. Each scrubber costs $180,000 and the Environmental Protection Agency (EPA) fines the plant $5,000 for every part of pollution emitted per million.

<table>
<thead>
<tr>
<th>Number of air scrubbers</th>
<th>Amount of pollution (parts per million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>150</td>
</tr>
<tr>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>60</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>

Based on the information above, the first air scrubber decreases the total cost of pollution by $70,000.

a. increases, $180,000  
b. increases, $530,000  
c. decreases, $70,000  
d. decreases, $250,000  
e. none of the above

Answer: c

Difficulty: 02 Medium
Topic: Constrained Optimization
AACSBA: Analytic
Blooms: Apply
Learning Objective: 03-03
A metal refining plant emits sulfur dioxide into the air and has decided to install air scrubbers to reduce the amount of pollution. Each scrubber costs $180,000 and the Environmental Protection Agency (EPA) fines the plant $5,000 for every part of pollution emitted per million.

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</tr>
<tr>
<td>2</td>
<td>60</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>

Based on the information above, how many air scrubbers should the plant install in order to minimize the total cost of pollution?

a. 1  
b. 2  
c. 3  
d. 4  
e. 5  
Answer: b  
Difficulty: 02 Medium  
Topic: Constrained Optimization  
AACS: Analytic  
Blooms: Apply  
Learning Objective: 03-03

A politician, who wants to receive the maximum number of votes, spends 9 hours a week speaking to various groups. The table below shows his estimates of how time spent with each group will affect the number of votes he receives:

<table>
<thead>
<tr>
<th>Hours Per Week</th>
<th>Loyal Party Members (LMP)</th>
<th>Town Meetings (TM)</th>
<th>Local Civic Leaders (LCL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>400</td>
<td>200</td>
<td>300</td>
</tr>
<tr>
<td>2</td>
<td>750</td>
<td>380</td>
<td>560</td>
</tr>
<tr>
<td>3</td>
<td>1050</td>
<td>530</td>
<td>760</td>
</tr>
<tr>
<td>4</td>
<td>1300</td>
<td>640</td>
<td>920</td>
</tr>
<tr>
<td>5</td>
<td>1500</td>
<td>700</td>
<td>1000</td>
</tr>
<tr>
<td>6</td>
<td>1600</td>
<td>740</td>
<td>1060</td>
</tr>
</tbody>
</table>
Based on the information above, how should the politician allocate his speaking time?

a. 3 hours to LPM, 3 hours to TM, 3 hours to LCL
b. 4 hours to LPM, 2 hours to TM, 3 hours to LCL
c. 5 hours to LPM, 1 hour to TM, 3 hours to LCL
d. 5 hours to LPM, 2 hours to TM, 2 hours to LCL

Answer: c

Difficulty: 03 Hard
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03

A politician, who wants to receive the maximum number of votes, spends 9 hours a week speaking to various groups. The table below shows his estimates of how time spent with each group will affect the number of votes he receives:

<table>
<thead>
<tr>
<th>Hours Per Week</th>
<th>Total Number of Votes from Speaking to:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Loyal Party Members (LMP)</td>
</tr>
<tr>
<td>1</td>
<td>400</td>
</tr>
<tr>
<td>2</td>
<td>750</td>
</tr>
<tr>
<td>3</td>
<td>1050</td>
</tr>
<tr>
<td>4</td>
<td>1300</td>
</tr>
<tr>
<td>5</td>
<td>1500</td>
</tr>
<tr>
<td>6</td>
<td>1600</td>
</tr>
</tbody>
</table>

Based on the information above, how many EXTRA votes will the politician receive if he devotes one more hour to speaking engagements (i.e., speaks 10 instead of 9 hours per week)?

a. 150
b. 180
c. 200
d. 380
e. none of the above

Answer: b

Difficulty: 03 Hard
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03

A package delivery service currently has 12 vans and 16 employees. Vans cost $400 per week and employees earn $300 per week. The last van added 480 packages delivered to total output, while the last employee added 450 packages. The firm

a. is making the correct decision because the dollar expenditure ($4800) is equal for vans and employees.
b. should use more vans and fewer employees because the last van added 480 packages while the last employee only added 450 packages.
c. should use fewer vans and more employees because the last dollar spent on vans yielded 1.2 additional packages delivered, while the last dollar spent on employees yielded 1.5 packages delivered.
d. could deliver more packages for the same budget by using fewer vans and more employees.
e. both c and d
Answer: e

Difficulty: 03 Hard
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03

3-83 Your firm sells club soda in both grocery stores and convenience stores. You have a budget of $550 for store displays, and must decide how to allocate this budget between grocery stores and convenience stores to maximize the total number of sales. The following table shows the total number of units that can be sold in grocery stores and convenience stores, according to the number of displays in each type of store. Displays in grocery stores cost $150 each and displays in convenience stores cost $100 each.

<table>
<thead>
<tr>
<th>Number of displays in grocery stores</th>
<th>Total number of units sold in grocery stores</th>
<th>Number of displays in convenience stores</th>
<th>Total number of units sold in convenience stores</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>500</td>
<td>1</td>
<td>400</td>
</tr>
<tr>
<td>2</td>
<td>900</td>
<td>2</td>
<td>780</td>
</tr>
<tr>
<td>3</td>
<td>1,250</td>
<td>3</td>
<td>1,130</td>
</tr>
<tr>
<td>4</td>
<td>1,550</td>
<td>4</td>
<td>1,460</td>
</tr>
<tr>
<td>5</td>
<td>1,750</td>
<td>5</td>
<td>1,760</td>
</tr>
<tr>
<td>6</td>
<td>1,850</td>
<td>6</td>
<td>1,960</td>
</tr>
</tbody>
</table>

Given the above information, to maximize the total number of sales, you should choose
a. 3 grocery store displays and 2 convenience store displays.
b. 3 grocery store displays and 3 convenience store displays.
c. 3 grocery store displays and 4 convenience store displays.
d. 1 grocery store display and 4 convenience store displays.
Answer: d

Difficulty: 03 Hard
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03
Your firm sells club soda in both grocery stores and convenience stores. You have a budget of $550 for store displays, and must decide how to allocate this budget between grocery stores and convenience stores to maximize the total number of sales. The following table shows the total number of units that can be sold in grocery stores and convenience stores, according to the number of displays in each type of store. Displays in grocery stores cost $150 each and displays in convenience stores cost $100 each.

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</tbody>
</table>

Given the above information, at the optimal choice with a budget of $550, the last dollar spent on grocery store displays yields
a. 3.0 additional sales.
b. 3.3 additional sales.
A local charity has decided to solicit donations door-to-door. The table below shows estimated donations for each hour a volunteer spends in the city, in the suburbs, and on campus.

<table>
<thead>
<tr>
<th>Number of Hours</th>
<th>The city</th>
<th>The suburbs</th>
<th>Campus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$ 75</td>
<td>$ 65</td>
<td>$ 45</td>
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<tr>
<td>2</td>
<td>147</td>
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<td>239</td>
<td>159</td>
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<tr>
<td>5</td>
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<td>189</td>
</tr>
<tr>
<td>6</td>
<td>389</td>
<td>333</td>
<td>209</td>
</tr>
</tbody>
</table>

Given the above information, how should a volunteer allocate 10 hours in order to maximize the amount of total donations?

a. 3 hours in the city, 4 hours in the suburbs, 3 hours on campus
b. 4 hours in the city, 3 hours in the suburbs, 3 hours on campus
c. 5 hours in the city, 4 hours in the suburbs, 1 hour on campus
d. 6 hours in the city, 4 hours in the suburbs, 0 hours on campus

Answer: d

Difficulty: 03 Hard
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03

A local charity has decided to solicit donations door-to-door. The table below shows estimated donations for each hour a volunteer spends in the city, in the suburbs, and on campus.

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</tr>
<tr>
<td>6</td>
<td>389</td>
<td>333</td>
<td>209</td>
</tr>
</tbody>
</table>

Given the above information, and given an optimizing solution, the fourth hour solicited yielded

a. $ 64 in additional donations.
b. $ 68 in additional donations.
c. $239 in additional donations.
d. $279 in additional donations.
A local charity has decided to solicit donations door-to-door. The table below shows estimated donations for each hour a volunteer spends in the city, in the suburbs, and on campus.

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</tr>
<tr>
<td>6</td>
<td>389</td>
<td>333</td>
<td>209</td>
</tr>
</tbody>
</table>

Given the above information, with 10 hours of soliciting, the maximum possible amount of donations is
a. $ 106.
b. $ 157.
c. $ 628.
d. $3,290.

Answer: c
Difficulty: 03 Hard
Topic: Constrained Optimization
AACSB: Analytic
Blooms: Apply
Learning Objective: 03-03

A computer services center has a problem with "malicious" computer usage. The center's director has decided to hire additional personnel to monitor computer usage. In order to minimize the total cost of the malicious usage, the director should hire the number of monitors at which
a. the marginal revenue from the last monitor equals the marginal cost of the last monitor.
b. the decrease in the cost of malicious usage from the last monitor hired equals the cost of hiring the last monitor.
c. the marginal benefit per dollar is equal across monitors.
d. both b and c
e. all of the above

Answer: b
Difficulty: 02 Medium
Topic: Concepts and Terminology
AACSB: Reflective Thinking
Blooms: Understand
Learning Objective: 03-01
Refer to the following table:

<table>
<thead>
<tr>
<th>Level of Activity</th>
<th>Total Benefit</th>
<th>Total Cost</th>
<th>Marginal Benefit</th>
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<td>5</td>
<td>825</td>
<td>190</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What is marginal benefit for the 3rd unit of the activity?

a. 160  
b. 180  
c. 115  
d. 175  
e. none of the above  

Answer: d  
Difficulty: 03 Hard  
Topic: Unconstrained Maximization  
AACSBS: Analytic  
Blooms: Apply  
Learning Objective: 03-02

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<tr>
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<td>825</td>
<td>190</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What is the marginal cost for the 5th unit of the activity?

a. 180  
b. 175  
c. 189  
d. 186  
e. none of the above  

Answer: e  
Difficulty: 03 Hard  
Topic: Unconstrained Maximization  
AACSBS: Analytic  
Blooms: Apply  
Learning Objective: 03-02
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<td>825</td>
<td></td>
<td></td>
<td>190</td>
<td></td>
</tr>
</tbody>
</table>

What is the net benefit of the 6th unit of the activity?

a. $-39$
b. 0
c. 45
d. 50
e. none of the above

Answer: d

Difficulty: 03 Hard

Topic: Unconstrained Maximization

AACSB: Analytic

Blooms: Apply

Learning Objective: 03-02

The optimal level of activity is:

a. 2
b. 3
c. 4
d. 5
e. There is no optimal level in this case because marginal benefit does not equal marginal cost at any activity level.

Answer: c

Difficulty: 03 Hard

Topic: Unconstrained Maximization

AACSB: Analytic

Blooms: Apply

Learning Objective: 03-02
<table>
<thead>
<tr>
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<td>6</td>
<td>500</td>
<td>xxx</td>
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<td></td>
</tr>
</tbody>
</table>

What is marginal benefit for the 4\textsuperscript{th} unit of the activity?

a. 65  
b. 60  
c. 55  
d. 50  
e. none of the above

Answer: a

Difficulty: 03 Hard  
Topic: Unconstrained Maximization  
AACSB: Analytic  
Blooms: Apply  
Learning Objective: 03-02

3-95 Refer to the following table:

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<td>6</td>
<td>500</td>
<td>xxx</td>
<td></td>
<td>xxx</td>
<td></td>
</tr>
</tbody>
</table>

What is the marginal cost of the 1\textsuperscript{st} unit of the activity?

a. 0  
b. 5  
c. 10  
d. 15  
e. none of the above

Answer: e

Difficulty: 03 Hard  
Topic: Unconstrained Maximization  
AACSB: Analytic  
Blooms: Apply  
Learning Objective: 03-02

3-96 Refer to the following table:
### What is the net benefit of the 5th unit of the activity?

- a. 50
- b. 60
- c. 70
- d. 80
- e. none of the above

Answer: c

**Difficulty:** 03 Hard  
**Topic:** Unconstrained Maximization  
**AACSB:** Analytic  
**Blooms:** Apply  
**Learning Objective:** 03-02

---

### The optimal level of activity is:

- a. 2
- b. 3
- c. 4
- d. 5
- e. There is no optimal level in this case because marginal benefit does not equal marginal cost at any of the activity levels.

Answer: b

**Difficulty:** 03 Hard  
**Topic:** Unconstrained Maximization  
**AACSB:** Analytic  
**Blooms:** Apply  
**Learning Objective:** 03-02

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