**Problems**

**Future Worth**

9-1 Compute the future worth for the following cash flows.

\[
\begin{array}{c}
\text{0} \quad \text{1} \quad \text{2} \quad \text{3} \quad \text{4} \quad \text{5} \\
\text{100} \quad \text{150} \quad \text{200} \quad \text{250} \quad \text{300} \\
\end{array}
\]

\[
i = 12\%
\]

(Answer: \(F = \$1199\))

9-2 For the following cash flows, compute the future worth.

\[
\begin{array}{c}
\text{0} \quad \text{1} \quad \text{2} \\
\text{0} \quad \text{4x} \qquad \text{3x} \qquad \text{2x} \qquad x
\end{array}
\]

\[
i = 15\%
\]

9-3 For the following cash flows, compute the future worth.

\[
\begin{array}{c}
\text{0} \quad \text{1} \quad \text{2} \quad \text{3} \quad \text{4} \\
\text{0} \quad \text{30} \quad \text{30} \quad \text{30} \quad \text{30} \quad \text{30}
\end{array}
\]

\[
i = 10\%
\]

9-4 For a 12% interest rate, compute the value of  \(F\) so the following cash flows have a future worth of 0.

\[
\begin{array}{c}
\text{0} \quad \text{1} \quad \text{2} \quad \text{3} \quad \text{4} \\
\text{100} \quad \text{200}
\end{array}
\]

9-5 Compute \(F\) so the following cash flows have a future worth of 0.

\[
\begin{array}{c}
\text{0} \quad \text{1} \quad \text{2} \\
\text{100} \quad \text{100} \quad \text{100} \quad \text{100} \quad \text{100} \quad \text{100}
\end{array}
\]

\[
i = 10\%
\]

9-6 Calculate the present worth and the future worth of a series of 10 annual cash flows with the first cash flow equal to $15,000 and each successive cash flow increasing by $1200. The interest rate is 12%.

9-7 Sally deposited $100 a month in her savings account for 24 months. For the next 5 years she made no deposits. What is the future worth in Sally’s savings account at the end of the 7 years, if the account earned 6% annual interest, compounded monthly? (Answer: $3430.78)

9-8 A 20-year-old student decided to set aside $100 on his 21st birthday for investment. Each subsequent year through his 55th birthday, he plans to increase the investment on a $100 arithmetic gradient. He will not set aside additional money after his 55th birthday. If the student can achieve a 12% rate of return, what is the future worth of the investments on his 65th birthday? (Answer: $1,160,700)

9-9 You can buy a piece of vacant land for $30,000 cash. You plan to hold it for 15 years and then sell it at a profit. During this period, you would pay annual property taxes of $600. You would have no income from the property. Assuming that you want a 10% rate of return, at what net price would you have to sell the land 15 years hence? (Answer: $144,373)

9-10 An individual who makes $32,000 per year anticipates retiring in 30 years. If his salary is increased by $600 each year and he deposits 10% of his yearly salary into a fund that earns 7% interest, what is the future worth at retirement?

9-11 Stamp collecting has become an increasingly popular—and expensive—hobby. One favorite method is to save plate blocks (usually four stamps with the printing plate number in the margin) of each new stamp as it is issued. With rising postage rates and increased numbers of new stamps being issued, this collecting plan costs more each year.
Stamps have been a good place to invest money over the last 10 years, as the demand for stamps previously issued has caused resale prices to increase 18% each year. Suppose a collector purchased $100 worth of stamps 10 years ago, and increased his purchases by $50 per year in each subsequent year. After 10 years of stamp collecting, what is the future worth of the stamp collection?

9-12 The interest rate is 16% per year and there are 48 compounding periods per year. The principal is $50,000. What is the future worth in 5 years?

9-13 In the early 1980s, planners were examining alternate sites for a new London airport. The economic analysis included the value of structures that would need to be removed from various airport sites. At one potential site, the twelfth-century Norman church of St. Michaels, in the village of Stewkley, would have had to be demolished. The planners used the value of the fire insurance policy on the church—a few thousand pounds sterling—as the church’s value.

An outraged antiquarian wrote to the London Times that an equally plausible computation would be to assume that the original cost of the church (estimated at 100 pounds sterling) be increased at the rate of 10% per year for 800 years. Based on his proposal, what would be the future worth of St. Michaels? (Note: There was great public objection to tearing down the church, and it was spared.)

9-14 Bill made a budget and planned to deposit $150 a month in a savings account, beginning September 1. He did this, but on the following January 1, he reduced the monthly deposits to $100. He made 18 deposits, four at $150 and 14 at $100. If the savings account paid 6% interest, compounded monthly, what was the future worth of his savings immediately after the last deposit? (Answer: $2094.42)

9-15 A company deposits $1000 in a bank at the beginning of each year for 6 years. The account earns 8% interest, compounded every 6 months. What is in the account at the end of 6 years?

9-16 Don Ball is a 55-year-old engineer. According to mortality tables, a male at age 55 has an average life expectancy of 21 more years. Don has accumulated $48,500 toward his retirement. He is now adding $5000 per year to his retirement fund. The fund earns 12% interest. Don will retire when he can obtain an annual income from his retirement fund of $20,000, assuming he lives to age 76. He will make no provision for a retirement income after age 76. What is the youngest age at which Don can retire?

9-17 Jean invests $100 in Year 1 and doubles the amount each year after that (so the investment is $100, 200, 400, 800, ...). If she does this for 10 years, and the investment pays 10% annual interest, what is the future worth of her investment?

9-18 If you invested $2500 in a 24-month bank certificate of deposit (CD) paying 8.65%, compounded monthly, what is the future worth of the CD when it matures?

9-19 After receiving an inheritance of $25,000 on her 21st birthday, Ayn deposited the inheritance in a savings account with an effective annual interest rate of 6%. She decided to make regular deposits beginning with $1000 on her 22nd birthday and increasing by $200 each year (i.e., $1200 on her 23rd birthday, $1400 on her 24th birthday, etc.). What was the future worth of Ayn’s deposits on her 56th birthday?

9-20 The Association of General Contractors (AGC) is endowing a fund of $1 million for the Construction Engineering Technology Program at Grambling State University. The AGC established an escrow account in which 10 equal end-of-year deposits that earn 7% compound interest were to be made. After seven deposits, the Louisiana legislature revised laws relating to the licensing fees AGC can charge its members, and there was no deposit at the end of Year 8. What must the amount of the remaining equal end-of-year deposits be, to ensure that the $1 million is available on schedule for the Construction Engineering Technology Program?

9-21 A new engineer is considering investing in an individual retirement account (IRA) with a mutual fund that has an average annual return of 10%. What is the future worth of her IRA at age 65 if she makes annual investments of $2000 into the fund beginning on her 25th birthday? Assume that the fund continues to earn an annual return of 10%.

9-22 IPS Corp. will upgrade its package-labeling machinery. It costs $150,000 to buy the machinery and have it installed. Operation and maintenance costs, which are $1500 per year for the first 3 years, increase by 500 per year for the machine’s 10-year life. The machinery has a salvage value of 5% of its initial cost. Interest is 10%. What is the future worth of cost of the machinery?

9-23 A company is considering buying a new bottle capping machine. The initial cost of the machinery is $325,000 and it has a 10-year life. Monthly maintenance costs are expected to be $1200 per month for the
first 7 years and $2000 per month for the remaining years. The machine requires a major overhaul costing $55,000 at the end of the fifth year of service. Assume that all these costs occur at the end of the appropriate period. What is the future value of all the costs of owning and operating this machine if the nominal interest rate is 7.2%?

9-24 A family starts an education fund for their son Patrick when he is 8 years old, investing $150 on his eighth birthday, and increasing the yearly investment by $150 per year until Patrick is 18 years old. The fund pays 9% annual interest. What is the fund’s future worth when Patrick is 18?

9-25 A bank account pays 19.2% interest with monthly compounding. A series of deposits started with a deposit of $5000 on January 1, 2007. Deposits in the series were to occur each 6 months. Each deposit in the series is for $150 less than the one before it. The last deposit in the series will be due on January 1, 2022. What is the future worth of the account on July 1, 2024, if the balance was zero before the first deposit and no withdrawals are made?

9-26 A recent college graduate got a good job and began a savings account. He authorized the bank to automatically transfer $75 each month from his checking account to the savings account. The bank made the first withdrawal on July 1, 2007 and is instructed to make the last withdrawal on January 1, 2025. The bank pays a nominal interest rate of 4.5% and compounds twice a month. What is the future worth of the account on January 1, 2025?

9-27 Bob, an engineer, decided to start a college fund for his son. Bob will deposit a series of equal, semiannual cash flows with each deposit equal to $1500. Bob made the first deposit on July 1, 2008 and will make the last deposit on July 1, 2028. Joe, a friend of Bob’s, received an inheritance on April 1, 2013, and has decided to begin a college fund for his daughter. Joe wants to send his daughter to the same college as Bob’s son. Therefore, Joe needs to accumulate the same amount of money on July 1, 2028, as Bob will have accumulated from his semiannual deposits. Joe never took engineering economics and had no idea how to determine the amount that should be deposited. He decided to deposit $40,000 on July 1, 2013. Will Joe’s deposit be sufficient? If not, how much should he have put in? Use a nominal interest of 7% with semiannual compounding on all accounts.

9-28 A business executive is offered a management job at Generous Electric Company, which offers him a 5-year contract that calls for a salary of $62,000 per year, plus 600 shares of GE stock at the end of the 5 years. This executive is currently employed by Fearless Bus Company, which also has offered him a 5-year contract. It calls for a salary of $65,000, plus 100 shares of Fearless stock each year. The Fearless stock is currently worth $60 per share and pays an annual dividend of $2 per share. Assume end-of-year payments of salary and stock. Stock dividends begin one year after the stock is received. The executive believes that the value of the stock and the dividend will remain constant. If the executive considers 9% a suitable rate of return in this situation, what must the Generous Electric stock be worth per share to make the two offers equally attractive? Use the future worth analysis method in your comparison. (Answer: $83.76)

9-29 Pick a discretionary expense that you incur on a regular basis, such as buying cigarettes weekly, buying fashion items monthly, buying sports tickets monthly, or going to movies weekly. Assume that you instead place the money in an investment account that earns 9% annually. After 40 years, how much is in the account?

### Benefit–Cost Ratio

9-30 Each of the three alternatives shown has a 5-year useful life. If the MARR is 10%, which alternative should be selected? Solve the problem by benefit–cost ratio analysis.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>$600.0</td>
<td>$500.0</td>
<td>$200.0</td>
</tr>
<tr>
<td>Uniform annual benefit</td>
<td>158.3</td>
<td>138.7</td>
<td>58.3</td>
</tr>
</tbody>
</table>

(Answer: B)

9-31 Consider three alternatives, each with a 10-year useful life. If the MARR is 10%, which alternative should be selected? Solve the problem by benefit–cost ratio analysis.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>$800</td>
<td>$300</td>
<td>$150</td>
</tr>
<tr>
<td>Uniform annual benefit</td>
<td>142</td>
<td>60</td>
<td>33.5</td>
</tr>
</tbody>
</table>

9-32 An investor is considering buying some land for $100,000 and constructing an office building on it. Three different buildings are being analyzed.
### Building Height

<table>
<thead>
<tr>
<th></th>
<th>2 Stories</th>
<th>5 Stories</th>
<th>10 Stories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of building</td>
<td>$400,000</td>
<td>$800,000</td>
<td>$2,100,000</td>
</tr>
<tr>
<td>(excluding cost of</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>land)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resale value* of</td>
<td>200,000</td>
<td>300,000</td>
<td>400,000</td>
</tr>
<tr>
<td>land + building</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>after 20-year horizon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual net rental</td>
<td>70,000</td>
<td>105,000</td>
<td>256,000</td>
</tr>
<tr>
<td>income</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Resale value to be considered a reduction in cost, rather than a benefit.

Using benefit–cost ratio analysis and an 8% MARR, determine which alternative, if any, should be selected.

#### 9-33
Using benefit–cost ratio analysis, determine which one of the three mutually exclusive alternatives should be selected. Each alternative has a 6-year useful life. Assume a 10% MARR.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>First cost</td>
<td>$560</td>
<td>$340</td>
<td>$120</td>
</tr>
<tr>
<td>Uniform annual benefit</td>
<td>140</td>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td>Salvage value</td>
<td>40</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

#### 9-34
Consider four alternatives, each of which has an 8-year useful life:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>$100.0</td>
<td>$80.0</td>
<td>$60.0</td>
<td>$50.0</td>
</tr>
<tr>
<td>Uniform annual benefit</td>
<td>12.2</td>
<td>12.0</td>
<td>9.7</td>
<td>12.2</td>
</tr>
<tr>
<td>Salvage value</td>
<td>75.0</td>
<td>50.0</td>
<td>50.0</td>
<td>0</td>
</tr>
</tbody>
</table>

If the MARR is 8%, which alternative should be selected? Solve the problem by benefit–cost ratio analysis.

#### 9-35
Using benefit–cost ratio analysis, a 5-year useful life, and a 15% MARR, determine which of the following alternatives should be selected.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>$100</td>
<td>$200</td>
<td>$300</td>
<td>$400</td>
<td>$500</td>
</tr>
<tr>
<td>Uniform annual benefit</td>
<td>37</td>
<td>69</td>
<td>83</td>
<td>126</td>
<td>150</td>
</tr>
</tbody>
</table>

#### 9-36
Five mutually exclusive investment alternatives have been proposed. Based on benefit–cost ratio analysis, and a MARR of 15%, which alternative should be selected?

<table>
<thead>
<tr>
<th>Year</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-$200</td>
<td>-$100</td>
<td>-$125</td>
<td>-$150</td>
<td>-$225</td>
</tr>
<tr>
<td>1–5</td>
<td>+68</td>
<td>+25</td>
<td>+42</td>
<td>+52</td>
<td>+68</td>
</tr>
</tbody>
</table>

9-37 A project will cost $50,000. The benefits at the end of the first year are estimated to be $10,000, increasing at a 10% uniform rate in subsequent years. Using an 8-year analysis period and a 10% interest rate, compute the benefit–cost ratio.

9-38 A do-nothing and two mutually exclusive alternatives are being considered for reducing traffic congestion. User benefits come from reduced congestion once the project is complete, while user disbenefits are due to increased congestion during construction. The interest rate is 9%, and the life of each alternative is 15 years. Which alternative should be chosen?

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>User benefits ($/yr)</td>
<td>2.1</td>
</tr>
<tr>
<td>User disbenefits ($/yr)</td>
<td>1.2</td>
</tr>
<tr>
<td>First cost ($/yr)</td>
<td>6.9</td>
</tr>
<tr>
<td>Operations and maintenance ($/yr)</td>
<td>0.75</td>
</tr>
</tbody>
</table>

(a) Use the benefit–cost ratio.
(b) Use the modified benefit–cost ratio.
(c) Use the public/government version of the B/C ratio.
(d) Assume these numbers apply to a private firm and use a present worth index.
(e) Are your recommendations for (a) through (d) consistent? Which measure gives the largest value? Why?

9-39 A school is overcrowded and there are three options. The do-nothing alternative corresponds to continuing to use modular classrooms. The school can be expanded, or a new school can be built to "split the load" between the schools. User benefits come from improvements in school performance for the expanded or new schools. If a new school is built, there are more benefits because more students will be able to walk to school, the average distance for those who ride the school bus will be shorter, and the schools will be smaller and more "student friendly." The disbenefits for the expanded school are due to the impact of the construction process during the school year. The interest rate is 8%, and the life of each alternative is 20 years. Which alternative should be chosen? What is the incremental ratio for the preferred alternative?