Problem 1. [1 to 12, 3% at each]
Find the value of $x$ in the diagram below that will make the equivalent present worth of the cash flow equal to $15,000$, if the interest rate is 15% per year.

\[
P = $15,000 \\
0 1 2 3 4 5 6 7 \text{ Year} \\
\downarrow \downarrow \downarrow \downarrow \downarrow \downarrow \downarrow \downarrow \\
$2000 $1000 x \\
\]

\[
15,000 = 2000 + 2000(P/A,15\%,3) + 1000(P/A,15\%,3)(P/F,15\%,3) + x(P/F,15\%,7) \\
15,000 = 2000 + 2000(2.2832) + 1000(2.2832)(0.6575) + x(0.3759) \\
x = $18,442
\]

Problem 2.
An interest rate of 1% per month is equivalent to what effective rate per 2 months?

\[
i = (1 + 0.01)^2 - 1 \\
i = 2.01\%
\]

Problem 3.
Because testing of nuclear bombs was halted in 1992, the U.S. Department of Energy has been developing a laser project that will allow engineers to simulate (in a laboratory) conditions in a thermonuclear reaction. Due to soaring cost overruns, a congressional committee undertook an investigation and discovered that the estimated development cost of the project increased at an average rate of 3% per month over a 5-year period. If the original cost was estimated to be $2.7 billion 5 years ago, what is the expected cost today?

\[
F = 2.7(F/P,3\%,60) \\
= 2.7(5.8916) \\
= $15.91 \text{ billion}
\]
Problem 4.
How long would it take for a lump-sum investment to double in value at an interest rate of 1.5% per month, compounded continuously?

\[
\begin{align*}
  i &= e^{0.015} - 1 = 1.51\% \text{ per month} \\
  2P &= P(1 + 0.0151)^n \\
  2.000 &= (1.0151)^n \\

  \text{Take log of both sides and solve for } n \\
  n &= 46.2 \text{ months}
\end{align*}
\]

Problem 5.
The patriot missile, developed by Lockheed Martin for the U.S. Army, is designed to shoot down aircraft and other missiles. The Patriot Advanced Capability-3 was originally promised to cost $3.9 billion, but due to extra time needed to write computer code and scrapped tests (due to high winds) at White Sands Missile Range, the actual cost was much higher. If the total project development time was 10 years and costs increased at a rate of 0.5% per month, what was the final cost of the project?

\[
\begin{align*}
  F &= 3.9(F/P, 0.5\%, 120) \text{ (in } \text{billion)} \\
  &= 3.9(1.8194) \\
  &= $7,095,660,000
\end{align*}
\]

Problem 6.
Darnell Enterprises constructed an addition to its building at a cost of $70,000. Extra annual expenses are expected to be $1850, but extra income will be $14,000 per year. How long will it take for the company to recover its investment at an interest rate of 10% per year?

\[
\begin{align*}
  0 &= -70,000 + (14,000 - 1850)(P/A, 10\%, n) \\
  (P/A, 10\%, n) &= 5.76132 \\
  n \text{ is between 9 and 10; therefore, it would take 10 years.}
\end{align*}
\]

Problem 7.
A large textile company is trying to decide which sludge dewatering process it should use ahead of its sludge drying operation. The costs associated with centrifuge and belt press systems are shown below. Compare them on the basis of their annual worths, using an interest rate of 10% per year.
<table>
<thead>
<tr>
<th></th>
<th>Centrifuge</th>
<th>Belt Press</th>
</tr>
</thead>
<tbody>
<tr>
<td>First cost, $</td>
<td>–250,000</td>
<td>–170,000</td>
</tr>
<tr>
<td>Annual operating cost, $/year</td>
<td>–31,000</td>
<td>–35,000</td>
</tr>
<tr>
<td>Overhaul in year 2, $</td>
<td>—</td>
<td>–26,000</td>
</tr>
<tr>
<td>Salvage value, $</td>
<td>40,000</td>
<td>10,000</td>
</tr>
<tr>
<td>Life, years</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

\[
AW_{\text{centrifuge}} = -250,000(A/P,10\%,6) - 31,000 + 40,000(A/F,10\%,6)
\]
\[
= -250,000(0.22961) - 31,000 + 40,000(0.12961)
\]
\[
= $-83,218
\]

\[
AW_{\text{belt}} = -170,000(A/P,10\%,4) - 35,000 - 26,000(P/F,10\%,2)(A/P,10\%,4) + 10,000(A/F,10\%,4)
\]
\[
= -170,000(0.31547) - 35,000 - 26,000(0.8624)(0.31547) + 10,000(0.21547)
\]
\[
= $-93,549
\]

Select centrifuge.

**Problem 8.**
For the cash flow sequence shown below (in thousands of dollars), determine the amount of money that can be withdrawn annually for an infinite period of time, if the first withdrawal is to be made in year 10 and the interest rate is 12% per year.

<table>
<thead>
<tr>
<th>Year</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deposit amount, $</td>
<td>100</td>
<td>90</td>
<td>80</td>
<td>70</td>
<td>60</td>
<td>50</td>
<td>40</td>
</tr>
</tbody>
</table>

Find P in year –1, move to year 9, and then multiply by i. Amounts are in $1000.

\[
P_{-1} = [100(P/A,12\%,7) - 10(P/G,12\%,7)](F/P,12\%,10)
\]
\[
= [100(4.5638) - 10(11.6443)](3.1058)
\]
\[
= $1055.78
\]

\[
A = 1055.78(0.12)
\]
\[
= $126.69
\]

**Problem 9.**
What rate of return per month will an entrepreneur make over a 2½-year project period if he invested $150,000 to produce portable 12-volt air compressors? His estimated monthly costs are $27,000 with income of $33,000 per month.
Problem 10.
A small construction company has $100,000 set aside in a sinking fund to purchase new equipment. If $30,000 is invested at 30%, $20,000 at 25% and the remaining $50,000 at 20% per year, what is the overall rate of return on the entire $100,000?

\[ \text{Overall ROR: } 100,000(i) = 30,000(0.30) + 20,000(0.25) + 50,000(0.20) \]
\[ i = 24\% \]

Problem 11.
The incremental cash flow between alternatives Z1 and Z2 is shown below (Z2 has the higher initial cost). Use an AW-based rate of return equation to determine the incremental rate of return and which alternative should be selected, if the MARR is 17% per year. Let \( k \) = year 1 through 10.

<table>
<thead>
<tr>
<th>Year</th>
<th>Incremental Cash Flow, $ (Z2 – Z1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-40,000</td>
</tr>
<tr>
<td>1–10</td>
<td>9000 – 500k</td>
</tr>
</tbody>
</table>

\[ 0 = -40,000(A/P,i,10) + 8500 – 500(A/G,i,10) \]

Solve for \( i \) by trial and error or Excel
\[ i = 10.5\% \text{ is } < \text{MARR = 17\%} \]  
(Excel)
Select Z1

Problem 12.
The city of Ocean View, California, is considering various proposals regarding the disposal of used tires. All the proposals involve shredding, but the charges for the service and handling of the tire shreds differ in each plan. An incremental B/C analysis was initiated, but the engineer conducting the study left recently. (a) Fill in the blanks in the incremental B/C portion of the table. (b) What alternative should be selected?
(a) Projects are listed by increasing PW of cost values. First find benefits for each alternative and then find incremental B/C ratios:

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Initial Investment, $ Millions</th>
<th>B/C Ratio</th>
<th>Incremental B/C When Compared with Alternative</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>10</td>
<td>1.1</td>
<td>—</td>
</tr>
<tr>
<td>Q</td>
<td>40</td>
<td>2.4</td>
<td>2.83</td>
</tr>
<tr>
<td>R</td>
<td>50</td>
<td>1.4</td>
<td>—</td>
</tr>
<tr>
<td>S</td>
<td>80</td>
<td>1.5</td>
<td>—</td>
</tr>
</tbody>
</table>

Benefits for P

\[ \frac{B_P}{10} = 1.1 \]

\[ B_P = 11 \]

Benefits for Q

\[ \frac{B_Q}{40} = 2.4 \]

\[ B_Q = 96 \]

Benefits for R

\[ \frac{B_R}{50} = 1.4 \]

\[ B_R = 70 \]

Benefits for S

\[ \frac{B_S}{80} = 1.5 \]

\[ B_S = 120 \]

Incremental B/C for Q vs P

\[ \frac{B_Q}{40} - \frac{B_P}{10} = 2.83 \]

Incremental B/C for R vs P

\[ \frac{B_R}{50} - \frac{B_P}{10} = 1.48 \]

Incremental B/C for S vs P

\[ \frac{B_S}{80} - \frac{B_P}{10} = 1.56 \]

Incremental B/C for R vs Q

\[ \frac{B_R}{50} - \frac{B_Q}{40} = -2.60 \]

Disregard due to less B for more C.

Incremental B/C for S vs Q

\[ \frac{B_S}{80} - \frac{B_Q}{40} = 0.60 \]

Incremental B/C for S vs R

\[ \frac{B_S}{80} - \frac{B_R}{50} = 1.67 \]

(b) Compare P to DN; eliminate DN.

Compare Q to P; eliminate P.

Compare R to Q; disregarded.

Compare S to Q; eliminate S.

Select Q.