Problem 1.

Three types of drill bits can be used in a certain manufacturing operation. A bright high-speed steel (HSS) bit is the least expensive to buy, but it has a shorter life than either gold oxide or titanium nitride bits. The HSS bits will cost $3500 to buy and will last for 3 months under the conditions in which they will be used. The operating cost for these bits will be $2000 per month. The gold oxide bits will cost $6500 to buy and will last for 6 months with an operating cost of $1500 per month. The titanium nitride bits will cost $7000 to buy and will last 6 months with an operating cost of $1200 per month. At an interest rate of 12% per year, compounded monthly, which type of drill bit should be used on the basis of a future worth analysis?

FW<sub>HSS</sub> = -3500(F/P,1%,6) – 2000(F/A,1%,6) – 3500(F/P,1%,3)
= -3500(1.0615) – 2000(6.1520) – 3500(1.0303)
= $-19,625

FW<sub>gold</sub> = -6500(F/P,1%,6) – 1500(F/A,1%,6)
= -6500(1.0615) – 1500(6.1520)
= $-16,128

FW<sub>titanium</sub> = -7000(F/P,1%,6) – 1200(F/A,1%,6)
= -7000(1.0615) – 1200(6.1520)
= $-14,813

Use titanium nitride bits

Problem 2.

A company that manufactures amplified pressure transducers is trying to decide between the machines shown below. Compare them on the basis of their present worth values, using an interest rate of 15% per year.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Speed</th>
<th>Dual Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>First cost, $</td>
<td>-250,000</td>
<td>-224,000</td>
</tr>
<tr>
<td>Annual operating cost, $/year</td>
<td>-231,000</td>
<td>-235,000</td>
</tr>
<tr>
<td>Overhaul in year 3, $</td>
<td>—</td>
<td>-26,000</td>
</tr>
<tr>
<td>Overhaul in year 4, $</td>
<td>-140,000</td>
<td>—</td>
</tr>
<tr>
<td>Salvage value, $</td>
<td>50,000</td>
<td>10,000</td>
</tr>
<tr>
<td>Life, years</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

\[
PW_{variable} = -250,000 - 231,000(P/A,15%,6) - 140,000(P/F,15%,4) + 50,000(P/F,15%,6)
= -250,000 - 231,000(3.7845) - 140,000(0.5718) + 50,000(0.4323)
= $-1,182,656
\]

\[
PW_{dual} = -224,000 -235,000(P/A,15%,6) -26,000(P/F,15%,3)
+ 10,000(P/F,15%,6)
= -224,000 -235,000(3.7845) -26,000(0.6575) + 10,000(0.4323)
= $-1,126,130
\]

Select dual speed machine
Problem 3.

Compare the following alternatives on the basis of their capitalized cost at an interest rate of 10% per year.

<table>
<thead>
<tr>
<th></th>
<th>Petroleum- Based</th>
<th>Inorganic- Based</th>
</tr>
</thead>
<tbody>
<tr>
<td>First cost, $</td>
<td>-250,000</td>
<td>-110,000</td>
</tr>
<tr>
<td>Annual operating cost, $/year</td>
<td>-130,000</td>
<td>-65,000</td>
</tr>
<tr>
<td>Annual revenues, $/year</td>
<td>400,000</td>
<td>270,000</td>
</tr>
<tr>
<td>Salvage value, $</td>
<td>50,000</td>
<td>20,000</td>
</tr>
<tr>
<td>Life, years</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

CC\text{petroleum} = \frac{-250,000(A/P,10\%,6) – 130,000 + 400,000 + 50,000(A/F,10\%,6)}{0.10}
= \frac{-250,000(0.22961) – 130,000 + 400,000 + 50,000(0.12961)}{0.10}
= $2,190,780

CC\text{inorganic} = \frac{-110,000(A/P,10\%,4) – 65,000 + 270,000 + 20,000(A/F,10\%,4)}{0.10}
= \frac{-110,000(0.31547) – 65,000 + 270,000 + 20,000(0.21547)}{0.10}
= $1,746,077

Petroleum-based alternative has a larger profit.

Problem 4.

A city that is attempting to attract a professional football team is planning to build a new stadium costing $250 million. Annual upkeep is expected to amount to $800,000 per year. The artificial turf will have to be replaced every 10 years at a cost of $950,000. Painting every 5 years will cost $75,000. If the city expects to maintain the facility indefinitely, what will be its capitalized cost at an interest rate of 8% per year?

CC = -250,000,000 – 800,000/0.08 – [950,000(A/F,8\%,10)]/0.08
= -250,000,000 – 800,000/0.08 – [950,000(0.06903)]/0.08
= -251,979,538

Problem 5.

The machines shown below are under consideration for an improvement to an automated candy bar wrapping process. Determine which should be selected on the basis of an annual worth analysis using an interest rate of 15% per year.

<table>
<thead>
<tr>
<th></th>
<th>Machine C</th>
<th>Machine D</th>
</tr>
</thead>
<tbody>
<tr>
<td>First cost, $</td>
<td>-40,000</td>
<td>-65,000</td>
</tr>
<tr>
<td>Annual cost, $/year</td>
<td>-10,000</td>
<td>-12,000</td>
</tr>
<tr>
<td>Salvage value, $</td>
<td>12,000</td>
<td>25,000</td>
</tr>
<tr>
<td>Life, years</td>
<td>3</td>
<td>6</td>
</tr>
</tbody>
</table>

AW\text{C} = -40,000(A/P,15\%,3) – 10,000 + 12,000(A/F,15\%,3)
= -40,000(0.43798) – 10,000 + 12,000(0.28798)
= $2,4063

AW\text{D} = -65,000(A/P,15\%,6) – 12,000 + 25,000(A/F,15\%,6)
= -65,000(0.26424) – 12,000 + 25,000(0.11424)
= $6,320

Select machine C.
Problem 6.

The cash flow associated with landscaping and maintaining a certain monument in Washington, D.C., is $100,000 now and $50,000 every 5 years forever. Determine its perpetual equivalent annual worth (in years 1 through infinity) at an interest rate of 8% per year.

\[
AW = -100,000(0.08) - 50,000(A/F, 8\%, 5) \\
= -100,000(0.08) - 50,000(0.17046) \\
= -$16,523
\]

Problem 7.

The following cash flows interest rate is 10% per year, compounded semiannually.

<table>
<thead>
<tr>
<th></th>
<th>Alternative X</th>
<th>Alternative Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>First cost, $</td>
<td>-200,000</td>
<td>-800,000</td>
</tr>
<tr>
<td>Annual cost, $/year</td>
<td>-60,000</td>
<td>-10,000</td>
</tr>
<tr>
<td>Salvage value, $</td>
<td>20,000</td>
<td>150,000</td>
</tr>
<tr>
<td>Life, years</td>
<td>5</td>
<td>∞</td>
</tr>
</tbody>
</table>

In comparing the alternatives by the annual worth method, select the best alternatives.

Problem 8.

PPG manufactures an epoxy amine that is used to protect the contents of polyethylene terephthalate (PET) containers from reacting with oxygen. The cash flow (in millions) associated with the process is shown below. Determine the rate of return.

<table>
<thead>
<tr>
<th>Year</th>
<th>Cost, $</th>
<th>Revenue, $</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-10</td>
<td>—</td>
</tr>
<tr>
<td>1</td>
<td>-4</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>-4</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>-4</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>-3</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>-3</td>
<td>9</td>
</tr>
<tr>
<td>6</td>
<td>-3</td>
<td>9</td>
</tr>
</tbody>
</table>

\[
0 = -10 - 4(P/A, i\%, 3) - 3(P/A, i\%, 3)(P/F, i\%, 3) + 2(P/F, i\%, 1) + 3(P/F, i\%, 2) \\
+ 9(P/A, i\%, 4)(P/F, i\%, 2)
\]

Solve by trial and error or Excel

\[i = 14.6\% \quad \text{(Excel)}\]

Problem 9.

ASM International, an Australian steel company, claims that a savings of 40% of the cost of stainless steel threaded bar can be achieved by replacing machined threads with precision weld depositions. A U.S. manufacturer of rock bolts and grout-in fittings plans to purchase the equipment. A mechanical engineer with the company has prepared the following cash flow estimates. Determine the expected rate of return per year (nominal).

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Cost, $</th>
<th>Savings, $</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-450,000</td>
<td>—</td>
</tr>
<tr>
<td>1</td>
<td>-50,000</td>
<td>10,000</td>
</tr>
<tr>
<td>2</td>
<td>-40,000</td>
<td>20,000</td>
</tr>
<tr>
<td>3</td>
<td>-30,000</td>
<td>30,000</td>
</tr>
<tr>
<td>4</td>
<td>-20,000</td>
<td>40,000</td>
</tr>
<tr>
<td>5</td>
<td>-10,000</td>
<td>50,000</td>
</tr>
<tr>
<td>6–12</td>
<td>—</td>
<td>80,000</td>
</tr>
</tbody>
</table>

\[
0 = -450,000 - [50,000(P/A, i\%, 5) - 10,000(P/G, i\%, 5)] + 10,000(P/A, i\%, 5) \\
+ 10,000(P/G, i\%, 5) + 80,000(P/A, i\%, 7)(P/F, i\%, 5)
\]
Solve by trial and error or Excel
\[ i = 2.36\% \text{ per quarter} \quad (\text{Excel}) \]
\[ = 2.36(4) \]
\[ = 9.44\% \text{ per year (nominal)} \]

**Problem 10.**

Five years ago, an alumnus of a small university donated $50,000 to establish a permanent endowment for scholarships. The first scholarships were awarded 1 year after the money was donated. If the amount awarded each year (i.e., the interest) is $4500, compute the rate of return earned on the fund.

\[ i = \frac{4500}{50,000} \]
\[ = 9\% \text{ per year} \]
Answer is (c)

**Problem 11.**

Alternative R has a first cost of $100,000, annual M&O costs of $50,000, and a $20,000 salvage value after 5 years. Alternative S has a first cost of $175,000 and a $40,000 salvage value after 5 years, but its annual M&O costs are not known. Determine the M&O costs for alternative S that would yield an incremental rate of return of 20% per year.

Let \( x = M \& O \) costs. Perform an incremental cash flow analysis.

\[ 0 = -75,000 + (-x + 50,000)(P/A,20\%,5) + 20,000(P/F,20\%,5) \]
\[ 0 = -75,000 + (-x + 50,000)(2.9906) + 20,000(0.4019) \]
\[ x = $27,609 \]

M & O cost for S = $-27,609

**Problem 12.**

An independent dirt contractor is trying to determine which size dump truck to buy. The contractor knows that as the bed size increases, the net income increases, but he is uncertain whether the incremental expenditure required for the larger trucks is justified. The cash flows associated with each size truck are estimated below. The contractor’s MARR is 18% per year, and all trucks are expected to have a useful life of 5 years. (a) Determine which size truck should be purchased. (b) If two trucks of different size are to be purchased, what should be the size of the second truck?

<table>
<thead>
<tr>
<th>Truck Bed Size, Cubic Meters</th>
<th>Initial Investment, $</th>
<th>Annual Operating Cost, $/year</th>
<th>Salvage Value, $</th>
<th>Annual Income, $/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>-30,000</td>
<td>-14,000</td>
<td>+2000</td>
<td>+26,500</td>
</tr>
<tr>
<td>10</td>
<td>-34,000</td>
<td>-15,500</td>
<td>+2500</td>
<td>+30,000</td>
</tr>
<tr>
<td>15</td>
<td>-38,000</td>
<td>-18,000</td>
<td>+3000</td>
<td>+33,500</td>
</tr>
<tr>
<td>20</td>
<td>-48,000</td>
<td>-21,000</td>
<td>+3500</td>
<td>+40,500</td>
</tr>
<tr>
<td>25</td>
<td>-57,000</td>
<td>-26,000</td>
<td>+4600</td>
<td>+49,000</td>
</tr>
</tbody>
</table>

Alternatives are revenue alternatives. Therefore, add DN

(a) DN vs 8: \[ 0 = -30,000(A/P,i,5) + (26,500 - 14,000) + 2000(A/F,i,5) \]
Solve for \( i \) by trial and error or Excel
\[ i = 31.7\% \quad (\text{Excel}) \]
Eliminate DN
8 vs 10: \[ 0 = -4000(A/P, i, 5) + (14,500 – 12,500) + 500(A/F, i, 5) \]
Solve for \( i \) by trial and error or Excel
\[ i = 42.4\% \] (Excel)
Eliminate 8

10 vs 15: \[ 0 = -4000(A/P, i, 5) + (15,500 – 14,500) + 500(A/F, i, 5) \]
Solve for \( i \) by trial and error or Excel
\[ i = 10.9\% \] (Excel)
Eliminate 15

10 vs 20: \[ 0 = -14,000(A/P, i, 5) + (19,500 – 14,500) + 1000(A/F, i, 5) \]
Solve for \( i \) by trial and error or Excel
\[ i = 24.2\% \] (Excel)
Eliminate 10

Problem 13.

The estimated annual cash flows for a proposed city government project are costs of $450,000 per year, benefits of $600,000 per year, and disbenefits of $100,000 per year. Determine the (a) B/C ratio and (b) value of B – C.

(a) \[ \frac{B}{C} = \frac{600,000 – 100,000}{450,000} = 1.11 \]
(b) \[ B-C = 600,000 – 100,000 – 450,000 = $+50,000 \]

Problem 14.

Apply incremental B/C analysis at an interest rate of 8% per year to determine which alternative should be selected. Use a 20-year study period, and assume the damage costs might occur in year 6 of the study period.

<table>
<thead>
<tr>
<th></th>
<th>Alternative A</th>
<th>Alternative B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial cost, $</td>
<td>600,000</td>
<td>800,000</td>
</tr>
<tr>
<td>Annual M&amp;O costs, $/year</td>
<td>50,000</td>
<td>70,000</td>
</tr>
<tr>
<td>Potential damage costs, $</td>
<td>950,000</td>
<td>250,000</td>
</tr>
</tbody>
</table>

Incr cost = \((800,000 – 600,000) + (70,000 – 50,000)(P/A, 8\%, 20)\)
\[ = $200,000 + 20,000(9.8181) \]
\[ = $396,362 \]

Incr benefit = \((950,000 – 250,000)(P/F, 8\%, 6)\)
\[ = 700,000(0.6302) \]
\[ = 441,140 \]

Incr B/C = \( \frac{441,140}{396,362} \)
\[ = 1.11 \]

Problem 15.

The Water Service Authority of Dubay is considering four sizes of pipe for a new water line. The costs per kilometer ($/km) for each size are given in the table. Assuming that all pipes will last 15 years and the MARR is 8% per year, which size pipe should be purchased based on a B/C analysis? Installation cost is considered a part of the initial cost.
<table>
<thead>
<tr>
<th>Pipe Size, Millimeters</th>
<th>130</th>
<th>150</th>
<th>200</th>
<th>230</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial equipment cost, $/km</td>
<td>9,180</td>
<td>10,510</td>
<td>13,180</td>
<td>15,850</td>
</tr>
<tr>
<td>Installation cost, $/km</td>
<td>600</td>
<td>800</td>
<td>1,400</td>
<td>1,500</td>
</tr>
<tr>
<td>Usage cost, $/km per year</td>
<td>6,000</td>
<td>5,800</td>
<td>5,200</td>
<td>4,900</td>
</tr>
</tbody>
</table>

1, 2. Order of incremental analysis:  

<table>
<thead>
<tr>
<th>Size</th>
<th>130</th>
<th>150</th>
<th>200</th>
<th>230</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total first cost, $</td>
<td>9,780</td>
<td>11,310</td>
<td>14,580</td>
<td>17,350</td>
</tr>
<tr>
<td>Annual benefits, $</td>
<td>--</td>
<td>200</td>
<td>600</td>
<td>300</td>
</tr>
</tbody>
</table>

3. Not used since the benefits are defined by usage costs.

5-7. Determine incremental B and C and select at each pairwise comparison of defender vs challenger.

**150 vs 130 mm**
\[
\Delta C = (11,310 - 9,780)(A/P,8\%,15) \\
= 1,530(0.11683) \\
= $178.75 \\
\Delta B = 6,000 - 5,800 \\
= $200 \\
\Delta B/C = 200/178.75 \\
= 1.12 > 1.0 \\
\text{Eliminate 130 mm size.}
\]

**200 vs 150 mm**
\[
\Delta C = (14,580 - 11,310)(A/P,8\%,15) \\
= 3270(0.11683) \\
= $382.03 \\
\Delta B = 5800 - 5200 \\
= $600 \\
\Delta B/C = 600/382.03 \\
= 1.57 > 1.0 \\
\text{Eliminate 150 mm size.}
\]

**230 vs 200 mm**
\[
\Delta C = (17,350 - 14,580)(A/P,8\%,15) \\
= 2770(0.11683) \\
= $323.62 \\
\Delta B = 5200 - 4900 \\
= $300 \\
\Delta B/C = 0.93 < 1.0 \\
\text{Eliminate 230 mm size.}
\]

Select 200 mm size.