1. (35 p) From the accompanying cash flow diagram given below, find the value of \( C \) that will establish the economic equivalence between the deposit series (up arrow) and the withdrawal series (down arrow) at an interest rate of 8\% compounded semiannually.

2. (35 p) A plant engineer is considering the two types of solar water heating system given below in table. The firm’s MARR is 12\%. On the basis of the capitalized equivalent (CE) method:
   a) Which alternative should be selected?
   b) If the rate of return (ROR) analysis based on the incremental cash flow is used to decide, write down the corresponding equation to be solved for the decision.

<table>
<thead>
<tr>
<th></th>
<th>Model A</th>
<th>Model B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial cost, $</td>
<td>-7 000</td>
<td>-10 000</td>
</tr>
<tr>
<td>Annual maintenance cost, $</td>
<td>-150</td>
<td>-100</td>
</tr>
<tr>
<td>Annual savings, $</td>
<td>1 100</td>
<td>1 200</td>
</tr>
<tr>
<td>Salvage value, $</td>
<td>600</td>
<td>700</td>
</tr>
<tr>
<td>Expected life, years</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

3. (30 p) Consider the following data on an asset:

| Cost of the asset, \( I \) | $100 000 |
| Useful life, \( N \)       | 5 years  |
| Salvage value, \( S \)      | $5000    |

Compute the annual depreciation allowances and the resulting book values in a table, initially using the % 175 DB and then switching to SL.
ECON 305 ENGINEERING ECONOMICS FALL 13-14 RESIT EXAM SOLUTIONS

1. Establish economic equivalence at $N = 8$ (it can be used any period for economic equivalence)

$$ r = 8\% \text{ compounded semiannually} $$

**Deposit Series (up arrow)**

Find: Equivalent amount of deposits at $N = 8$ by using effective interest rate per deposit period $(i_p)$ that is equal to effective annual interest rate $i_a$.

$i_p$ should be determined according to the deposit period of the cash flow by considering compounding semiannually:

$$ K = 1, M = 2 \\
C = \frac{M}{K} = \frac{2}{1} = 2 \\
i_p = i_a = (1 + i_c)^C - 1 = \left(1 + \frac{r}{M}\right)^C - 1 = \left(1 + \frac{0.08}{2}\right)^2 - 1 = 0.0816 (8.16\%)

**Withdrawal Series (down arrow)**

$i_p$ should be determined according to the withdrawal period of the cash flow by considering compounding semiannually:

$$ K = 1, M = 2 \\
C = \frac{M}{K} = \frac{2}{1} = 2 \\
i_p = i_a = (1 + i_c)^C - 1 = \left(1 + \frac{0.08}{2}\right)^2 - 1 = 0.0816 (8.16\%)

$C$ can be calculated by equating the worth of the deposit cash flow at $N = 8$ to the worth of the withdrawal cash flow at $N = 8$ as follows:

$\$6000(P/A, 8.16\% , 2) = C(F/A, 8.16\% , 8) - C(F/A, 8.16\% , 2)(F/P, 8.16\% , 3)$

From the formulas given in Table 3.4/Textbook/Park 4th ed.:

$$ \$6000 \left[ \frac{(1 + 0.0816)^2 - 1}{0.0816 (1 + 0.0816)^2} \right] = C \left[ \frac{(1 + 0.0816)^8 - 1}{0.0816} \right] - C \left[ \frac{(1 + 0.0816)^2 - 1}{0.0816} \right] (1 + 0.0816)^3 $C = $1323.86

2. a)

*Given: Nominal Interest Rate 12% compounded annually (MARR)*

Annual maintenance costs and savings (K=1); $r=12\%$, $M=1$ (annual compounding); $C=M/K=1/1=1$

$$ r = i_p = i_a = 0.12 \text{ (effective annual interest rate 12\%)} $$

$$(CE)_{Model\ A} = \frac{(AE)_{Model\ A}}{i_p}$$

$$(AE)_{Model\ A} = -$7000(A/p, 12\% , 20) - $150 + $1100 + $600(A/F, 12\% , 20)$$

$$(AE)_{Model\ A} = -$7000(0.1339) - $150 + $1100 + $600(0.0139) = $21.04$$

$$(CE)_{Model\ A} = \frac{$21.04}{0.12} = $175.33$$
\[
(CE)_{Model\ B} = \frac{(AE)_{Model\ B}}{t_p}
\]

\[
(AE)_{Model\ B} = -$10000\left(\frac{A}{P}, 12\%, 20\right) - $100 + $1200 + $700\left(\frac{A}{F}, 12\%, 20\right)
\]

\[
(AE)_{Model\ B} = -$10000(0.1339) - $100 + $1200 + $700(0.0139) = -$229.27
\]

\[
(CE)_{Model\ B} = \frac{-229.27}{0.12} = -$1910.58
\]

\[
(CE)_{Model\ A} > (CE)_{Model\ B}
\]

$175.33 > -$1910.58

Select: Model A based on AE or CE method.

b)

<table>
<thead>
<tr>
<th></th>
<th>Model A</th>
<th>Model B</th>
<th>B-A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial cost, $</td>
<td>-7000</td>
<td>-10000</td>
<td>-3000</td>
</tr>
<tr>
<td>Annual maintenance cost, $</td>
<td>-150</td>
<td>-100</td>
<td>50</td>
</tr>
<tr>
<td>Annual savings, $</td>
<td>1100</td>
<td>1200</td>
<td>100</td>
</tr>
<tr>
<td>Salvage value, $</td>
<td>600</td>
<td>700</td>
<td>100</td>
</tr>
<tr>
<td>Expected life, years</td>
<td>20</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

\[
PW(i^*) = -$3000 + \frac{150(P/A, i^*, 20) + 100(P/F, i^*, 20)}{1 + i^*^{20} - 1} + +$100(1 + i^*)^{-20} = 0
\]

This equation given above should be solved for the root \( i^* \) by trial and error or Excel. For the decision based on incremental analysis, \( i^* \) to be found should be higher than 12\% (MARR) to select higher investment (Model B).

3.

\[
\alpha = (Multiplier)\left(\frac{1}{N}\right) = (175\%)\left(\frac{1}{5}\right) = (1.75)\left(\frac{1}{5}\right) = 0.35
\]

\[
D_n = \alpha B_{n-1}; B_{n-1} = I(1 - \alpha)^{n-1} = 100000(1 - 0.35)^{n-1}
\]

The depreciation allowances and book values were tabulated as follows by switching to SL on the year 4:

<table>
<thead>
<tr>
<th>( n )</th>
<th>( D_n )</th>
<th>( B_n )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100000(0.35) = 35000</td>
<td>100000 - 350000 = 65000</td>
</tr>
<tr>
<td>2</td>
<td>65000(0.35) = 22750</td>
<td>65000 - 22750 = 42250</td>
</tr>
<tr>
<td>3</td>
<td>42250(0.35) = 14788</td>
<td>42250 - 14788 = 27462</td>
</tr>
<tr>
<td>4</td>
<td>27462(0.35) = 9612</td>
<td>27462 - 11231 = 16231</td>
</tr>
<tr>
<td>5</td>
<td>11231</td>
<td>16231 - 11231 = 5000 = S</td>
</tr>
</tbody>
</table>

\[
D_{SL} = \frac{27462 - 5000}{2} = 11231 > 9612 \quad switch to SL
\]

\[
D_{SL} = \frac{42250 - 5000}{3} = 12417 < 14788 \quad do not switch to SL
\]