ME 353 ENGINEERING ECONOMICS
Second Midterm Exam – Fall 2000

Scoring gives priority to the correct formulation. Numerical answers without the correct formulas for justification receive no credit. Decisions without numerical justification receive no credit. Interest tables and factor formulas are at the end of the exam.

1. (16 Points) Your company is purchasing a machine. The machine costs $28,000. The useful life of the machine is four years. The machine will have a salvage value of $10,000 the end of the four years. The annual net revenue provided by the machine is $9,000.

The machine is depreciated using the sum-of-years digits line method using a tax life of 7 years and zero tax salvage. You pay a tax rate of 40% on all taxable net income. With an after-tax MARR of 20%, is this an acceptable investment? Use one of the methods learned in class to make this decision.

The SYD = 7*8/2 = 28

Compute the Depr in each year with the SYD
D1 = (7/28)28000 = 7000
D2 = (6/28)28000 = 6000
D3 = (5/28)28000 = 5000
D4 = (4/28)28000 = 4000

The ATCF in year 1 is 9000 - (9000 - 7000).4 = 8200
The ATCF in year 1 is 9000 - (9000 - 6000).4 = 7800
The cash flow is a decreasing gradient with value of -400

Compute the after tax salvage.
At year 5 the book value is 28000 - 22000 = 6000
The AT Salvage = 10000 - (10000 - 6000).4 = 5000 + 1200 = 8400

Compute the NPW with a 20% return.
NPW = -28000+ 8200(P/A, .2, 4) -400(P/G, .2, 4) + 8400(P/F, .2, 4)
NPW = -4041
Reject the investment.
2. (16 Points) Two different kinds of bits are being considered for a machine tool. Bit A has an initial cost of $1000 and has a life of three years. The energy cost associated with using this bit is $300 per year. Bit B has an initial cost of $1300 and has a life of three years. The energy cost for this bit is $200 per year. In each case below evaluate the two alternatives and select the most economic alternative.

The general rate of inflation is 4% a year. Your actual-dollar MARR is 20%.

a. The energy cost is increasing at a rate of 4% a year.

Since all costs are increasing at the same rate as general inflation, we can neglect inflation and analyze the alternatives with the real-MARR.

The easiest way to solve this is not note that in real terms, the extra investment of 300 in B over A has a total return of 300. Thus the real-ROR of B over A is 0.

Using the NPW method the real-dollar MARR is \((.2 - .04)/(1.04) = .1538\)

NPW(A) = 1000 + 300\((P/A, .1538, 3) = 1680\)

NPW(B) = 1300 + 200\((P/A, .1538, 3) = 1753\)

or

NAW(A) = 1000\((A/P, .1538, 3) + 300 = 741\)

NAW(B) = 1300\((A/P, .1538, 3) + 200 = 773\)

Choose A.

b. Change the inflation situation. The general inflation rate is 4%, but the energy cost is increasing at 30% rate.

Compute the NPW of cost for the two alternatives using the actual values of the energy cost. Find the NPW using the actual-dollar MARR

Alternative A

NPW(costs) = 1000 + 300\([(1.3) (P/F, .2, 1) + 1.3^2(P/F, .2, 2) + 1.3^3(P/F, .2, 3)] = 2058\)

Alternative B

NPW(costs) = 1300 + 200\([(1.3) (P/F, .2, 1) + 1.3^2(P/F, .2, 2) + 1.3^3(P/F, .2, 3)] = 2005\)

Choose B.
3. (16 Points) You bought a computer 2 years ago for a cost of $6000. It has been
   depreciated with the double rate declining balance method. The tax life for
depreciation purposes of the computer is 5 years, and the tax salvage is 0. The tax rate
is 30%. You have depreciated the computer for 2 years.

   You are considering replacing the computer with a new one. A dealer offers to sell
you a new computer for $4000. With your computer as a trade in, the net cost of the
new computer is $3000. The new computer has a tax life of 3 years and a tax salvage
of 0. The actual life of the new computer is 4 years, and if you keep the old computer
you will keep it for another two years.

   For a replacement analysis, call the old computer the defender, and the new computer
the challenger. Give the values for $P_D$, the investment in the defender and $P_C$, the
investment in the challenger. Consider taxes for your analysis.

Compute the BV of the old computer.
$D_1 = 6000 (.4) = 2400$. BV$_1 = 3600$. $D_2 = 3600 (.4) = 1440$, BV$_2 = 2160$.

The investment in the defender is $PD = \text{Market value} - \text{Taxes}$
$1000 - (1000 - 2160) .3 = 1348$

The investment value for the challenger PC.
4000
4. (18 Points) Aladdin's wife, Jasmine, is considering buying a new lamp to replace an old one she found around the house. The old lamp has been burning an unusually large amount of oil lately. She estimates the following cost structure for oil during the next few months. Costs are in denarii (the currency in Aladdin's time).

<table>
<thead>
<tr>
<th>Month</th>
<th>Cost of oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td>4 and after</td>
<td>Increases by 0.5 in each month.</td>
</tr>
</tbody>
</table>

A man down the street likes the old lamp and offers three denarii for the lamp if Jasmine sells it today. She'll have to polish the lamp for the man. Polishing costs one denarii for supplies and labor. One month from today and thereafter, the lamp can be sold for only one denarii and will not require polishing.

Although the new lamp costs ten denarii, it will last essentially forever. Because of a new design, the cost for oil will be only 1/2 denarii per month.

In Aladdin's time, capital is very scarce. His family only accepts investments that return at least 20% per month.

Should Jasmine keep the old lamp or sell it and buy the new one?

The weekly cost of the new lamp is

\[ 10 \times (A/P, .2, \text{ inf.}) + .5 = 10 \times .2 + .5 = 2.5 \text{ per week.} \]

Use market value of lamp less the cost of polishing: \( 3 - 1 = 2 \) denarii

The weekly cost of the old lamp is

\[
\text{Investment}(1 + i) - \text{Salvage} + \text{Operating Expense} = NAC = 2 \times (A/P, .2, n) - 1 \times (A/F, .2, n) + 1.5 + 0.5 \times (A/G, .2, n)
\]

\[ \begin{align*}
n = 1: & \quad NAC = 2.9 \\
n = 2: & \quad NAC = 2.58 \\
n = 3: & \quad NAC = 2.61 \\
\end{align*} \]

Economic Life is 2 weeks with a cost of 2.58.

**Decision (New or Old):** Buy the new lamp.
5. (18 Points) In the following assume the general inflation rate is 4% a year.

a. You borrow $20,000 to buy a car. The bank charges a nominal annual interest rate of 12% for new car loans. Using an interest table for 1% (per month) and 60 months, the bank computes your payment as $449 per month. What "real" nominal annual interest rate are you paying on this loan? (For convenience assume that inflation compounds monthly.)

The actual interest rate is 1% a month.
The general inflation rate is .04/12 = 0.0033/month

The real interest rate is \( i_r = \frac{i_c - f}{1 + f} = \frac{0.01 - 0.0033}{1 + 0.0033} = 0.006678 \) per month

Or 0.006678*12 = 8.01% per year. (8% is OK)

b. You just received a check in the amount of $20,000 from your stock broker. The money is the proceeds from some Dell stock that the broker sold for you. You bought the stock 3 years ago for $10,000. What "real" annual rate of return do you earn from that investment?

Compute the actual rate by setting the NPW of the cash flow equal to 0.

\[
NPW = -10000 + 20000(P/F, i, 3) = 0
\]

or \( (F/P, i, 3) = (1 + i)^3 = 2. \) or \( i = 26\% \).

The real rate is \( i_r = (i_c - f)/(1 + f) = 21\% \).
6. (18 Points)
   a. The GDS rate percentages for the MACRS method for the five year class are derived from the double rate declining balance depreciation method with a switch point at year 4. What is the relationship between the depreciation percentages in years 4, 5 and 6. You don't have to give values, just explain how the numbers are related to each other.

   Since the straight line method is used, the rate in years 4 and 5 are equal. The rate in year 6 is half of the rates in years 4 and 5 because of the half year convention.

   b. You finance $150,000 for the purchase of a house. The loan is a 30 year mortgage loan with monthly payments. The interest rate on the loan is 9% a year, and the payment amount is $1,207 a month. You live in the house for ten years and then decide to move. You must pay the bank the amount that you still owe. During the period in which you have owned the house there has been a 4% annual general inflation rate. Write the formula for the amount that you still owe the bank. Use explicit interest rates, but do not evaluate.

   The amount you owe is the present worth of the payments still owed. Use the interest rate of the loan. Inflation doesn't effect the amount you owe.
   \[ \text{Owed} = 1207(P/A, .0075, 240) \]

   c. You purchase an asset with the initial cost P. The tax and useful life are both 10 years. The tax and actual salvage are both S. Compare straight line (SL) and sum-of-years digits (SYD) methods.

<table>
<thead>
<tr>
<th>Question</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which gives the smallest book value after 5 years of ownership?</td>
<td>SYD</td>
</tr>
<tr>
<td>Which gives the smallest total depreciation over the 10 years of life?</td>
<td>Both the same</td>
</tr>
<tr>
<td>Which gives the smallest NPW for the asset for the 10 year period?</td>
<td>SL</td>
</tr>
</tbody>
</table>
### Compound Interest Formulas

<table>
<thead>
<tr>
<th>Interest Rate</th>
<th>20%</th>
<th></th>
<th>20%</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>F/P</td>
<td>P/F</td>
<td>A/F</td>
</tr>
<tr>
<td>1</td>
<td>1.000</td>
<td>0.8333</td>
<td>1.0000</td>
</tr>
<tr>
<td>2</td>
<td>1.440</td>
<td>0.6944</td>
<td>0.4545</td>
</tr>
<tr>
<td>3</td>
<td>1.728</td>
<td>0.5787</td>
<td>0.2747</td>
</tr>
<tr>
<td>4</td>
<td>2.074</td>
<td>0.4823</td>
<td>0.1863</td>
</tr>
<tr>
<td>5</td>
<td>2.488</td>
<td>0.4019</td>
<td>0.1344</td>
</tr>
<tr>
<td>6</td>
<td>2.986</td>
<td>0.3349</td>
<td>0.1007</td>
</tr>
<tr>
<td>7</td>
<td>3.583</td>
<td>0.2791</td>
<td>0.0774</td>
</tr>
<tr>
<td>8</td>
<td>4.300</td>
<td>0.2326</td>
<td>0.0606</td>
</tr>
<tr>
<td>9</td>
<td>5.160</td>
<td>0.1938</td>
<td>0.0481</td>
</tr>
<tr>
<td>10</td>
<td>6.192</td>
<td>0.1615</td>
<td>0.0385</td>
</tr>
<tr>
<td>11</td>
<td>7.430</td>
<td>0.1346</td>
<td>0.0311</td>
</tr>
<tr>
<td>12</td>
<td>8.916</td>
<td>0.1122</td>
<td>0.0253</td>
</tr>
<tr>
<td>13</td>
<td>10.699</td>
<td>0.0935</td>
<td>0.0206</td>
</tr>
<tr>
<td>14</td>
<td>12.839</td>
<td>0.0779</td>
<td>0.0169</td>
</tr>
<tr>
<td>15</td>
<td>15.407</td>
<td>0.0649</td>
<td>0.0139</td>
</tr>
</tbody>
</table>

| Single Payment Compound Amount Factor | (F/P, i, n) = (1 + i)^n |
| Single Payment Present Worth Factor | (P/F, i, n) = \( \frac{1}{(1 + i)^n} = \frac{1}{(F/P, i, n)} \) |
| Uniform Series Compound Amount Factor | (F/A, i, n) = \( \frac{(1 + i)^n - 1}{i} \) |
| Uniform Series Sinking Fund Factor | (A/F, i, n) = \( \frac{i}{(1 + i)^n - 1} = \frac{1}{(F/A, i, n)} \) |
| Uniform Series Present Worth Factor | (P/A, i, n) = \( \frac{(1 + i)^n - 1}{i(1 + i)^n} \) |
| Uniform Series Capital Recovery Factor | (A/P, i, n) = \( \frac{i(1 + i)^n}{(1 + i)^n - 1} = \frac{1}{(P/A, i, n)} \) |
| Arithmetic Gradient Present Worth Factor | (P/G, i, n) = \( \frac{(1 + i)^n - in - 1}{i^2(1 + i)^n} \) |
| Arithmetic Gradient Uniform Series Factor | (A/G, i, n) = \( \frac{(1 + i)^n - in - 1}{i(1 + i)^n - i} \) |