ME 353 ENGINEERING ECONOMICS  
Sample Second Midterm Exam

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) 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(A/P, .2, inf.) + .5 = 10*.2 + .5 = 2.5 per week.

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

The weekly cost of the old lamp is
Investment(1 + i) - Salvage + Operating Expense
NAC = 2*(A/P, .2, n) - 1(A/F, .2, n) + 1.5 + 0.5(A/G, .2, n)

n = 1: NAC = 2.9  
n = 2: NAC = 2.58  
n = 3: NAC = 2.61

Economic Life is 2 weeks with a cost of 2.58.
Decision (New or Old): Buy the new lamp.
2. (10 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 $PC$. $4000$

3. (12 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 = $7 \times 8 / 2 = 28$

Compute the Depr in each year with the SYD

$D_1 = (7/28)28000 = 7000$
$D_2 = (6/28)28000 = 6000$
$D_3 = (5/28)28000 = 5000$
$D_4 = (4/28)28000 = 4000$

The ATCF in year 1 is $9000 - (9000 - 7000).4 = 8200$
The ATCF in year 2 is \( 9000 - (9000 - 6000) \cdot 0.4 = 7800 \)
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 = \( 10000 - (10000 - 6000) \cdot 0.4 = 5000 + 1200 = 8400 \)

Compute the NPW with a 20% return.
\[
NPW = -28000 + 8200 \left( \frac{1}{P/A, 0.2, 4} \right) -400 \left( \frac{1}{P/G, 0.2, 4} \right) + 8400 \left( \frac{1}{P/F, 0.2, 4} \right)
\]
\( NPW = -4041 \)
Reject the investment.

4. (10 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 costs are 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 to 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 NAW method the real-dollar MARR is \( \frac{0.2 - 0.04}{1.04} = 0.1538 \)
\[
NAW(A) = 1000 \left( \frac{1}{A/P, 0.1538, 3} \right) + 300 = 1680
\]
\[
NAW(B) = 1300 \left( \frac{1}{A/P, 0.1538, 3} \right) + 200 = 1753
\]
Choose A.

b. Change the inflation situation. The general inflation rate is 4%, but energy costs are 
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**

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

**Alternative B**

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

Choose B.
5. (12 Points) You are considering two alternatives, A and B, to perform some function for an indefinite period. We identify two components of operating cost, fuel and labor. Expressed in today’s prices we make the following estimates about the investment, cost and salvage values of the alternatives. Note that A has a two-year economic life and B has a three-year economic life.

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Initial Cost</th>
<th>Annual Labor cost</th>
<th>Annual Fuel Cost</th>
<th>Life</th>
<th>Salvage Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>100,000</td>
<td>15,000</td>
<td>40,000</td>
<td>2</td>
<td>30,000</td>
</tr>
<tr>
<td>B</td>
<td>150,000</td>
<td>10,000</td>
<td>30,000</td>
<td>3</td>
<td>20,000</td>
</tr>
</tbody>
</table>

We expect a general inflation rate of 4% a year. The initial costs and salvage values will increase at the same rate as general inflation, but the operating cost components will increase at a higher rate. The inflation rate for labor cost will be 6% per year, and the inflation rate for fuel will be 10% a year. Which of the two alternatives is the best selection? The actual dollar MARR (including inflation) is 20%.

The most direct way to work this problem is to find the PW of each alternative over its lifetime and then find the real dollar NAC.

NPW(Costs A) = 100 + (15*(1.06)+40*(1.1))*PF(1)+
   (15*(1.06^2)+40*(1.1^2)*PF(2) – 30*(1.04^2))* PF(2)
   = 171.7

NPW(Costs B) = 150 + (10*(1.06)+30*(1.1))*PF(1)+
   (10*(1.06^2)+30*(1.1^2))*PF(2) + (10*(1.06^3)+30*(1.1^3))*PF(3) –
   20*(1.04^3))* PF(3)
   = 236.33

Find the NAC in real dollars

Use \( i_r = (0.2 - 0.04)/1.04 = 0.154 \)

NAC(A) = 171.7*AP(2) = 106

NAC(B) = 236.33*AP(3) = 104.35

Choose B

6. (12 Points) We bought a truck eight years ago for $15,000 to handle product delivery. We have been depreciating the truck with the straight-line method for 8 years. Annual depreciation is computed with a tax life of 10 years and a tax salvage of 0.
We are considering two options. We could sell the truck now and hire a delivery service, or we will keep the truck for another three years. The resale value for the truck at this time is $6,000 and we estimate the resale value of the truck will be $1,000 after three years. The operating costs for the next three years are: $1000, $2,000, and $3,000 respectively. If we sell the truck, we will use a delivery service that will cost $4000 per year. Assume the delivery service payments are paid throughout the year, but for analysis purposes we accumulate them to the end of each year.

Our after tax minimum acceptable rate of return is 20%. The tax rate is 20% on both ordinary income and capital gains. Use an after tax analysis. Should we sell the truck or keep it?

The cost of the delivery service is 4000*0.8 or $3200 per year. The expense is tax deductible.

We must compute the NAC cost of keeping the truck for 3 years. The book value for the truck is 15000 – 1500*8 = 3000
The tax effect on selling the truck is
ATSV = BTSV – Tax = BTSV – (BTSV – BV)*tax rate
= 6000 – (6000 – 3000)*.2 = 6000 – 600 = 5400

Showing the tax analysis for three years we have:

<table>
<thead>
<tr>
<th>Year</th>
<th>BTCF</th>
<th>Depr</th>
<th>TI</th>
<th>Tax</th>
<th>ATCF</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-6000</td>
<td></td>
<td></td>
<td></td>
<td>-5400</td>
</tr>
<tr>
<td>1</td>
<td>-1000</td>
<td>1500</td>
<td>-2500</td>
<td>-500</td>
<td>-500</td>
</tr>
<tr>
<td>2</td>
<td>-2000</td>
<td>1500</td>
<td>-3500</td>
<td>-700</td>
<td>-1300</td>
</tr>
<tr>
<td>3</td>
<td>-3000</td>
<td>0</td>
<td>-3000</td>
<td>-600</td>
<td>-2400</td>
</tr>
<tr>
<td>3 Salvage</td>
<td>1000</td>
<td>0</td>
<td>1000</td>
<td>200</td>
<td>800</td>
</tr>
</tbody>
</table>

ATPW = 5400 + 500*PF(1)+1300*PF(2)+2400*PF(3)-200*PF(3) = 7645
AT NAC = 7818*AP(3) = 3629

The delivery service is cheaper.
7. (12 Points) Consider the cash flow at the right with different assumptions regarding the effect of inflation. In each case the general inflation rate is 4% and the MARR including the adjustment for inflation is 20%. Write the formulas that can be used to compute the desired quantities. The formulas should use as few time value of money terms as possible. Use numerical interest rates in the factors. You do not have to evaluate the formulas.

a. The cash flows at the different times are estimated in today’s prices, but the future flows are expected to increase at a rate of 4% a year. Write the formula for the net present worth.

\[ i_c = 20\%, \ i_r = \frac{(.2 - .04)}{1.04} = .154 \text{ or } 15.4\%. \]
\[ \text{NPW} = -10 + 2(P/A, .154, 5) + (P/G, .154, 5) \]

b. The cash flows at the different times are estimated in actual dollars. Write the formula for the net annual worth expressed in real dollars.

\[ \text{NAW} = (-10 + 2(P/A, .2, 5) + (P/G, .2, 5))(A/P, 0.514, 5) \]

c. The cash flows at the different times are estimated in today’s prices, but the future flows are expected to increase at a 10% rate. Write the formula for the future worth at time 5 expressed in actual dollars.

One way is to move each payment expressed in actual dollars to time 5.

\[ \text{FW} = (-10)(F/P, .2, 5) + 2(1.1)(F/P, .2, 4) + 3(1.1)^2 (F/P, .2, 3) + 4(1.1)^3 (F/P, .2, 2) + 5(1.1)^4 (F/P, .2, 1) + 6(1.1)^5 \]
8. (16 Points) In all parts of this problem the tax rate is 40% for both ordinary income and capital gains. All parts consider an asset that has an initial investment of $100,000 and a useful life of 5 years. After 5 years the asset will have a salvage value of $50,000. The net annual before tax income is $40,000. Provide justification for your answers.

a. You can choose one of the following depreciation plans: (1) depreciate with the straight line method with 0 tax salvage and a tax life of 5 years or (2) depreciate with the straight line method with 0 tax salvage and a tax life of 10 years. Which method will yield the lowest total tax payments?

All methods yield the same total tax payments. They only differ in the timing.

b. You depreciate the asset with the double rate declining balance method using a tax life of 5 years. What is the depreciation allowed in the 3rd year?

<table>
<thead>
<tr>
<th>Initial cost</th>
<th>100000</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40000</td>
</tr>
<tr>
<td>2</td>
<td>24000</td>
</tr>
<tr>
<td>3</td>
<td>14400</td>
</tr>
</tbody>
</table>

Depreciation in 3rd year is $14,400.

c. You are using the ACRS method with the depreciation schedule below. If the net income from operations is $40,000 in the 3rd year, what is the after tax cash flow in the 3rd year?

<table>
<thead>
<tr>
<th>Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACRS %</td>
<td>20%</td>
<td>32%</td>
<td>20%</td>
<td>11%</td>
<td>11%</td>
<td>6%</td>
</tr>
</tbody>
</table>

ATCF = BTCF – (BTCF – Depr)*Tax rate
ATCF = 40000 – (40000 – 100000*.2)(0.4)
ATCF = 40000 – (40000 – 20000)(0.4) = 40000 – 8000 = 32000

d. After one year you are considering replacing this asset with a new improved version. The asset has a resale value at that time of $70,000. In an after tax replacement analysis, what value should we assign to the investment for the defender considering the ACRS method, the straight-line method with a 5 year life and the straight-line method with a 10 year life?

Assuming ACRS the BV after 1 year is 80000.
After tax MV = 70000 – (70000 – 80000)(0.4) = $74,000

Assuming St-Line with 5 year life the BV after 1 year is 80000.
After tax MV = 70000 – (70000 – 80000)(0.4) = $74,000
Assuming St-Line with 10 year life the BV after 1 year is 90000.
After tax MV = 70000 – (70000 – 90000)(0.4) = $78,000
## Compound Interest Formulas

<table>
<thead>
<tr>
<th>Interest Rate</th>
<th>20%</th>
<th>Single Payment Compound Amount Factor</th>
<th>Single Payment Present Worth Factor</th>
<th>Uniform Series Compound Amount Factor</th>
<th>Uniform Series Sinking Fund Factor</th>
<th>Uniform Series Present Worth Factor</th>
<th>Uniform Series Capital Recovery Factor</th>
<th>Arithmetic Gradient Present Worth Factor</th>
<th>Arithmetic Gradient Uniform Series Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>((F/P, i, n) = (1 + i)^n)</td>
<td>((P/F, i, n) = \frac{1}{(1+i)^n} = \frac{1}{(F/P, i, n)})</td>
<td>((F/A, i, n) = \frac{(1 + i)^n - 1}{i})</td>
<td>((A/F, i, n) = \frac{i}{(1+i)^n - 1} = \frac{1}{(F/A, i, n)})</td>
<td>((P/A, i, n) = \frac{(1 + i)^n - 1}{i(1 + i)^n})</td>
<td>((A/P, i, n) = \frac{i(1+i)^n}{(1+i)^n - 1} = \frac{1}{(P/A, i, n)})</td>
<td>(\frac{(1 + i)^n - in - 1}{i^2(1 + i)^n})</td>
<td>((A/G, i, n) = \frac{(1 + i)^n - in - 1}{i(1 + i)^n - i})</td>
</tr>
<tr>
<td>1</td>
<td>1.200</td>
<td>0.8333</td>
<td>1.0000</td>
<td>1.2000</td>
<td>1.000</td>
<td>0.833</td>
<td>0.000</td>
<td>0.000</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1.440</td>
<td>0.6944</td>
<td>0.4545</td>
<td>0.6545</td>
<td>2.200</td>
<td>1.528</td>
<td>0.455</td>
<td>0.694</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>1.728</td>
<td>0.5787</td>
<td>0.2747</td>
<td>0.4747</td>
<td>3.640</td>
<td>2.106</td>
<td>0.879</td>
<td>1.852</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>2.074</td>
<td>0.4823</td>
<td>0.1863</td>
<td>0.3863</td>
<td>5.368</td>
<td>2.589</td>
<td>1.274</td>
<td>3.299</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>2.488</td>
<td>0.4019</td>
<td>0.1344</td>
<td>0.3344</td>
<td>7.442</td>
<td>2.991</td>
<td>1.641</td>
<td>4.906</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>2.986</td>
<td>0.3349</td>
<td>0.1007</td>
<td>0.3007</td>
<td>9.930</td>
<td>3.326</td>
<td>1.979</td>
<td>6.581</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>3.583</td>
<td>0.2791</td>
<td>0.0774</td>
<td>0.2774</td>
<td>12.916</td>
<td>3.605</td>
<td>2.290</td>
<td>8.255</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>4.300</td>
<td>0.2326</td>
<td>0.0606</td>
<td>0.2606</td>
<td>16.499</td>
<td>3.837</td>
<td>2.576</td>
<td>9.883</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>5.160</td>
<td>0.1938</td>
<td>0.0481</td>
<td>0.2481</td>
<td>20.799</td>
<td>4.031</td>
<td>2.836</td>
<td>11.434</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td>6.192</td>
<td>0.1615</td>
<td>0.0385</td>
<td>0.2385</td>
<td>25.959</td>
<td>4.192</td>
<td>3.074</td>
<td>12.887</td>
<td>10</td>
</tr>
<tr>
<td>11</td>
<td>7.430</td>
<td>0.1346</td>
<td>0.0311</td>
<td>0.2311</td>
<td>32.150</td>
<td>4.327</td>
<td>3.289</td>
<td>14.233</td>
<td>11</td>
</tr>
<tr>
<td>12</td>
<td>8.916</td>
<td>0.1122</td>
<td>0.0253</td>
<td>0.2253</td>
<td>39.581</td>
<td>4.439</td>
<td>3.484</td>
<td>15.467</td>
<td>12</td>
</tr>
<tr>
<td>13</td>
<td>10.699</td>
<td>0.0935</td>
<td>0.0206</td>
<td>0.2206</td>
<td>48.497</td>
<td>4.533</td>
<td>3.660</td>
<td>16.588</td>
<td>13</td>
</tr>
<tr>
<td>14</td>
<td>12.839</td>
<td>0.0779</td>
<td>0.0169</td>
<td>0.2169</td>
<td>59.196</td>
<td>4.611</td>
<td>3.817</td>
<td>17.601</td>
<td>14</td>
</tr>
<tr>
<td>15</td>
<td>15.407</td>
<td>0.0649</td>
<td>0.0139</td>
<td>0.2139</td>
<td>72.035</td>
<td>4.675</td>
<td>3.959</td>
<td>18.509</td>
<td>15</td>
</tr>
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