ME 353 ENGINEERING ECONOMICS
First Midterm Exam – Fall 2000
Correct use of formulas receives more credit than numerical answers. Numerical answers without the correct formulas or justification receive no credit. Use the interest rate tables provided on the last page.

1. (15 Points) In each case there is a cash flow shown on the left. Write the formula for the quantity requested on the right. Use as few time value of money factors in the formula as possible.

As the present worth at time 0..
\[ P = -150(P/A,i,10) + 50*(P/G,i,10) \]

As an end of period uniform series over the 10 periods.
\[ A = 100(F/A,i,3)(A/F,i,5) \]

As a single equivalent payment at time 5.
\[ F_5 = 100(F/A,i,4) -100 -300(P/A,i,5) \]
2. (10 Points) A homeowner needs a new roof. She can buy a standard asphalt roof for $10,000. It has a guaranteed life of 8 years. For $15,000, she can buy a sheet-metal roof. That roof has a guaranteed life of 20 years. There are no additional costs associated with either roof, but the roofs must be replaced at the intervals indicated. The homeowner's MARR is 18%.

Use present worth analysis to see if it is better to spend the extra money to obtain the longer-lasting roof?

\[ \text{NAW(Steel)} = 15000 (A/P, .18, 20) = 2802 \]
\[ \text{NPW(Steel for 40 years)} = 15547 \]

\[ \text{NAW(Asphalt)} = 10000 (A/P, .18, 8) = 2452 \]
\[ \text{NPW(Asphalt for 40 years)} = 13606 \]

Choose the Asphalt roof
3. (15 Points) You have three options to perform some function. The required investment and annual costs are shown below. Use a rate of return analysis to select the best. All three options have 0 salvage. Your MARR is 14%.

<table>
<thead>
<tr>
<th>Option</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment</td>
<td>110</td>
<td>210</td>
<td>80</td>
</tr>
<tr>
<td>Annual Cost</td>
<td>50</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>Life</td>
<td>5</td>
<td>10</td>
<td>5</td>
</tr>
</tbody>
</table>

Rank C, B, A
Use C as the defender. Challenger is A.
Compute ROR A - C
\[
\text{NAW}_A - \text{NAW}_C = -30(A/P, i, 5) + 10 = 0. \text{ Trial and error yields 20%}. 
\]

Accept A:

Use B as the challenger.
\[
\text{NAW}_B - \text{NAW}_A = -210(A/P, i, 10) -40 + 110(A/P, i, 5) + 50
-210(A/P, i, 10) + 110(A/P, i, 5) + 10 = 0. \text{ Trial and error yields 16%}. 
\]

Accept B - A.

Choose B
4. (15 Points) A company must buy a heavy duty earth moving machine. It has three alternatives.

The first involves a $50,000 initial investment with no maintenance costs and a four year life. The resale value of this machine after four years is $20,000.

The second alternative involves a $30,000 initial investment, a $20,000 overhaul expense after four years, and $2,000 per year operating expense. The alternative is discarded with no salvage value after six years.

The third alternative involves renting the machine. The rental cost is $10,000 per year, payable at the beginning of the year. The operating cost is $2,500 per year. The machine can be rented for any number of years.

Compare the alternatives with an annual worth analysis using the company’s MARR of 18%. The company has a need for the machine for an indefinite period.

Compute the NAW with costs as positive.
NAWA = 50(A/P, .18, 4) – 20(A/F, .18, 4) = 14.75

NAWB = (30 + 20*(P/F, .18, 4))(A/P, .18, 6) + 2 = 13.52

NAWC = 10*(A/P, .18, 1) + 2.5 = 14.3

Choose B as the least expensive alternative.
5. (15 Points) A city is considering installing a merry-go-round at Zilker park as an extra source of funds. The ride can be purchased for $8,000. It has a life of 10 years and at the end of the its life it will have a salvage value of $5000. The cost of the operator and maintenance is $8,000 per year. This cost is independent of the number of riders. The cost of electricity and other variable costs is $0.25 per rider. The MARR for the city is 18%.

The city plans to pay for the machine and make a profit by selling rides to customers and others. The following estimates are made regarding the annual demand for rides.

- At a price of $2.00 a ride, nobody will want to ride.
- For each reduction in price of $0.10 the demand will increase by 1,000 riders. We assume a linear relationship between price and demand up to a maximum of 10,000 riders. At that level of demand the price is $1.00 per ride. The demand will not exceed 10,000.

Answer the following questions regarding this plan.

a. Write an expression for the annual cost (just costs, not revenue) of the merry-go-round project as a function of the number of persons who ride per year. Use \( x \) as the number of riders.

Annual Cost = \((8000 - 5000)(A/P, .18, 10) + 5000(.18) + 8000 + 0.25x\)

Annual Cost = \(9568 + 0.25x\)

b. Write an expression for the annual revenue from rides as a function of the number of riders. The expression only holds up to 10,000 riders.

Revenue = \(p*D\)

\(p = 2.00 - 0.10*x/1000\)

Revenue = \((2.00 - 0.10*x/1000)x = 2x - (0.0001)x^2\)

c. Determine the ride price that will yield the greatest annual profit?

Profit = Revenue - Cost = \(2x - (0.0001)x^2 - 9568 - 0.25x\)

\(d(Profit)/dD = 1.75 - 0.0002x\) or \(x^* = 1.75/0.0002 = 8750\) rides

price = \(p = 2.00 - 0.10*8750/1000 = 1.125\)

d. Based on these results, would you recommend that the city purchase the ride?

Net Profit = Revenue - Cost = \((1.125 - 0.25)*8750 - 9568 = -1912\)

At the optimum revenue, this plan does not make money. You should not recommend the purchase.
6. (15 Points) Trilogy Corp. is considering has purchased downtown location for a new building complex. The company paid $75 million for the land. There is room for three buildings on the land. Three plans are proposed for development. The plans all involve building the three buildings, but at different points in time. The following is true for all three plans.

- The planning horizon is 15 years.
- The resale value after 15 years is $150 million for land and buildings.
- With one building the annual net revenue is $10 million.
- With two buildings the annual net revenue is $18 million.
- With three buildings the annual net revenue is $24 million.
- Each building costs $20 million to build.

The three plans are:
A. Build all three buildings immediately (the building cost is $60 million).
B. Build two buildings now ($40 million) and a third building at year 10 ($20 million).
C. Build one building now ($20 million), one building in 5 years ($20 million) and one building in 10 years ($20 million).

Select the best development plan with the rate of return method. You must do the method correctly to get full credit. The company's MARR is 35%. Note that the company has already purchased the land, and you are only to choose the development plan.

Rank the projects in the order of initial investment: C, B, A.

Compute ROR of B - C

\[ ROR = 40\%. \text{ Accept } B - C \]

Compute ROR of A - B

\[ ROR = \frac{6}{20} = 30\%. \text{ Reject } A - B \]

Choose B
You don't have to make detailed computations to answer these questions.

7. (5 Points) You are planning to take out a loan to buy a new car. The amount of the loan is $20,000, the term of the loan is 5 years and the nominal interest rate is 12%. Compounding periods are the same as payment periods. The dealer offers two payment plans:
   A. Pay the loan with a payment every two months (30 payments)
   B. Pay the loan with a payment every month (60 payments)

   a. Which plan (A or B) has the smallest effective interest rate?
   Plan A has the smallest effective interest rate.

   b. Which plan (A or B) has the smallest total cost (the sum of payments)?
   Plan B will have the smallest total of the payments.

8. (5 Points) You have a business opportunity requires you to invest $100,000 now. You will get back the entire amount of your investment ($100,000) in ten years. In addition you will receive a dividend of $20,000 at the end of each year. Your MARR is 20%,

   a. What is the capital recovery (CR) associated this investment?
   CR = 100,000i = 20,000

   b. What is the ROR associated with this investment?
   The ROR 20/100 = 20%

9. (5 Points) We learned about several classifications of costs in this class. Demonstrate your knowledge by filling in the blanks. You are advising Jerry Jones, the owner of the Dallas Cowboys football team.

   a. Jerry complains that he is still paying Deon Sanders money even though Deon doesn't play for the Cowboys any more. The money is part of a signing bonus.
   What kind of cost is the money he is paying to Deon? ______Sunk__________ cost.

   b. Jerry tells you that the Cowboys could be sold for $100 million. Jerry's MARR is 30%.
   What kind of cost is: ( Market Value )* (MARR) = $30 million per year?
   __________Opportunity__________ cost