ISE 307, Term 153

ENGINEERING ECONOMIC ANALYSIS

HW# 4 Solution

Due date: Saturday, August 13

Q.1. The owner of a business is considering investing $80,000 in new equipment. He estimates that the net cash flows will be $8,000 during the first year and will increase by $2,000 per year each year thereafter. The equipment is estimated to have a 10-year service life and a net salvage value at the end of this time of $10,000. The firm's interest rate is 15%.

a. Determine the annual capital cost (ownership cost) for the equipment.

CR(15%) = (80,000-10,000)(A/P, 15%, 10) + 0.15*10,000
= 70,000*0.1993 + 1,500
= $15,451

b. Determine the equivalent annual savings (revenues).

$AE_{savings}$(15%) = 8,000 +2,000 (P/G, 15%, 10)(A/P, 15%, 10)
= 8,000 + 2,000*16.9795*0.1993
= $14,768.03

OR

$AE_{savings}$(15%) = 8,000 +2,000 (A/G, 15%, 10)
= 8,000 + 2,000*3.3832
= $14,766.4

c. Determine whether this investment is wise.

AE(15%) = 14,768.03 - 15,451 = -$682.97

So, this investment is not wise.

Q.2. You invest in a piece of equipment costing $100,000. The equipment will be used for three years, and it will be worth $20,000 at the end of three years. The machine will be used for 4,000 hours during the first year, 5,000 hours during the second year and 6,000 hours during the third year. The expected annual savings associated with the use of the piece of equipment will be $30,000 for the first year, $40,000 for the second year and $50,000 for the third year. Your interest rate is 10%.

a. What is the capital recovery cost?

$CR(10\%) = (100{,}000 - 20{,}000)(A/P, 10\%, 3) + 0.1 * 20{,}000$
$= 80{,}000*0.4021 + 2{,}000$
$= \$34{,}168$

b. What is the annual equivalent worth?

$AE_{savings}(10\%) = [30{,}000(P/F, 10\%, 1) + 40{,}000(P/F, 10\%, 2) + 50{,}000(P/F, 10\%, 3)](A/P, 10\%, 3)$
$= [30{,}000*0.9091 + 40{,}000*0.8264 + 50{,}000*0.7513]*0.4021$
$= 97{,}894*0.4021 = \$39{,}363.18$

$AE(15\%) = 39{,}363.18 - 34{,}168 = \$5{,}195.18$

c. What is the net savings generated per machine-hour?

Let C be savings per machine hour
Then, $AE(15\%) = 4000C(P/F, 10\%, 1) + 5000C(P/F, 10\%, 2) + 6000C(P/F, 10\%, 3)](A/P, 10\%, 3)$
$= [4{,}000C*0.9091 + 5{,}000C*0.8264 + 6{,}000C*0.7513]*0.4021$
$= 12{,}276.2C*0.4021 = 4{,}936.26C$

Thus, $C = 5{,}195.18/4{,}936.26 = \$1.05$ per machine hour

Q.3. Company X has been contracting its overhauling work to Company Y for $30,000 per machine per year. Company X estimates that by building a $800,000 maintenance facility with a life of 10 years and a salvage value of $100,000 at the end of its life, it could handle its own overhauling at a cost of only $10,000 per machine per year. What is the minimum annual number of machines that Company X must operate to make it economically feasible to build its own facility, assuming an interest rate of 10%?

$CR(10\%) = (800{,}000 - 100{,}000)(A/P, 10\%, 10) + 0.1 * 100{,}000$
$= 700{,}000*0.1627 + 10{,}000$
$= \$123{,}890$

Let M be the number of machines.
$AE_{savings}(10\%) = (30{,}000 - 10{,}000)\ M$
$AE(10\%) = (30{,}000 - 10{,}000)\ M - 123{,}890 = 0$
$20{,}000\ M = 123{,}890 \Rightarrow M = 123{,}890/20{,}000 = 6.19 \Rightarrow 7$ machines

Q.4. You are considering developing an 18-hole championship golf course that requires an investment of $25,000,000. This investment cost includes the course development, club house, and golf carts. Once constructed, you expect the maintenance cost for the golf course to be $500,000 in the first year, $500,000 in the second year, $550,000 in the third year and continue to increase by $50,000 in subsequent years. The net revenue generated from selling food and beverage will be about 10% of greens fees paid by the players. The cart fee per player is $20, and 50,000 rounds of golf are expected per year. You will own and operate the course complex for 15 years and expect to sell it for $35,000,000. What is the greens fee per round that will provide a return on investment of 15%? Assume that the greens fee will be increased at an annual rate of 5%.

Let C denote the greens fee per round.

$CR(15\%) = (25{,}000{,}000 - 35{,}000{,}000)(A/P, 15\%, 15) + 0.15 \times 35{,}000{,}000$
$= -10{,}000{,}000*0.1710 + 5{,}250{,}000$
$= \$3{,}540{,}000$

$AE_{maintenance}(15\%) = 500{,}000 + 50{,}000(P/G, 15\%, 14)\,(P/F, 15\%, 1)(A/P, 15\%, 15)$
$= 500{,}000 + 50{,}000*24.9725*0.8696*0.1710$
$= \$685{,}672.54$

$AE_{revenue}(15\%) = 20*50{,}000 + 1.10C*50{,}000(P/A1, 5\%, 15\%, 15)\,(A/P, 15\%, 15)$
$= 1{,}000{,}000 + 55{,}000C*7.445*0.1710$
$= 1{,}000{,}000 + 70{,}020.23C$

$AE(15\%) = 1{,}000{,}000 + 409{,}475C - 685{,}672.54 - 3{,}540{,}000$
$= 70{,}020.23C - 3{,}225{,}672.54 = 0$
$\Rightarrow$ $C = 3{,}225{,}672.54/70{,}020.23 = \$46.07$

Q.5. Consider two investments with the following sequences of cash flows:

n	Project A	Project B
0	-$100,000.00	-$100,000.00
1	$30,000.00	$50,000.00
2	$60,000.00	$50,000.00
3	$60,000.00	$50,000.00

a. Compute the IRR for each investment.

$PW_A = -100{,}000 + 30{,}000(1 + IRR_A)^{-1} + 60{,}000(1 + IRR_A)^{-2} + 60{,}000(1 + IRR_A)^{-3} = 0$
$IRR_A = 20.793\%$

$PW_B = -100{,}000 + 50{,}000(1 + IRR_B)^{-1} + 50{,}000(1 + IRR_B)^{-2} + 50{,}000(1 + IRR_B)^{-3} = 0$
$IRR_B = 23.375\%$

b. At MARR = 10%, determine the acceptability of each project.

Both projects have IRR greater than MARR, so both of them are acceptable.

c. If A and B are mutually exclusive projects, which project would you select on the basis of the rate of return on incremental investment?

n	A-B
0	0
1	-$20,000.00
2	$10,000.00
3	$10,000.00

$PW_{A\text{-}B}$=-20,000$(1 + IRR_{A\text{-}B})^{-1}$+ 10,000$(1 + IRR_{A\text{-}B})^{-2}$+ 10,000$(1 + IRR_{A\text{-}B})^{-3} = 0$

IRR_{A-B} = 0% < 10%. Thus, project B is better and is selected.

Q.6. Consider three investments with the following sequences of cash flows:

n	Project A	Project B	Project C
0	-$10,000.00	-$15,000.00	-$20,000.00
1	$15,000.00	$20,000.00	$10,000.00
2	$15,000.00	$15,000.00	$12,000.00

a. Compute the IRR for each investment.

$PW_A = -10{,}000 + 15{,}000(1 + IRR_A)^{-1} + 15{,}000(1 + IRR_A)^{-2} = 0$
Let $X = (1 + IRR_A)^{-1}$
- ⇨ $-10{,}000 + 15{,}000\,X + 15{,}000\,X^2 = 0$
- ⇨ $-2 + 3X + 3X^2 = 0$
- ⇨ $X = 0.45743$ OR $X = -1.4574$
- ⇨ $(1 + IRR_A)^{-1} = 0.45743$
- ⇨ $(1 + IRR_A) = 2.1861$
- ⇨ $IRR_A = 1.1861 = 118.61\%$

$PW_B = -15{,}000 + 20{,}000(1 + IRR_B)^{-1} + 15{,}000(1 + IRR_B)^{-2} = 0$
Let $X = (1 + IRR_B)^{-1}$
- ⇨ $-15{,}000 + 20{,}000\,X + 15{,}000\,X^2 = 0$
- ⇨ $-3 + 4X + 3X^2 = 0$
- ⇨ $X = 0.5352$ OR $X = -1.8685$
- ⇨ $(1 + IRR_B)^{-1} = 0.5352$
- ⇨ $(1 + IRR_B) = 1.18685$
- ⇨ $IRR_A = 0.8685 = 86.85\%$

$PW_C = -20{,}000 + 10{,}000(1 + IRR_C)^{-1} + 12{,}000(1 + IRR_C)^{-2} = 0$

Let $X = (1 + IRR_C)^{-1}$

- ⇨ $-20{,}000 + 10{,}000\,X + 12{,}000\,X^2 = 0$
- ⇨ $-10 + 5X + 6X^2 = 0$
- ⇨ $X = 0.9399$ OR $X = -1.7732$
- ⇨ $(1 + IRR_C)^{-1} = 0.9399$
- ⇨ $(1 + IRR_C) = 1.0639$
- ⇨ $IRR_C = 0.0639 = 6.39\%$

b. At MARR = 15%, if A, B and C are mutually exclusive projects, which project would you select on the basis of the rate of return on incremental investment?

Since the IRR of Project C is less than the MARR, it should be excluded.

n	B-A
0	-$5,000.00
1	$5,000.00
2	0

$PW_{B\text{-}A} = -5{,}000 + 5{,}000(1 + IRR_{B\text{-}A})^{-1} = 0$

$5{,}000(1 + IRR_{B\text{-}A})^{-1} = 5{,}000$

$(1 + IRR_{B\text{-}A})^{-1} = 1$

$IRR_{B\text{-}A} = 0 < 15\%$

Thus, project A is better.