KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

Department of Systems Engineering

ISE 307: Engineering Economic Analysis

Major Exam 2

Summer 2017-2018 (173)

 Time: 2 hours

Name: \_KEY\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

ID: \_\_\_\_\_\_\_\_\_\_\_\_\_\_ Section \_\_\_\_\_\_

* Dr. Syed Mujahid (Sect 1, 2)
* Dr. Aiman El-Maleh (Sect 3, 5)
* Dr. Samir Al-Amer (Sect 6, 7)

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| --- | --- | --- | --- | --- | --- |
| **Question** | **1** | **2** | **3** | **Multiple Choice Questions** | **Total** |
| **Points** | **10** | **9** | **9** | **11\*2=22** | **50** |
| **Score** |  |  |  |  |  |

**Instructions:**

* Mobiles are not allowed.
* Do not start before you are told to do so.
* For the first 3 questions, show all details of your work.
* You are not allowed to share anything with other students.
* Check that you have 3 questions and 11 multiple choice questions.
* For multiple choice questions, clearly mark one answer only.

[Question 1] (10 points)

Jamal wants to start saving for the education of his 9 years old son. He is planning to deposit $60,000 now and is planning to pay 8 additional equal actual dollar payments for the next 8 years. Assume that the inflation-free interest rate is 4% and the general inflation rate is 3%. He needs to pay 5 yearly college fees with each payment equivalent to $40,000 in today’s money. The first college fee payment is due at the end of year 9.

1. (1 point) Draw the cash flow diagram.

0 1 2 3 4 5 6 7 8

9 10 11 12 13

60000

A A ….. A

40000 in constant dollars

1. (2 points) What is the market interest rate?

i = i’ +f’ + i’ f’ = 0.04 + 0.03 + 0.04\*0.03 = 0.0712

1. (2 points) What is the actual value of the college fee to be paid at end of year 11?



1. (3 points) What is the amount of actual dollar value of each of the eight payments?



1. (2 points) What is the constant dollar value of the 7th payment?



[Question 2] (9 points)

A manufacturing firm is considering three projects with the following cash flows and MARR=10%:

|  |  |
| --- | --- |
| Year | Net Cash Flow |
| Project 1 | Project 2 | Project 3 |
| 0 | ─ 4,000 | ─ 4,000 | ─ 4,000 |
| 1 | 2,000 | 2,000 | 1,200 |
| 2 | 2,000 | 1,000 | 1,200 |
| 3 | 1,000 | 1,000 | X |
| 4 | 2,500 | 4,000 | 1,200 |
| IRR | ?% | 29.81% | 8% |

1. (2 points) Given that for Project 1, NPW(30.0%)=52.38 and NPW(31.0%)= ─ 14.13, find IRR for Project 1 using a single step linear interpolation.

IRR = 0.30 + 52.38/(52.38+14.13) = 30.788%

1. (2 points) Compute the value of X missing in Project 3.

-4000+1200\*(1.08)-1+1200\*1.08)-2+X\*(1.08)-3+1200\*(1.08)-4=0

-4000+1111.11+1028.807+882.036+0.7938X=0

-978.046+0.7938X=0

=> X = 978.046/0.7938 = 1232.06

1. (5 points) Using IRR criterion, find out which project is a better candidate. Show all the details of your work.

Since IRR for Project 3 < MARR, Project 3 is eliminated (1 point).

We do incremental analysis between Project 1 and Project 2 as follows: (1.5 points)

|  |  |
| --- | --- |
| Year | Net Cash Flow |
| Project 1 | Project 2 | Project 2 – Project 1 |
| 0 | ─ 4,000 | ─ 4,000 | 0 |
| 1 | 2,000 | 2,000 | 0 |
| 2 | 2,000 | 1,000 | -1,000 |
| 3 | 1,000 | 1,000 | 0 |
| 4 | 2,500 | 4,000 | 1,500 |
| IRR | 30.788% | 29.81% | ? |

-1000(1+IRR)-2 + 1500(1+IRR)-4 = 0

1000(1+IRR)-2 = 1500(1+IRR)-4

(1+IRR)2 = 1.5 => (1+IRR) = (1.5)1/2 = 1.22475

* IRR = 0.22475 = 22.475% (1.5 points)

Since IRR > MARR, then Project 2 is better than Project 1. (1 point)

[Question 3] (9 points)

Hejaz Public Co. (HPC) has won the contract of maintaining the city roads in Jeddah for the next 20 years. HPC is considering the flowing different alternatives for the maintenance:

* **Model-1:** Costs $1,000,000 initial investment, and yearly operating and maintenance costs are $400,000. The equipment life is 10 years, and has no salvage value.
* **Model-2:** Costs $2,000,000 initial investment, and yearly operating and maintenance costs are $100,000. The equipment life is 5 years, and the salvage value $100,000.
* **Model-3:** Subcontract to a third party, which will charge $600,000 per year.

Assume that the above alternatives will be available in the market for the next 20 years without any significant change in any of the costs. Therefore, HPC’s replacement policy for any alternative is to exactly repeat the same alternative until the required 20 years period. For example: Model-3 will be repeated every year for the next 20 years without any change in the cost. Assume that the MARR of HPC is 8%.

1. (2 points) Compute the present worth (PW) of Model-1.

$PW\left(8\%\right)\_{10 years}= -1,000,000-400,000 \left(A,8\%,10\right)= -\$3,684,032.$

$PW\left(8\%\right)\_{20 years}= -3,684,032 \left(1+\left(1.08^{-10}\right)\right)= -\$5,390,452.45.$

1. (1 point) Compute the capital recovery (CR) of Model-2.

$$CR\left(8\%\right)=\left(2,000,000-100,000\right)\left(P,8\%,5\right)+0.08\left(100,000\right)=\$483,866.$$

1. (2 points) Compute the annual equivalence (AE) of Model-2.

$$ AEC\left(8\%\right)=CR\left(8\%\right)+100,000=\$583,466$$

1. (4 points) Rank the above models such that Rank-1 is the most preferred, and Rank-3 is the least preferred. You are free to choose PW, FW, AE, or IRR criteria for comparing the above mutually exclusive alternatives.

**Note: Show your steps. FW = future worth, IRR = internal rate of return.**

If AE analysis is used, then different project lives can be compared. However, if PW analysis is used, then same analysis period should be used.

Model-1: $AEC\left(8\%\right)=\$549,029.49$ (Rank-1)

Model-2: $AEC\left(8\%\right)=\$583,866$ (Rank-2)

Model-3: $AEC\left(8\%\right)=\$600,000$ (Rank-3)

Multiple Choice Questions

Clearly mark one answer only. All questions have the same weight (2 points each)

[MC Question 1]

Given a simple investment project with MARR=10%. Assume that the net present worth at i=15% is equal to 1000, i.e. NPW(15%)=1000. The internal rate of return for the investment project is:

1. **Greater than 15%**
2. Greater than 10% and less than 15%
3. Less than 10%
4. It cannot be concluded based on the given information.

Increasing IRR decreases the NPW for a simple investment project.

[MC Question 2]

Consider the following cash flow for an investment project.

|  |  |
| --- | --- |
| Year | Net Cash Flow |
| 0 | -9,936.38 |
| 1 | 3,000 |
| 2 | 3,000 |
| 3 | 3,000 |
| 4 | 3,000 |

What is the internal rate of return on the investment?

1. 6%
2. 7%
3. **8%**
4. 9%

9,936.38 = 3000 [(1+i)4 – 1] / [ i \*(1+i)4] = 3000 [(1+0.08)4 – 1] / [ 0.08 \*(1+0.08)4]

 = 3000\*3.31213

**[MC Question 3]**

An average small car costs $90,000 in 2017. If the market interest rate is 6% and the inflation free interest rate is 2%. How much do you expect the price of a similar car in 2030?

1. $191963
2. $135882
3. **$148394**
4. $116424

f’ = (0.06-0.02)/(1+0.02) = 0.0392

Price =90000\*(1+0.0392)^(30-17)= 148394.1

[MC Question 4]

Consider the following cash flows for two investment projects.

|  |  |
| --- | --- |
| Year | Net Cash Flow |
| Project 1 | Project 2 |
| 0 | -10,000 | -12,000 |
| 1 | 5,000 | 5,000 |
| 2 | 8,000 | 10,500 |
| IRR | 17.87% | 16.67% |

For what MARR Project 2 is considered more profitable that Project 1?

1. **MARR < 11.8%**
2. MARR > 11.8%
3. 11.8% < MARR < 17.87%
4. 11.8% < MARR < 16.67%

|  |  |
| --- | --- |
| Year | Net Cash Flow |
| Project 1 | Project 2 | Project 2 - Project 1 |
| 0 | -10,000 | -12,000 | -2,000 |
| 1 | 5,000 | 5,000 | 0 |
| 2 | 8,000 | 10,500 | 2,500 |
| IRR | 17.87% | 16.67% | ? |

-2000 + 2500(1+IRR)-2 = 0

2000 (1+IRR)2 = 2500

(1+IRR)2 = 2500/2000= 0.75

* IRR = (1.25)1/2 – 1 = 1.118 – 1 = 0.118 = 11.8%
* Thus, Project 2 is better than Project 1 for MARR < IRR=11.8%

**[MC Question 5]**

A starting monthly salary of a freshly graduated industrial Engineer is $11000 in 2018. The annual market interest rate is 6% and the general inflation rate is 4%. Assume that the starting salary remains the same in constant dollar values. What do you expect the starting salary (in actual dollar values) to be after 10 years?

1. $19283
2. $15162
3. $13308
4. **$16283**

=11000\*(1+0.04)^10= 16282.69

**[MC Question 6]**

 The consumer price index is given in the table below. Compute the average general inflation rate in the period 2007 to 2017.

|  |  |
| --- | --- |
| Year | Consumer Price Index |
| 2000 | 261.3 |
| 2007 | 419.5 |
| 2017 | 982.4 |

1. 7.64 %
2. 8.04 %
3. **8.88 %**
4. 9.99 %

=(982.4/419.5)^(1/10)-1= 0.088819

**[MC Question 7]**

 Maryam wants to save some money for future use. She deposited $5000 now and 6 equal annual payments of $1000 at end of years 1 to year 6. The account pays 8% market interest compounded annually.

What is the future worth of the account at the end of year 10?

1. $22437
2. **$20775**
3. $15270
4. $9623

PW = 5000+1000\*(P/A,0.08,6)

 = 5000+1000\*(1.08^6-1)/(0.08\*1.08^6) = 9622.88

FW = 9622.88\*1.08^10 = 20775.08

**The following material is related to MC Questions 8-11**

Dhahran Motor Works (DMW), a local car manufacturer, has a minimum accepted rate of return of 20% from their existing car manufacturing project. DMW is planning to invest in the new area of bike manufacturing. The following investments options are available to DMW:

Project-A: Invest $15 million to buy the new equipment that will have a useful service life of 15 years. The equipment can manufacture 2000 bikes per year, with operation time of 3000 hours per year. The operation & maintenance costs for running the equipment is $1200 per hour. The estimated selling price will be $4000 per bike. The equipment is expected to have a net salvage value of $5 million.

Project-B: Invest $8.5 million to buy the equipment from an existing local company, which will have a useful service life of 10 years, and can manufacture 2000 bikes per year. The estimated net revenue per year will be 3,680,000. The equipment is expected to have a net salvage value of $100,000. In addition to that, with a cost of $1,000,000 the equipment can be overhauled (the service life can be extended by 5 years with a new salvage value of $500,000). The net revenues after the overhaul will be the same as before the overhaul.

**[MC Question 8]**

How long will it take for DMW to recover **Project-B**’s investment (use the discounted payback period approach)?

1. Between 2-3 years
2. **Between 3-4 years**
3. Between 4-5 years
4. None of the above

For 3 years: $PB\_{2 years}= -8.5 +3.68 \left(A,20\%,3\right) <0$

For 4 years: $PB\_{3 years}= -8.5 +3.68 \left(A,20\%,4\right) >0$

|  |  |  |  |
| --- | --- | --- | --- |
| 0 | -8500000 | 0 | -8500000 |
| 1 | 3680000 | -1700000 | -6520000.0 |
| 2 | 3680000 | -1304000 | -4144000.0 |
| 3 | 3680000 | -828800 | -1292800.0 |
| 4 | 3680000 | -258560 | 2128640.0 |

**[MC Question 9]**

What is the present worth of **Project-B** over the analysis period of 15 years?

1. Around 7.5 millions
2. Around 8.0 millions
3. **Around 8.5 millions**
4. Around 9.0 millions

$$PW\left(20\%\right)= -8.5+3.68\left(A,20\%,15\right)-1 \left(A,20\%,10\right)+0.5\left(F,20\%,15\right)$$

$$=8.576 million $$

**[MC Question 10]**

If the investors in DMW want to recover **Project-A’s** investment at the end of 4 years of operation, then what should be the minimum increase in the selling price of each bike (use the discounted payback period approach).

1. Increase by $400
2. Increase by $500
3. Increase by $600
4. **None of the above**

$$15,000,000=\left[2000 \left(4000+X\right)-3,600,000\right]\left(A,20\%,4\right)$$

$$=> X=697.207 $$

**[MC Question 11]**

What is the ownership cost (CR) per year for **Project-A**?

1. Around 2.1 million
2. **Around 3.1 million**
3. Around 4.1 million
4. Around 5.1 million

$$CR(20\%)= \left(15,000,000-324,527.36\right)0.213882=3.13879 million$$