

ORDRE DES INGÉNIEURS DU QUÉBEC

MAY 2022 SESSION

Open-book examination

Calculators : only authorized models

Duration : 3 hours

14-EC-1 Engineering Economics

Question 1:	20
Question 2:	20
Question 3:	20
Question 4:	20
Question 5:	20
Total	100

Question 1 (20 points):

Olivia & Hugo are a couple of engineers and have just celebrated their 35th birthday each. Even if they are young, they are already beginning to discuss their retirement. They both want to retire on their 65th birthday, in exactly 30 years.

Obviously, they wisely made an appointment with a financial planner to define how much to set aside for the next 30 years, from their 36th to 65th birthday inclusively. However, loving to prepare well for this kind of meeting, the couple would like to get an idea of the order of magnitude of this annual amount of savings.

They identified that if they had access to an amount of \$80,000 per year in today's dollars from their 65th birthday until their 84th birthday inclusively (so for 20 years), their retirement would be great!

If they expect to make a monthly compounded nominal average return of (6%; 12) per year from now until their 84th birthday,

- a) How much should they set aside annually in exactly one year? (16 points)

**Note 1:** For this question, assume a tax-free world. In a real case, several possibilities of registered investments are to be considered (TFSA, RRSP, etc.).

**Note 2:** For this question, assume that inflation does not exist.

- b) Without doing any calculations, if you anticipate an inflation rate of 2% per year, all other things being equal, what will be the impact on your amount calculated in a)? (4 points)

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**Question 2 (20 points):**

Here are the annual after-tax cash flows for four projects. Projects A, B, C and D are mutually exclusive.

No.	A	B	C	D
0	-10 000\$	-25 000\$	-7 000\$	-29 600\$
1	2 000\$	17 000\$	4 000\$	19 000\$
2	5 000\$	6 000\$	5 000\$	10 000\$
3	8 000\$	2 000\$	9 000\$	19 000\$

- a) Explain in a few words why project B can be totally neglected before doing the differential analysis. (5 points)
- b) Based on the **differential analysis of the IRR** criteria (internal rate of return), which project should be retained in order to be as profitable as possible? The firm's **MARR** (minimum acceptable rate of return) is **10%**. (15 points)

**Note:** You must use the differential process and demonstrate, by at least one calculation, that you are able to calculate the value of an IRR.

**Note 1:** For this question, assume that inflation does not exist.

**Question 3 (20 points):**

ImpaK is a die manufacturer for several OEMs of aluminum products. During the last strategic planning of the organization, senior management decided to increase the production capacity of their Saint-Jérôme plant. After a financial study, the senior management wishes to become autonomous of their electricity supplies and therefore plans to generate their own electricity. To do this, two options are considered:

1. **Natural gas turbine.** The initial investment would be 1.5 million. Annual expenses (natural gas, maintenance, etc.) would be estimated at \$300,000. The life of the gas turbine would be 20 years. The residual value at the end of the life would be \$0. The possible tax depreciation would be \$75,000 per year.

2. **Biomass boiler combined with a steam turbine.** The initial investment would be 2 millions. Annual expenses (biomass, maintenance, etc.) would be estimated at \$195,000. The lifetime of the boiler and its steam turbine would be 15 years. The residual value at the end of the life would be \$200,000. The possible tax depreciation would be \$120,000 per year.

The company wants a **MARR** of 15% and its tax rate is 40%. The company plans to continue operations indefinitely. Under these conditions, which option should it choose?

**Note 1:** The after-tax cash flow year by year is necessary in the development of the solution.

**Note 2:** For this question, assume that inflation does not exist.

<b>Question 4 (20 points):</b>
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For each of the statements below, please answer true or false and then justify your answer with a brief explanation.

- 4.1** One way to make the payback period method just as valid as the NPV (net present value) method is to discount cash flows from the same project to today's dollars. (4 points)
  
- 4.2** The main difference between \$1 today and \$1 later is the interest factor. Thus, projects with higher cash flows at the start of the project are better projects. (4 points)
  
- 4.3** To determine cash flows, depreciation expense must be added to net income because it does not constitute a cash outflow. (4 points)
  
- 4.4** The analysis period of a project (the investment horizon) consists of the period of time over which it is possible to generate interesting cash flows for the company. (4 points)
  
- 4.5** The criteria of NPV (net present value) and IRR (internal rate of return) rank in the same order the viability of several mutually exclusive projects. (4 points)

<b>Question 5 (20 points):</b>
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Given the global warming of its region, the municipality of KoujiNorth must improve its water treatment system. Indeed, only during the last summer season, it had to issue a boil water advisory 12 times because of the presence of pathogenic bacteria and undesirable viruses. Residents have obviously come forward and the municipality, which must provide 2,000 residences with drinking water, must take action. To do this, it considers two options:

**Option 1**

Improvement of the current water treatment center. The lifetime of these improvements would be 12 years. The cost of the improvements would be \$2 million, the annual operating and maintenance costs of \$150,000 (maintenance would be provided by a supplier who would submit a tender for a price contract annual fixed over 12 years). The resale value of the improvements would be \$100,000 after 10 years. All of these amounts would be in current dollars.

**Option 2**

The other option would be to equip each residence with UV light treatment equipment. This equipment would have a lifespan of 4 years and costs \$400 per unit. The annual operating and maintenance costs would be \$100 per unit annually. The resale value of the equipment would be zero after 4 years. All of these amounts would be in constant dollars.

Knowing that the **constant (not indexed to inflation) MARR** of the municipality is **8%** and that the annual general inflation rate is estimated at **2%**, calculate which is the most profitable option.

**Note1:** The municipality does not pay tax.

**Note 2:** For this question, at your discretion, you can do the solution either in current dollars or in constant dollars.

**Note 3:** You must do a 10-year analysis. Thus, make the repeatability assumption for option 2.