

ORDRE DES INGÉNIEURS DU QUÉBEC

MAY 2021 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):

For each of the statements below, please answer true or false and then justify your answer with a brief explanation.

1.1 One way to make the internal rate of return (IRR) method equivalent to the NPV (Net Present Value) method in order to prioritize mutually exclusive projects is to incorporate a reinvestment rate into the intermediate cash flows of the project. (4 points)

1.2 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)

1.3 To determine the cash flows, the amortization expense must be added to the net profit because it does not constitute an outflow of funds. (4 points)

1.4 The duration of a project analysis (the investment horizon) consists of the period of time over which it is possible to generate interesting cash flows for the company. (4 points)

1.5 When ranking multiple investment projects in order of financial viability, the criteria of NPV (net present value) and IRR (internal rate of return) will rank these projects in the same order. (4 points)

Question 2 (20 points):

A young engineer has just celebrated his 30th birthday. Even though he is still very young, he is starting to think about his retirement. He would like to retire on his 60th birthday, which is exactly 30 years from now.

He made an appointment with a financial planner to define how much to set aside for the next 30 years, from his 31st (in 1 year) to his 60th birthday (in 30 years) inclusive. Because he likes to be prepared well for this kind of meeting, our engineer would like to give himself an order of magnitude of this annual amount of savings.

After some reading on retirement planning, he identified that to maintain his current lifestyle, he must withdraw in annual retirement income 70% of his current gross salary which is \$ 100,000. In other words, he aims to withdraw \$ 70,000 per year, in today's dollars, from his 60th birthday up to his 84th birthday inclusive (so for 25 years).

If he considers making an average nominal monthly capitalized return of (6%; 12) per year from now until his 84th birthday,

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

Note 1: For this question, suppose a world without taxes. In a real case, several possibilities of registered investment are to be considered (TFSA, RRSP, RESP, etc..).

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

- b) Without doing any math, if you expect 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 3 (20 points):

Here are the annual after-tax cash flows for four projects. F1, F2, F3 and F4 projects are mutually exclusive.

No.	Project F1	Project F2	Project F3	Project F4
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 the F2 project can be completely omitted before doing the differential analysis. (5 points)
- b) Based on **the differential analysis of the IRR** (internal rate of return) criterion, which project should be retained in order to be as profitable as possible? The company'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 4 (20 points):

Matxium 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 independent 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 million. Annual expenses (biomass, maintenance, etc.) would be estimated at \$ 195,000. The lifespan of the boiler and its steam turbine would be 15 years. The residual value at the end of the useful life would be \$ 200,000. The possible tax depreciation would be \$ 120,000 per year.

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

Note1: The net after-tax cash flow year by year is required to develop your answer.

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

Question 5 (20 points):

Given the global warming of its region, the municipality of KoujiNorth must improve its water treatment system. In fact, only during the last summer season, it had to issue a boil water warning 12 times because of the presence of pathogenic bacteria and unwanted viruses. The residents have obviously come forward and the municipality, which must provide 2,000 homes with drinking water, must take action. To do this, two options are considered:

Option 1

Improvement of the current water treatment center. The lifespan of these improvements would be 12 years. The costs of the improvements would be \$ 2 million, the annual operation 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. Annual operation 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 municipality's **constant MARR** is **8%** (real interest rate) and that the general annual inflation rate is estimated at **2%**, calculate which option is the most profitable.

Note 1: The municipality doesn't pay taxes.

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

Note 3: You have to do a 10 years analysis. To do it, make the repeatability assumption for option 2.