1.011 Project Evaluation
C.D. Martland
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Quiz Review # 1

Part I Introduction to CEE Projects

Chapter 1: Introduction to Engineering Economy

Basic principles of engineering economy.

Project evaluation can be viewed in terms of both economics and sustainability. The major economic criteria is that the costs exceed the benefits, noting that some costs and benefits will be difficult to quantify, let alone to monetarize. Sustainability is a very useful concept for considering projects and programs:

- Financial sustainability: will there be enough cash to pay for construction, operation and maintenance? [This is a distinctly different question than the economic concern with costs and benefits.]
- Social sustainability: will there be enough public support for the project to obtain initial approvals for the location, design, and construction process and to support continued operation, maintenance, rehabilitation, and expansion of the project? Social sustainability must consider the distribution of costs and benefits, now and in the future, as well as the alternatives uses of the resources required by a project.
- Environmental sustainability: will the impacts on the environment be acceptable in terms of their short- and long-run implications?

Crossing the Isthmus of Panama - an example of a series of ever more complex projects seeking similar objectives. The nature, successfulness, and consequences of the projects changed dramatically over time as technology, political interests, and world trade evolved.

Development of roads, canals, railroads, and paved highways allowed much faster or cheaper transportation, which had a marked effect on regional growth, prices of goods, and location of cities, industries, and families.

Part II Life Cycle Costs

Chapter 2: Cost Concepts and Design Economics

You should understand the basic cost terminology: fixed and variable costs, marginal costs, incremental costs, opportunity costs, sunk costs etc.

You should be able to develop techniques for common cost and design questions:

- Calculate the breakeven volume required for selecting a technology with higher fixed cost, but lower variable cost.
- Determine the breakeven volume required to achieve profitability, the range of volume for which production is profitable, and the level of production that maximizes profitability.
- Using cost and revenue functions, optimize design or operations (cost-driven optimization).

Any questions on a quiz will be structured so that they do not require a great deal of arithmetic – but you will need to understand the concepts and how to express them graphically.

Chapter 7: Cost Estimation Techniques

Work breakdown structure: this is a standard technique for breaking down a project into simple pieces for which cost information is readily available (as seen in the example of the 5-10 story building). A WBS is useful in any study, as it provides a structure for a cost model (and this is, in effect, part of what you did in the canal assignment).

Cost estimation techniques:

- Unit costs (e.g. the fixed cost per mile per year for canal maintenance)
- Activity-based costs (e.g. the variable cost per boat in the canal study)
- Parametric costs: many more complex relationships are possible for estimating and relating costs. You should understand power-sizing techniques and the learning curve.

Chapter 3: Money Time Relationships and Equivalence
Note on Equivalence

Equivalence of cash flows; present value of an arbitrary stream of cash flows; equivalence of present worth, future worth, annual worth.

Use of equivalence relationships to compare various options related to cash flows:

- How many years will I need to make $X in order to justify my investment?
- Will a return of $X per year beginning at the end of year 3 be sufficient to justify investing $Y right now?
- If I pay my mortgage payment of $X per year for N years, how much will I still owe after I make the Nth payment, assuming interest rate is i% and the mortgage is for M years?

Discrete compounding of interest: the text derives formulas that can be used to convert an arbitrary stream of cash flows into an equivalent present worth (P), future worth (F), or an annuity. You should be able to do simplest of these with a calculator:

- Calculate the future value F given a present value P: $F= P * (1+i)^t$
- Calculate present value P given a future value F: $P = F/(1+i)^t$

- Estimate the capital worth of a long-term annuity: CW = A/I
- Estimate the equivalent long-term annuity given a present value P: A P*i
- Simple combinations: what is the present worth of an indefinite annuity A that begins in N years? P = (A/i)/(1+i)^N

The discrete formulas are what will be used in essentially all project evaluation studies – but it is useful to understand the concepts of continuous discounting. A key result (see "Note on Equivalence") can be very handy for discounting cash flows very quickly and easily:

$$[F/P,r\%,N] = e^{rN} = (1 + i)^N$$

This relationship is used to obtain the factors for continuous compounding (Table 3-7) – just substitute e^{rN} for $(1 + i)^N$ in any of the discrete formulas. It also provides a neat way to estimate discount factors, once you realize that $e^{.7} \sim 2$ and $e^{1.1} \sim 3$ [e.g. you can double your money in 10 years at 7% or in 14 years at 5%.]

There will be no questions involving any of the gradient method.

Note on NPV Analysis for a Major CEE Project

A discount rate is needed to compare present future sums of money. The discount rate reflects three key factors:

- Risk free investment opportunities: money can be expected to grow at a risk-free rate
- Risk premium: expectations for money in the future are subject to various risk; the riskier the investment, the greater the discount rate for future cash flows
- Inflation: a dollar in the future is likely to have less purchasing power than a dollar today

The discount rate can therefore be conceived as incorporating these three factors:

Discount rate = (1+i) * (1+r) * (1+inf) $\sim$ (1+i + r + inf) for small values

The risk premium is based upon the market for capital, which places a greater discount on future cash flows that are perceive to be riskier.

Leveraging: this is the process of borrowing money (or selling bonds) at an interest that is lower than the expected return on the project. This reduces the developer's investment, but adds a risk that the project might fail because it cannot meet the interest payments.

Equity financing: selling stock is another way to raise capital. This approach gives up a portion of the ownership in the company (i.e. reduces the developer's share of future profits), but does not require interest payments (i.e. reduces the risk of bankruptcy). The financial markets generally require a higher expected return for stock than for bonds (which means that the price of a stock implies a discount rate for future cash flows that is higher than the interest rate earned by bonds).

Weighted average cost of capital: a large firm will have many sources of capital, all of which should be considered in calculating the average cost of capital. At the simplest level, the weighted average cost of capital is:

WACC = Avg. Interest on bonds * %Debt + Return on stock * %Stock

The minimum attractive rate of return (MARR): the minimum attractive rate of return is based upon the options that an individual or a company has for investment and their cost of capital. The MARR must be greater than their cost of capital (otherwise they end up with less than they started with) and it must reflect the investment opportunities that are available. The MARR will vary for investments with different levels of risk.

Readings

There will be an essay question on the exam, and there will be a choice of two topics. The essay will relate to the issues that we have discussed in class, and you will be encouraged to draw upon the readings in your response.

General:

PLEASE PLEASE PLEASE do not leave the essay blank because you have run out of time!!!! There is no credit for a blank, and some credit for almost anything else.

If you are stuck with a question, write down what you are trying to do, why, maybe show and equation – and go on to the next question! Don't get stuck, and don't leave merely cryptic marks.