ISE 307: Engineering Economic Analysis

Lecture 2: Engineering Economic Decisions (Chapter 1)

Term 253 (Summer)

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Lecture 2

Engineering Economic Decisions (Chapter 1)

Announcements and Reminders

1. HW 1 (out of 4 max) is posted, due Wednesday June 24th, 11:59 PM
2. Formula sheet and tables are posted with HW 1
3. Major 1 is tentatively scheduled for Week 4, Sunday, July 5th
4. Major 2 is tentatively scheduled for Week 7, Sunday, July 26th
5. Course calendar (with due dates) is up on Blackboard
6. The college has requested us to enforce attendance and DNs more strictly

Lecture 2 Objectives

1. Explain what “engineering economics” is
2. Articulate why engineers should study engineering economics
3. Describe the rational decision-making process and give examples
4. List the types of strategic engineering economic decisions
5. State the four fundamental principles of engineering economics

What is Engineering Economy?

Engineering economy:

- applies **economic approaches** to evaluate **engineering alternatives**
- involves the **financial and economic evaluation** of projects
- studies industrial economics and the financial factors influencing industry

Engineering economy = choosing among engineering alternatives using money as the measuring stick

Why Engineers?

Engineers understand extraction, processing, and automation, so they:

- best judge the **useful lives** of assets (flotation cell, haul truck, robot)
- can estimate **how much** a plant or processing line can produce

Engineering economy deals with the justification and selection of projects:

- **Business** settings: justified by monetary criteria (e.g., profit on minerals)
- **Non-business** settings: other criteria matter (safety, public benefit)

In today's competitive world, engineers must practice financial analysis of engineering projects and make rational decisions.

Opening Story: Facebook

- Mark Zuckerberg launched Facebook as a **college student** at Harvard
- It grew to **2+ billion users**; its value rose to about **$450B by 2017**
- Similar stories: Google, Dell, Yahoo — all founded by motivated students

What these ventures share — capable, imaginative engineers who:

1. generated **sound ideas** for capital investment,
2. **executed** them well, and
3. obtained **good results**

The Rational Decision-Making Process

1. Recognize a decision problem
2. Define the goals or objectives
3. Collect all relevant information
4. Identify feasible alternatives
5. Select the decision criterion
6. Select the best alternative

Engineering economics provides the tools for steps 5 and 6 — but the quality of the decision depends on all six.

Which Haul Truck to Acquire?

Step	Process	Applied to the haul-truck decision
1	Recognize the decision problem	Need to move ore from pit to crusher
2	Define goals or objectives	Want low cost/tonne & improved site safety
3	Collect relevant information	Gather technical & financial data on both fleets
4	Identify feasible alternatives	Conventional fleet vs. autonomous fleet
5	Select the decision criterion	Minimum cost per tonne-km at acceptable risk
6	Select the best alternative	Select the autonomous fleet

The same 6 steps scale from a single robot to a billion-riyal complex.

Design Decisions vs. Economic Decisions

Design Decisions

- Based on **physical properties**, principles of chemistry and physics, engineering correlations
- **Time invariant** — the laws of physics don't change next year

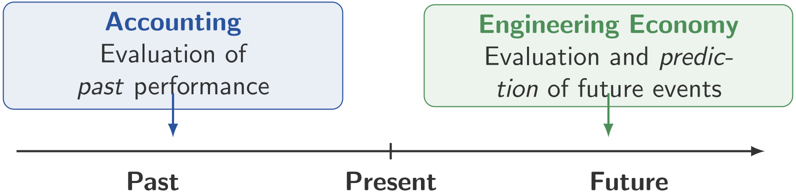
Economic Decisions

- Based on **forecasting** future mineral prices, demand, and costs over a time period
- **Not time invariant** — forecasts depend on when they're made

Time and **uncertainty** are the defining aspects of any engineering economic decision.

What must we predict? required investment · demand · selling price · asset life

Accounting vs. Engineering Economy



- **Accounting** answers: *How did the mine do last quarter?* (records, reports, past performance)
- **Engineering economy** answers: *Should we build the new processing line?* (prediction of future events)

Role of Engineers in Business

Engineers participate in:

1. Making **capital expenditure** decisions (a flotation circuit, a robot fleet)
2. **Large-scale** economic decisions (a full processing complex)
3. Understanding the impact of engineering projects on **financial statements**

Why large-scale minerals & AI/robotics projects are hard:

- Require a **large sum of investment**
- Take a **long time** to see the financial outcomes
- **Difficult to predict** the revenue and cost streams (volatile mineral prices)

Types of Strategic Engineering Economic Decisions

An **engineering economic decision** = any investment decision related to an engineering project

Examples:

1. **New product / expansion** — build a new lithium-refining line? open a new mine to meet battery demand?
2. **Equipment & process selection** — which separation tech? which inspection robot?
3. **Cost reduction** — automate a manual sampling task? deploy AI process control to cut energy use? make-or-buy?
4. **Equipment replacement** — replace an aging haul truck now? if not now, when? upgrade the autonomy stack instead?
5. **Service & quality improvement** — improving throughput, recovery, or safety

Four Fundamental Principles

1. An earlier riyal is worth **more** than a later riyal
2. All that matters is the **differences** among alternatives
3. **Marginal revenue** must exceed **marginal cost**
4. Additional **risk** is not taken without the expected additional **return**

Let's look at each one...

Principle 1

An earlier riyal is worth more than a later riyal

100 SAR today $\xrightarrow{\times 1.10}$ **110 SAR** one year later $\xrightarrow{\times 1.10}$ **121 SAR** two years later

- With an interest rate of 10%, 100 SAR today grows to 110 SAR in one year and 121 SAR in two years
- Money has **earning power** over time — this is the **time value of money**
- Receiving 100 SAR today $\neq$ receiving 100 SAR next year!

Will be covered in detail in Chapters 2–4.

Principle 2

All that matters is the differences among alternatives

Inspecting a pipeline network: a **robot** vs. a **manual crew** (annual figures, SAR).

Option	Permit fees	Site access	Capital outlay	Annual operating	Salvage (yr 5)
Robot	12,000	8,000	400,000	60,000	90,000
Manual crew	12,000	8,000	0	280,000	0

- Permit fees and site access are **identical** ⇒ **irrelevant** to the choice
- Only compare what **differs**: capital outlay, operating cost, salvage

Items identical across alternatives cannot change the ranking.

Principle 3

Marginal revenue must exceed marginal cost

Marginal cost cost of refining **one more** tonne	$<$	**Marginal revenue** revenue from selling **one more** tonne

- Refining one more tonne of concentrate only makes sense if the extra revenue exceeds the extra cost
- Used to decide **how much** to produce, **when** to stop expanding capacity, **which** orders to accept

Principle 4

Additional risk is not taken without the expected additional return

Where to put project capital	**Potential risk**	**Expected return**
Government sukuk / cash reserve	Low / None	3.0%
Established processing-plant upgrade	Moderate	9%
New autonomous-mining venture	High	22%

- Investors demand a **risk premium**: more risk needs more expected return
- The same applies to engineering projects: a riskier robotics venture must promise a higher return to be justified

Through the Chapter 1 Lens

A national minerals company is weighing, right now:

- Build a lithium-refining line or import refined product — new product / expansion
- Adopt an autonomous haul fleet or keep manual trucks — equipment selection
- Finance the expansion by debt or from reserves — financing decision

A robotics team at the plant is weighing:

- Deploy AI process control now, later, or not at all — cost reduction
- Replace the inspection robots or upgrade their sensors — replacement decision

Each is a **rational decision under uncertainty about the future**,
the principles of engineering economics will be useful.

Summary

- An **engineering economic decision** = any investment decision related to an engineering project
- The five types: **(1)** new product/expansion, **(2)** equipment/process selection, **(3)** cost reduction, **(4)** replacement, **(5)** service & quality
- **Time** and **uncertainty** are the defining aspects of any investment project
- The **rational decision-making process** has 6 steps, from recognizing the problem to selecting the best alternative
- The 4 principles: earlier money > later money; only differences matter; marginal revenue > marginal cost; no extra risk without extra return

Before Class

To do before our class meeting:

1. **Read Chapter 1** from the textbook (Park, 3rd Ed.)
2. Complete the **Lecture 2 pre-class quiz** on Blackboard before class
3. Think of **one engineering economic decision** from a project, internship, or the news — we'll classify these in class

In class: we'll work in groups and conceptualize the "engineering project" context for each group for us to work as in-class activities throughout the semester.