- **Course Title:** Engineering Cost Analysis & Economy (ENGR 222)
- **Session:** Fall 2024
- **Instructor:** Sudipta Chowdhury (chowdhurys@marshall.edu)
- **Class Time: TR 9.30 PM-10.45 AM**
- **Office hours: TR 11.00 AM-12.30 PM**

Rate of Return Analysis: Multiple Alternatives

Capital *not* invested in a project is assumed to *earn at MARR*

Example: Assume \$90,000 is available for investment and MARR = 16% per year. If alternative A would earn 35% per year on investment of \$50,000, and B would earn 29% per year on investment of \$85,000, the weighted averages are:

$$\textbf{Overall } \mathbf{ROR_A} = [\mathbf{50,000(0.35) + 40,000(0.16)}]/\mathbf{90,000} = \mathbf{26.6\%}$$

$$\textbf{Overall } \mathbf{ROR_B} = [\mathbf{85,000(0.29) + 5,000(0.16)}]/\mathbf{90,000} = \mathbf{28.3\%}$$

Which investment is better, economically?

Why Incremental Analysis is Necessary

If selection basis is higher ROR:

Select alternative A (wrong answer)

If selection basis is higher overall ROR:

Select alternative B

Conclusion: Must use an incremental ROR analysis to make a consistently correct selection

Calculation of Incremental CF

Incremental cash flow = cash flow$_B$ − cash flow$_A$

where *larger initial investment* is Alternative B

Example: Either of the cost alternatives shown below can be used in a grinding process. Tabulate the incremental cash flows.

	A	B	B – A
First cost, $	−40,000	− 60,000	− 20,000
Annual cost, $/year	− 25,000	− 19,000	+6000
Salvage value, $	8,000	10,000	+ 2000

The incremental CF is shown in the (B − A) column

The ROR on the extra $20,000 investment in B determines which alternative to select

Interpretation of ROR on Extra Investment

Based on concept that any *avoidable investment* that does not yield at least the MARR should not be made.

The ROR on the *extra investment* (*i.e., additional amount of money* associated with a higher first-cost alternative) must also yield a ROR $\geq$ MARR (because the extra investment *is avoidable* by selecting the economically-justified lower-cost alternative).

This incremental ROR is identified as Δi^*

For independent projects, select all that have ROR $\geq$ MARR
(no incremental analysis is necessary)

Example 1.

2. Certain parts for NASA's reusable space exploration vehicle can be either anodized (A) or powder coated (P). Some of the costs for each process are shown in the table below. The incremental cash flow future worth equation associated with (P-A) is

$$0 = -50{,}000(F/P,\Delta i^*_{P-A},5) + 21{,}000(F/A,\Delta i^*_{P-A},5) + 8000$$

Please provide the answers taking sign conventions into consideration (i.e. cash inflows as positive and cash outflows as negative.) Determine the following:

a) The first cost for P

b) The M&O for A

c) The resale value of P

Process	Anodized, *A*	Powder coated, *P*
First Cost, $	-30,000	?
M&O, $/Year	?	-11,000
Resale Value, $	4,000	?
Life, Years	5	5

ROR Evaluation for Two ME Alternatives

(1) Order alternatives by *increasing initial investment cost*

(2) *Develop incremental CF series* using LCM of years

(3) Draw incremental *cash flow diagram*, if needed

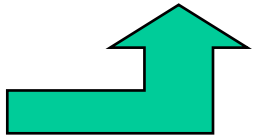
(4) Set up PW, AW, or FW = 0 relation and *find* Δi^*_{B-A}
Note: Incremental ROR analysis requires equal-service comparison. The LCM of lives must be used in the relation

(5) If $\Delta i^*_{B-A} < MARR$, *select A*; otherwise, select B

Example 2: ROR Evaluation of Two Alternatives

Solution, using procedure:

	A	B	B – A
First cost, $	–40,000	–60,000	–20,000
Annual cost, $/year	–25,000	–19,000	+6000
Salvage value, $	8,000	10,000	+2000
Life, years	5	5	



Order by first cost **and** ***find incremental cash flow*** **B – A**

Write ROR equation **(in terms of PW, AW, or FW) on incremental CF**

$$0 = -20{,}000 + 6000(\mathrm{P/A}, \Delta i^*, 5) + 2000(\mathrm{P/F}, \Delta i^*, 5)$$

Solve **for Δi^* and** ***compare*** **to MARR**

$$\Delta i^*_{B\text{-}A} = 17.2\% > \text{MARR of } 15\%$$

ROR on $20,000 extra investment is acceptable: **Select B**

Example 3

A company that manufactures amplified pressure transducers wishes to decide between the machines shown—variable speed (VS) and dual speed (DS). Compare them on the basis of rate of return and determine which should be selected if the MARR = 15% per year.

	VS	DS
First cost, $	−250,000	-225,000
AOC, $ per year	-231,000	-235,000
Overhaul in year 3, $	-	-26,000
Overhaul in year 4, $	-39,000	-
Salvage value, $	50,000	10,000
Life, years	6	6

Remember this Example from Previous class (Lecture 8)?

Applications of green, lean manufacturing techniques coupled with value stream mapping can make large financial differences over future years while placing greater emphasis on environmental factors. Engineers with Monarch Paints have recommended to management an investment of $200,000 now in novel methods that will reduce the amount of wastewater, packaging materials, and other solid waste in their consumer paint manufacturing facility. Estimated savings are $15,000 per year for each of the next 10 years and an additional savings of $300,000 at the end of 10 years in facility and equipment upgrade costs. Determine the rate of return using hand solution.

You can also do trial and error method using excel

Exam Structure

- There are ten “true/false” questions, four “multiple choice” questions, three “short answers”, and three “math problems”
- “True/false” questions are each worth 1 point, “multiple choice questions” are each worth 2.5 points, “short answers” are each worth 6 points, and “math problems” questions are worth 22, 20, and 20 points, respectively.
- You are encouraged to show calculations for “math problems” questions that will increase your chance of receiving partial credit
- You are allowed to bring 1 A4 sheet with equations and other relevant information written down by hand

QUESTIONS?