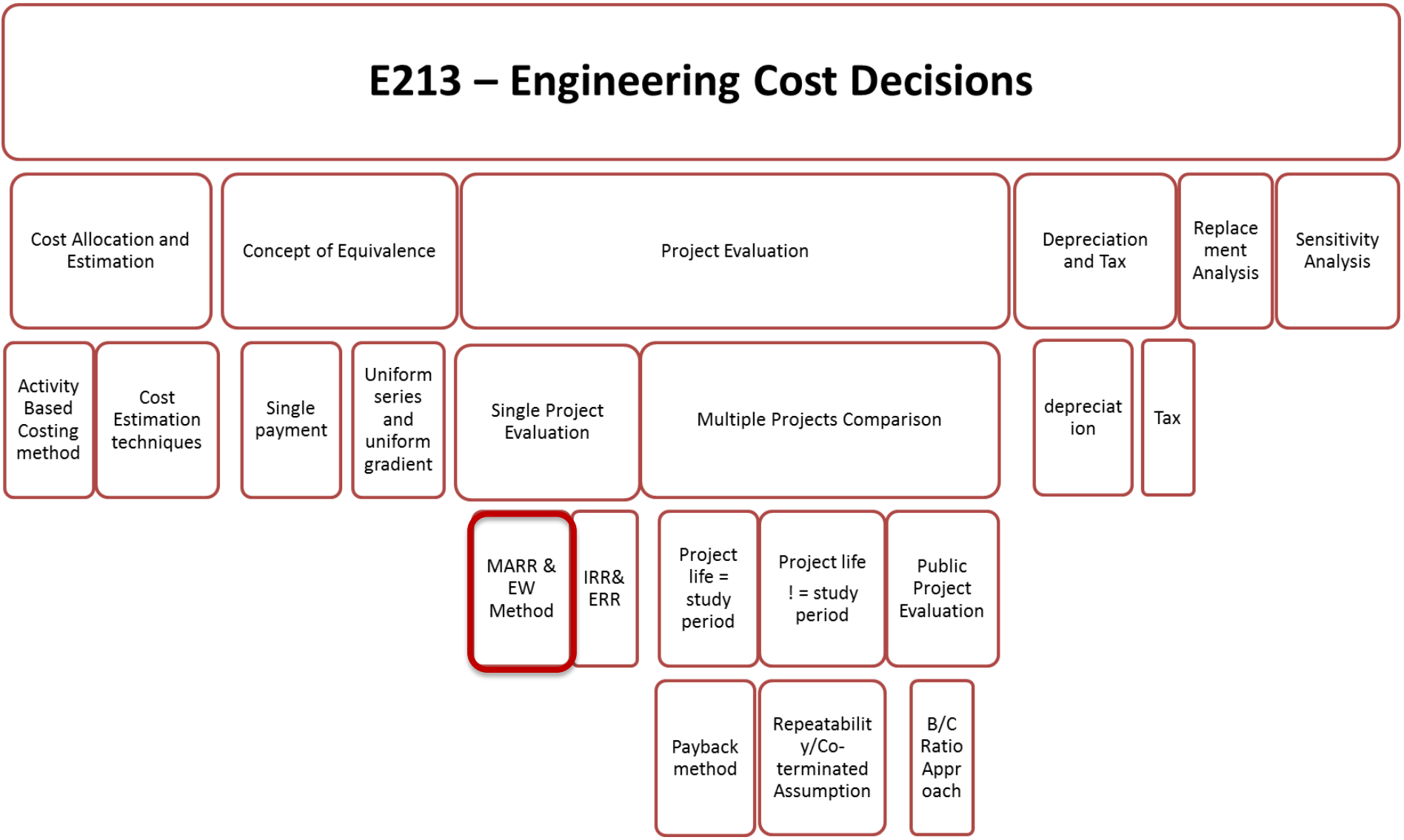
Problem 05

Toy Story

E213 – Engineering Cost Decisions

SCHOOL OF ENGINEERING

Module Coverage: Topic Tree



Return on Investment (ROI)

- A performance measure used to evaluate the efficiency of an investment or to compare the efficiency of a number of different investments
- It measures the amount of return on an investment relative to the investment's cost.
- One common way to define ROI is :

$$\text{ROI} = \frac{\text{Gain from Investment} - \text{Cost of Investment}}{\text{Cost of Investment}}$$

- ROI is easy to calculate and to interpret; can apply to a variety of types of investments.
- Possible limitations of ROI:
  - ✓ May not account for the duration during which the investment is taking place.
  - ✓ May not consider time value of money
- Therefore, Rate of Return (ROR) is often used together with ROI to evaluate the efficiency of an investment.

Rate of Return (ROR)

*"Rate of return (ROR) is **the rate paid on the unpaid balance of borrowed money**, or the rate earned on the unrecovered balance of an investment so that **the final payment** or receipt brings the balance to exactly zero with interest considered." – Engineering Economy, Leland Blank, Anthony Tarquin, McGraw-Hill*

Note:

- ***The above definition of ROR can be separated into two cases:***
  - ✓ the rate paid on the unpaid balance of borrowed money so that the final payment brings the balance to exactly zero with interest considered
  - ✓ the rate earned on the unrecovered balance of an investment so that the final receipt brings the balance to exactly zero with interest considered
- ***Pay attention to "balance to ZERO" & "interest considered"***
- ***Recall what you learned before, already have a clue to solve such type of problems?***

Same or Different?

Team1

	(A)	(B) = i * (A)	(C)	(D) = (A) + (B) - (C)
Period	Beginning unrecovered balance	Interest on unrecovered balance (10%)	Stipulated Repayment at end of period	Ending unrecovered balance
1	100000.00	10000.00	30000.00	80000.00
2	80000.00	8000.00	28000.00	60000.00
3	60000.00	6000.00	26000.00	40000.00
4	40000.00	4000.00	24000.00	20000.00
5	20000.00	2000.00	22000.00	0.00
			130000.00	

ROR for lender is 10%

Team2

	(A)	(B) = i * (A)	(C)	(D) = (A) + (B) - (C)
Period	Beginning unpaid balance	Interest on unpaid balance (10%)	Stipulated Repayment at end of period	Ending unpaid balance
1	100000.00	10000.00	20000.00	90000.00
2	90000.00	9000.00	22000.00	77000.00
3	77000.00	7700.00	25000.00	59700.00
4	59700.00	5970.00	29000.00	36670.00
5	36670.00	3667.00	34000.00	6337.00
			130000.00	

ROR for lender is less than 10%

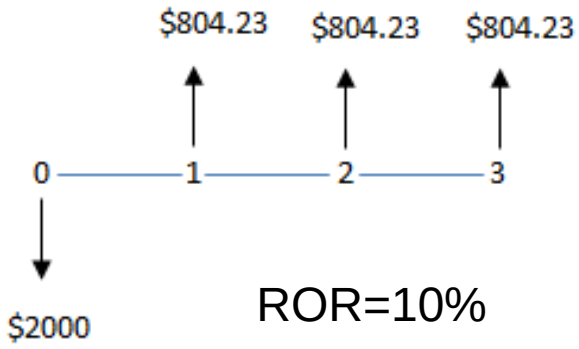
- Both teams paid 130000 dollars, same?
- But their rate of return are different!
- Recall what you learned before: time value of money.

ROR - example

- You paid $2,000 for a machine in anticipation that it will give you a rate of return of 10% at the end of 3 years.
- Using (A/P,10%,3), you will receive $804.23 per year
  - The benefits ($804.23) we obtained yearly from the investment cannot be kept at home under the pillow
  - If we do that, you will not be getting the required 10% return **2000(F/P,10%,3) ≠ 804.23x3**
  - To achieve 10% return, this $804.23 has to be **re-invested** at a ROR of 10% yearly until year 3.

At the end of year 3, it will receive

2000(F/P,10%,3) = 804.23(F/P,10%,2)
+804.23(F/P,10%,1)
+804.23



ROR Methods

- Higher ROR indicates higher return

- Two methods are used to determine the rate of return:
  - **Internal Rate of Return (IRR)**
  - **External Rate of Return (ERR)**

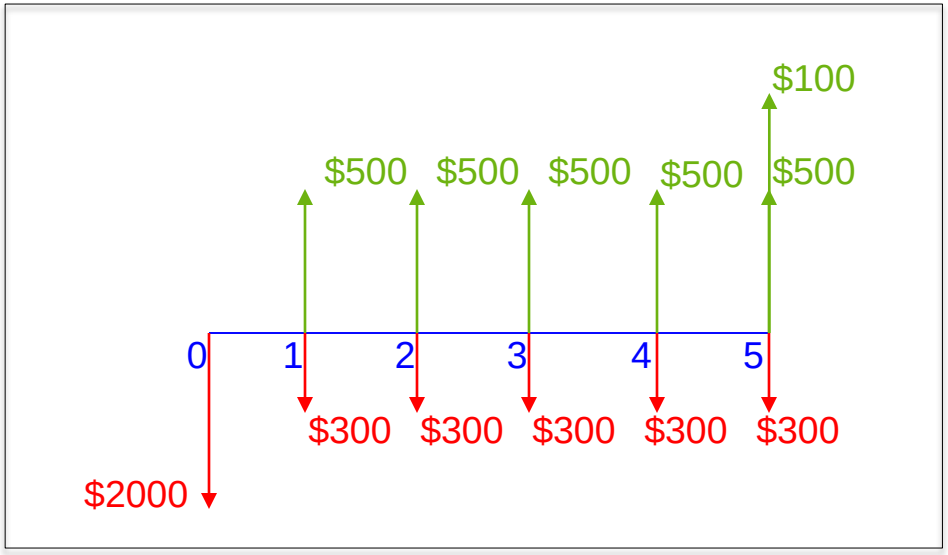
What is MARR?

- For a capital project to be acceptable, it must provide a return that exceeds the minimum level established by the organization.
- This minimum level is the organization's Minimum Acceptable Rate of Return (MARR) that it wants to achieve on its investment.
- Minimum Acceptable Rate of Return (Hurdle Rate)
  - MARR is an interest rate set by the company used to convert cash flows into equivalent worth at some point in time
- MARR is usually determined by the top management in an organization
  - Represents the rate at which a firm can always invest the money in its investment pool or borrow from the capital market if no funds are available
  - Company will only invest in a project if the rate of return (ROR) is higher than the MARR

Accounting for Different Risk

- The level of risk involved in each project generally varies
  - A project with higher risk should be compensated with a higher rate of return
- Firms may set different MARRs according to the level of risk involved
  - High Risk (MARR= 30~40%)
    - New products, New business, Acquisitions, Joint ventures
  - Moderate Risk (MARR= 20~30%)
    - Capacity increase to meet forecasted sales
  - Low Risk (MARR=10~20%)
    - Cost improvements, Make versus Buy, Capital increase to meet existing order

Re Cap: How to draw a Cash Flow Diagram?



i = 2% per year

N = 5

Cash Flow Diagram

- **Downward Arrow** – Negative cash flow (money outflow)
- **Upward Arrow** – Positive cash flow (money inflow)

- N: number of compounding periods (refers to numbers on the horizontal line or time scale)
- i: interest rate per interest period

Discounted Cash Flow Methods

- Discounted cash flow (DCF) takes into account the time value of money over the entire project life.
- It uses free cash flow projections and discounts them (using a discount rate) to arrive with a value at a given point in time; which is used to evaluate the potential of the investment.
- If the value arrived at through DCF analysis is higher than the current cost of the investment, the opportunity may be a good one.
- The discount rate reflects the riskiness of a project or events.
- It computes the return on investment at MARR.

Equivalent Worth Analysis

- Three discounted cash flow methods are used to compute net worth:
  1. **Present Worth Method (PW)**
  2. **Future Worth Method (FW)**
  3. **Annual Worth Method (AW)**
- Relationships of the three methods are based on the assumption of a constant interest rate throughout the life of a project.
- A **positive net worth** suggests that the investment can cater for a degree of risk exceeding MARR.
  - If **net worth > 0:** means the investment is earning a return at a rate > MARR
  - If **net worth < 0:** the investment is earning a return at a rate < MARR, which makes the project economically infeasible

The Present Worth Method (PW)

- Discount future amounts to the present by using the interest rate over the appropriate study period

$$PW(i) = \sum_{n=0}^{N} CF_n \left(1 + i \right)^{-n}$$

i = MARR per compounding period

n = Time Period at the end of each compounding period ($0 \leq n \leq N$)

CF_n = Net cash flow at the end of period n

N = Number of compounding periods in study period (or planning horizon)

- The higher the interest rate and further into future a cash flow occurs, the lower its PW

  If **PW(*i*) > 0**, accept the investment

  If **PW(*i*) = 0**, remain indifferent

  If **PW(*i*) < 0**, reject the investment

The Future Worth Method (FW)

- FW is based on the equivalent worth of all cash inflows and outflows at the end of the planning horizon at an interest rate that is generally MARR

$$FW(i\%) = \sum_{n=0}^{N} CF_n (1+i)^{N-n}$$

i = MARR per compounding period

n = Time Period at the end of each compounding period ($0 \leq n \leq N$)

CF_n = Net cash flow at the end of period n

N = Number of compounding periods in study period (or planning horizon)

If **FW(*i*) > 0**, accept the investment

If **FW(*i*) = 0**, remain indifferent

If **FW(*i*) < 0**, reject the investment

The Annual Worth Method (AW)

- AW is an **equal annual series** of dollar amounts, over a stated period (N), equivalent to the cash inflows and outflows at an interest rate that is generally MARR

- AW is **annual equivalent revenue R** minus **annual equivalent expense E** less the **annual equivalent capital recovery** (**CR**)

i.e AW (i %) = R - E - CR (i %)

i = MARR per compounding period

If **AW(*i*)** > **0**, accept the investment
If **AW(*i*)** = **0**, remain indifferent
If **AW(*i*)** < **0**, reject the investment

Capital Recovery (CR)

- Capital Recovery (CR) is the **equivalent uniform annual cost** of the capital invested
- CR is an annual amount that covers:
  - Loss in value of the asset
  - Interest on invested capital (i.e. at the MARR)

$$\mathbf{CR}(i\,\%) = \mathbf{I}(A/P, i\,\%, N) - \mathbf{S}(A/F, i\,\%, N)$$

where: I = Initial investment for the project

S = Salvage (market) value at the end of the study period

N = Project study period

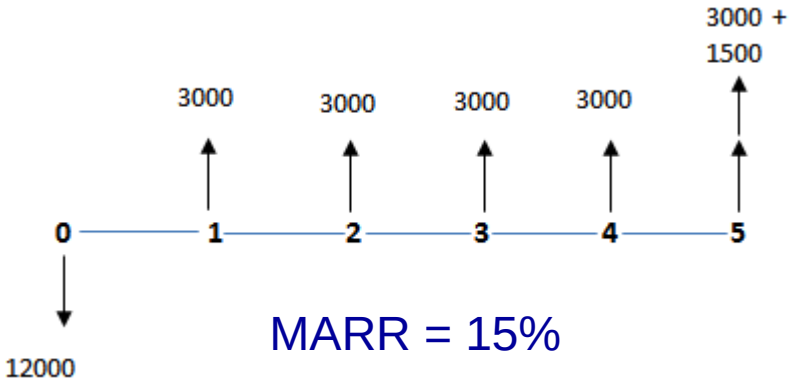
i = MARR per compounding period

Notation:

A|P is “find annual value ***given*** present value”

Examples of Equivalent Worth Analysis

	Cash Flows ($)
Investment Cost	12,000
Expected Life	5 Years
Salvage Value	1,500
Annual Receipts	6,000
Annual Expenses	3,000



- **Present Worth Method**:

  PW(15%) = - $12K+ $3K[P/A,15%,5] + $1.5K[P/F,15%,5]

  = -$1198 **< 0 Reject the project**

- **Future Worth Method**:

  FW(15%) = - $12K[F/P,15%,5]+ $3K[F/A,15%,5] + $1.5K

  = -$2409 **< 0 Reject the project**

- **Annual Worth Method:**

  AW (15%) = - $12K[A/P,15%,5]+ $3K+ $1.5K[A/F,15%,5]

  = -$357 **< 0 Reject the project**

Capital Recovery (CR)
= $12K[A/P,15%,5] - $1.5K[A/F,15%,5]
= $3357

Note: PW, AW & FW are equivalent

Example of Excel Financial Functions

Excel Financial Functions	Purpose
NPV (rate, value1, value2, …)	Calculates the **net present value** of an investment by using a discount rate and a **series of future payments** (negative values) and income (positive values).
PMT (rate, nper, pv, fv, type) PMT(10%,5,-200,,0)	Calculates the payment for a loan based on constant payments and a constant interest rate.
FV (rate, nper, pmt, pv, type) FV(10%,5,-20,,0)	Returns the **future value** of an investment based on periodic, constant payments and a constant interest rate.
PV (rate, nper, pmt, fv, type) PV(10%,5,-20,,0)	Returns the **present value** of an investment. The present value is the total amount that a series of future payments is worth now. For example, when you borrow money, the loan amount is the present value to the lender.
type 0	Default, **end** of period cash flow
type 1	**Beginning** of period cash flow

The *end-of-period cash flow convention* is the standard assumption for this module

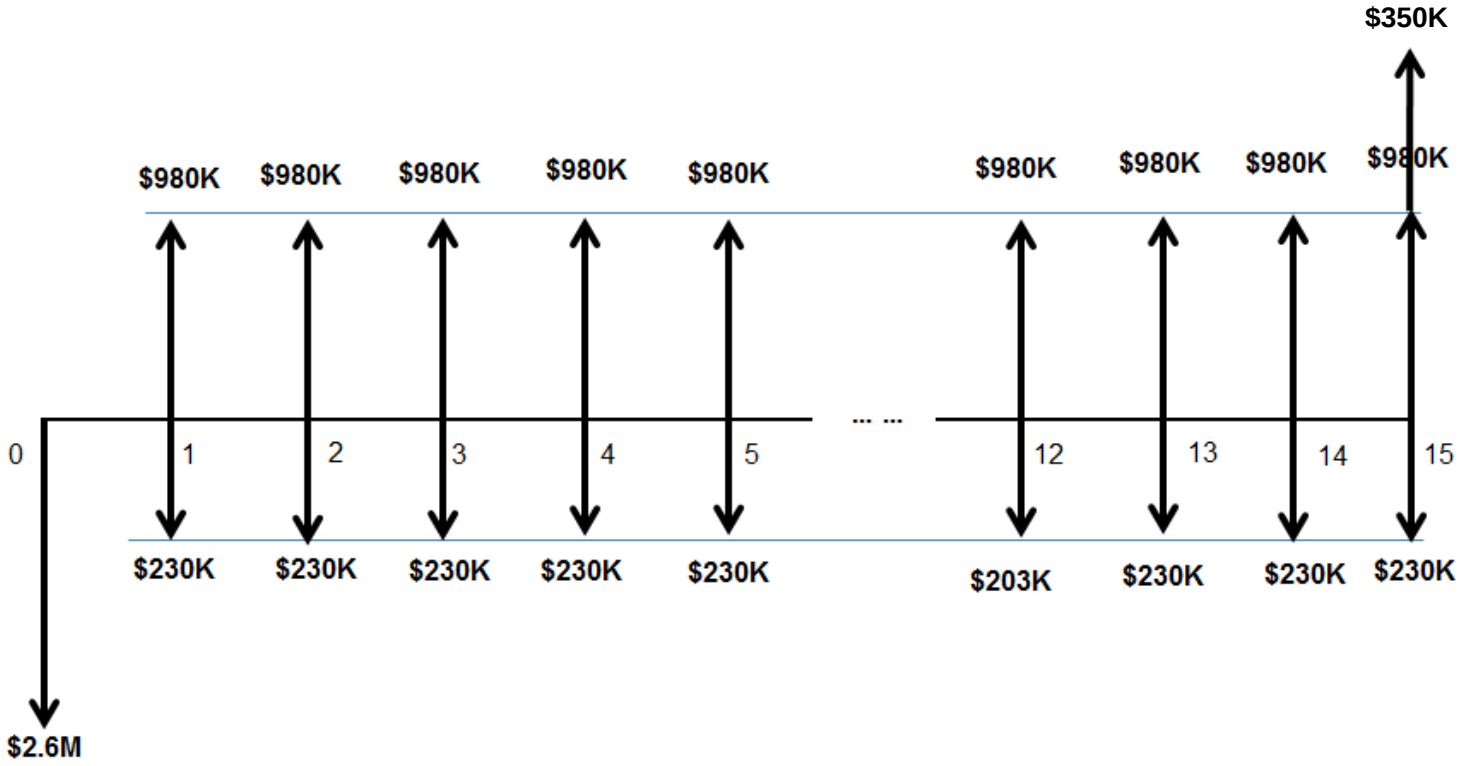
Excel Financial Functions

- *Assumptions*:
  - The per period interest rate, i, shall remain constant.
  - There is exactly one period between the cash flows
  - The period length shall remain constant
  - The default end-of-period cash flow convention (type=0) is used
  - The first cash flow is in a range at the end of the first period

P05 Suggested Solution

Problem Statement: Cash Flow

Cash Flow Diagram:



Cash Inflow: (Upward arrow)

Annual revenue = $980K (Year 1 to Year 15.

Salvage value = $350K (Year 15)

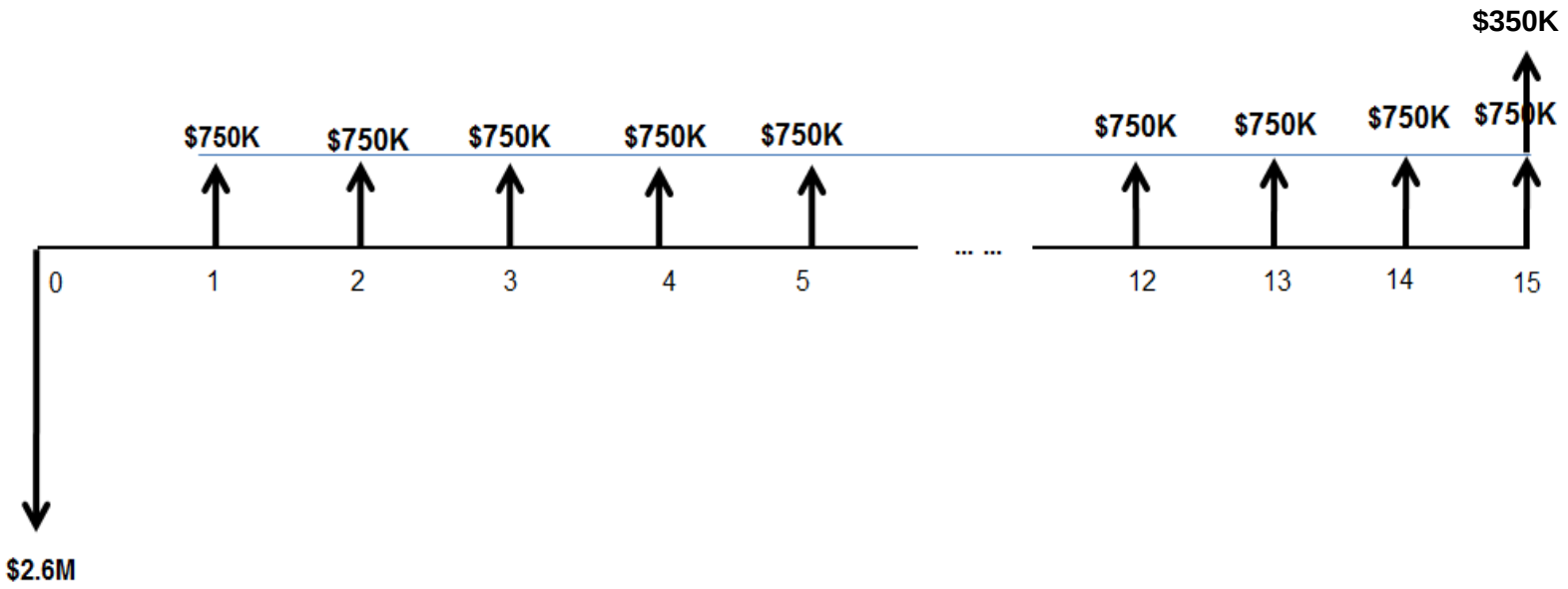
Cash Outflow: (Downward arrow)

Initial investment = $2.6 million (Year 0)

Operating cost = 230K (Year 1 to Year 15).

Problem Statement: Cash Flow

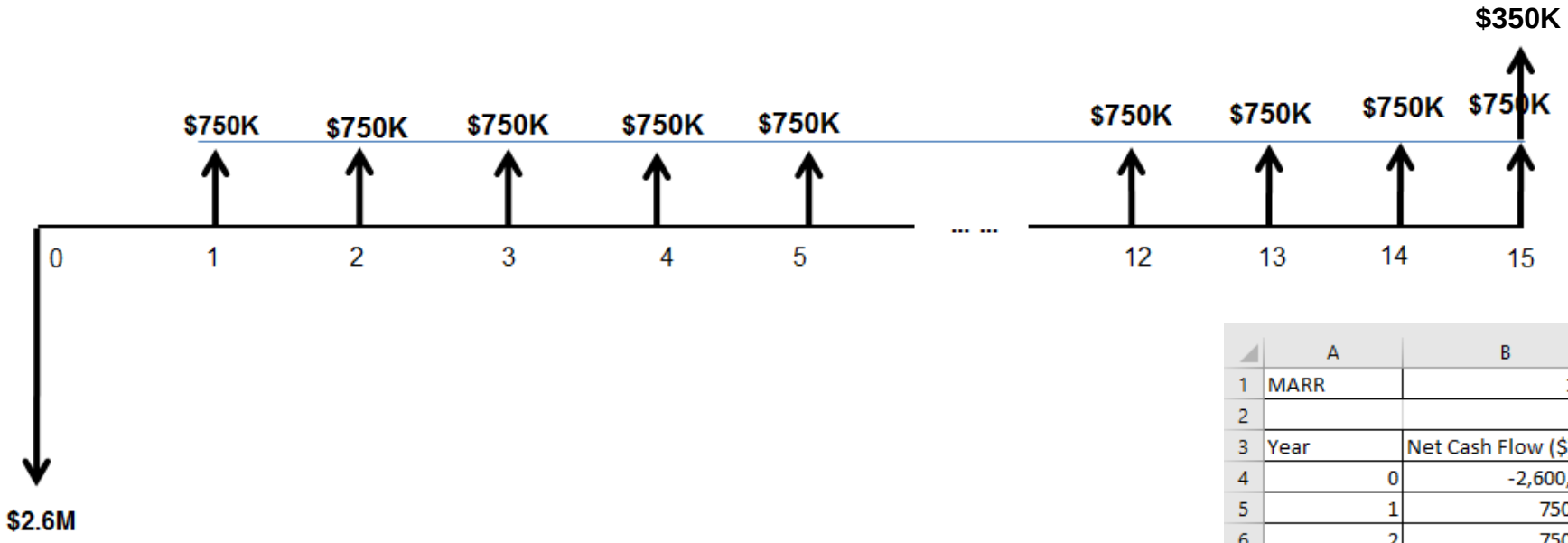
Net Cash Flow:



Net Cash Inflow = Cash Inflow - Cash Outflow

Problem Statement: Present Worth

Net Cash Flow:



	A	B
1	MARR	18%
2		
3	Year	Net Cash Flow ($)
4	0	-2,600,000
5	1	750000
6	2	750000
7	3	750000
8	4	750000
9	5	750000
10	6	750000
11	7	750000
12	8	750000
13	9	750000
14	10	750000
15	11	750000
16	12	750000
17	13	750000
18	14	750000
19	15	1100000
20	NPV	=NPV(B1,B5:B19)+B4

Present Worth Method:

Use **Interest Factor Notation**

Present Worth of the cash flows at 18% MARR

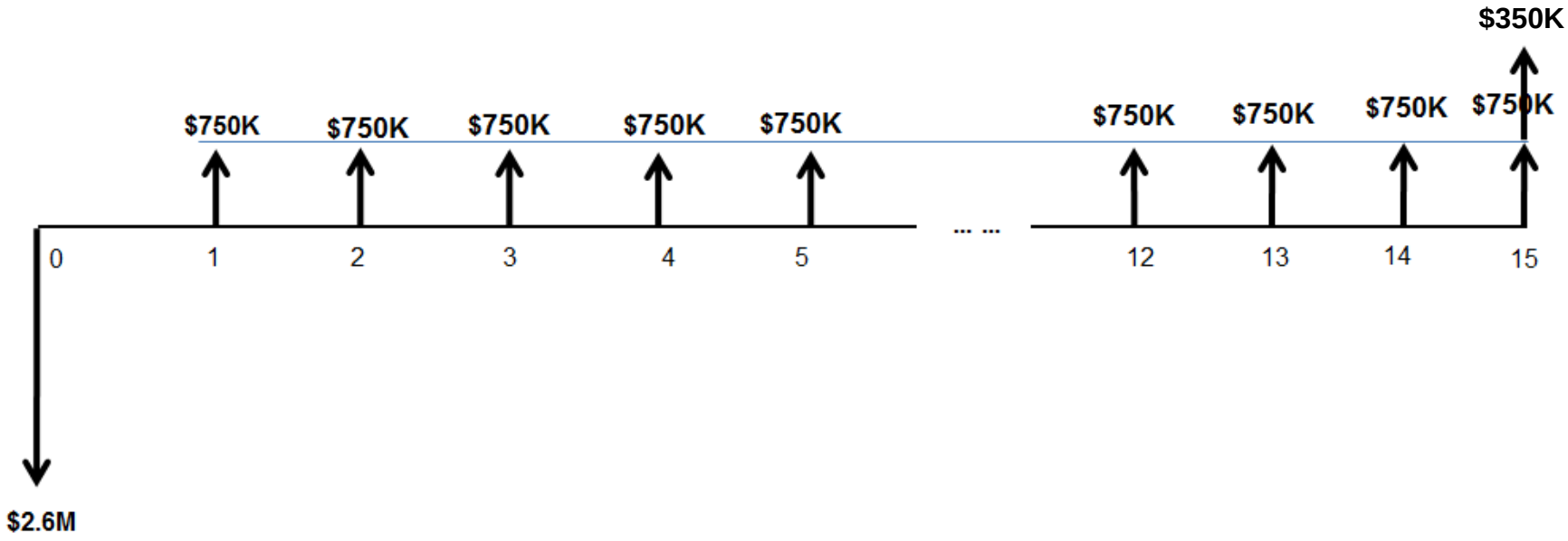
= – $2,600,000 + $750,000(P/A, 18%,15) + $350,000(P/F, 18%,15)

= – $2,600,000 + $750,000(5.0916) + $350,000(0.0835)

= $1,247,925 > 0 **=> The investment is feasible**

Problem Statement: Future Worth

Net Cash Flow:



Future Worth Method:

Use **Interest Factor Notation**

Future Worth of the cash flows at 18% MARR

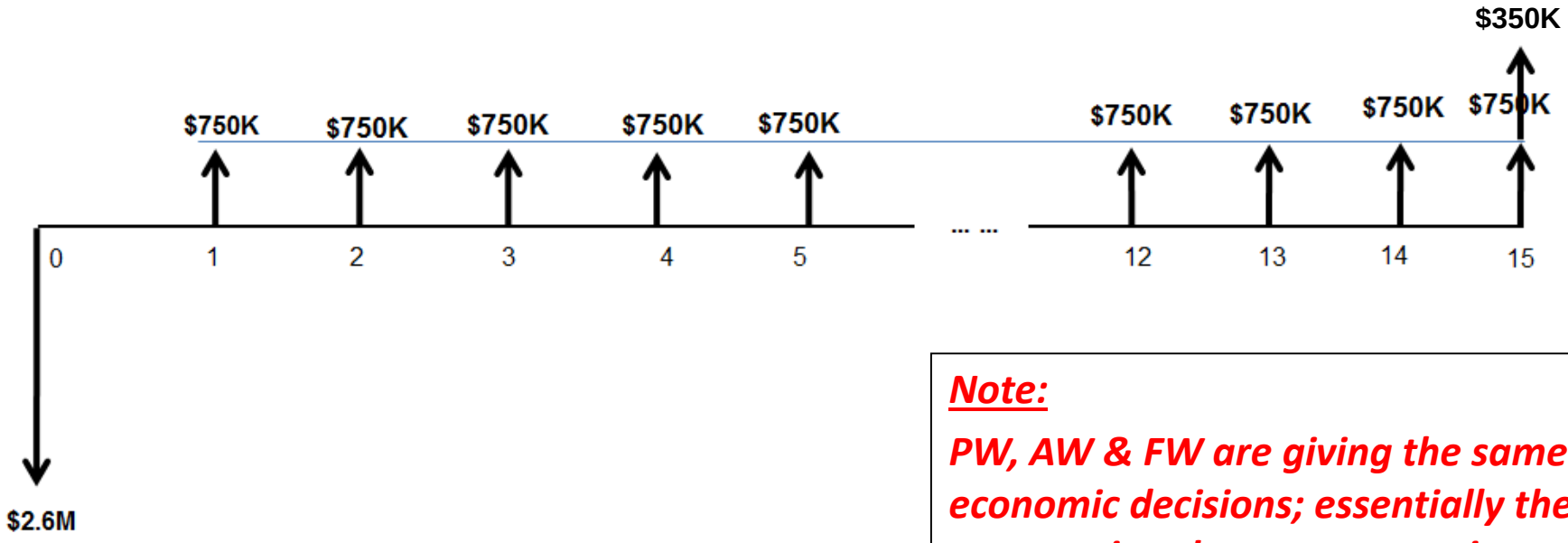
= – $2,600,000(F/P, 18%,15) + $750,000(F/A, 18%,15) + $350,000

= – $2,600,000(11.9737) + $750,000(60.9653) + $350,000

= $14,942,355. 0 > 0 **=> The investment is feasible**

Problem Statement: Annual Worth

Net Cash Flow:



Note:

PW, AW & FW are giving the same economic decisions; essentially they are treating the same scenario.

Annual Worth Method:

Use **Interest Factor Notation**

Annual Worth of the cash flows at 18% MARR

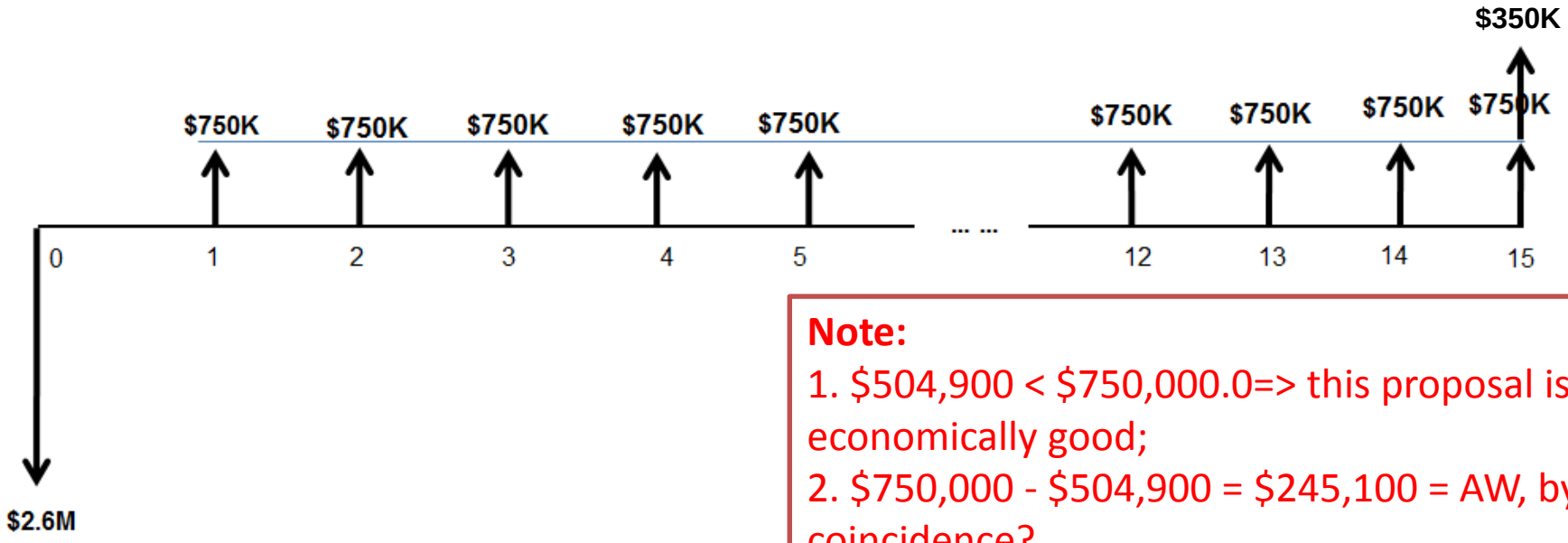
= – $2,600,000(A/P, 18%,15) + $750,000 + $350,000(A/F, 18%,15)

= – $2,600,000(0.1964) + $750,000 + $350,000(0.0164)

= $245,100.0 > 0 **=> The investment is feasible**

Problem Statement: Capital Recovery

Net Cash Flow:



Note:
1. $504,900 < $750,000.0=> this proposal is economically good;
2. $750,000 - $504,900 = $245,100 = AW, by coincidence?

Capital Recovery (CR) = P (A/P, i%, N) - S(A/F, i%, N)

Use **Interest Factor Notation**

CR at 18% MARR
= $2,600,000(A/P, 18%,15) - $350,000(A/F, 18%,15)
= $2,600,000(0.1964) - $350,000(0.0164)
= $504,900.0

Learning Objectives

- ✓ Interpret the concepts of Rate of Return (ROR) and Minimum Acceptable Rate of Return (MARR)
- ✓ Evaluate feasibility of a project using MARR and Equivalent Worth (EW) method
- ✓ Compute net worth using the three discounted cash flow methods, namely the Present Worth Method (PW), Future Worth Method (FW) and Annual Worth Method (AW)
- ✓ Compute the Capital Recovery (CR)
- ✓ Compute PW, FW and AW using MS Excel financial functions

E213 Engineering Cost Decisions (Topic Flow)

Today's learning

Application of ABC costing method in cost management

Application of different cost estimating techniques

Comparison of alternatives using the concept of equivalence

Alternatives evaluation using single, uniform series and uniform gradient cash flows

Project evaluation using MARR and Equivalent Worth method

Project evaluation based on Internal Rate of Return and External Rate of Return

Evaluate alternatives of equal life spans using payback method

Evaluate alternatives with different life spans

Evaluate public projects through incremental B/C analysis

Depreciation estimation and consideration in economic analysis

Tax consideration in economic analysis

Replacement analysis application

Risk and uncertainties handling in economic analysis