- **Course Title:** Engineering Cost Analysis & Economy (ENGR 222)
- **Session:** Fall 2024
- **Instructor:** Sudipta Chowdhury (chowdhurys@marshall.edu)
- **Class Time: TR 9.15 AM-10.45 AM**
- **Office hours: TR 11.00 AM-12.30 PM**

Breakeven Analysis (Two or More Alternatives)

The same type of analysis can be performed for three or more alternatives. Then, compare the alternatives in pairs to find their respective breakeven points. The results are the ranges through which each alternative is more economical.

Example 1. Three types of design proposals for a commercial one-story building is to be evaluated details given below:

	STEEL	CONCRETE	BRICK
First cost	$\$72/ft^2$	$\$76/ft^2$	$\$81/ft^2$
Annual maintenance	\$14000	\$9000	\$6000
Annual heating cost	$\$3/ft^2$	$\$3.4/ft^2$	$\$3.9/ft^2$
SV (%of first cost)	%80	%100	%110
Life (years)	20	20	20

For what range of building area (ft2) which type of design is the most suitable (cheapest) to select? Carry out breakeven analysis using an interest rate of 18% per year and plot your ranges to illustrate.

18%	Compound Interest Factors								18%
	Single Payment		Uniform Payment Series				Arithmetic Gradient		
	Compound Amount Factor	Present Worth Factor	Sinking Fund Factor	Capital Recovery Factor	Compound Amount Factor	Present Worth Factor	Gradient Uniform Series	Gradient Present Worth	
	Find *F* Given *P*	Find *P* Given *F*	Find *A* Given *F*	Find *A* Given *P*	Find *F* Given *A*	Find *P* Given *A*	Find *A* Given *G*	Find *P* Given *G*	
n	*F/P*	*P/F*	*A/F*	*A/P*	*F/A*	*P/A*	*A/G*	*P/G*	*n*
1	1.180	.8475	1.0000	1.1800	1.000	0.847	0	0	1
2	1.392	.7182	.4587	.6387	2.180	1.566	0.459	0.718	2
3	1.643	.6086	.2799	.4599	3.572	2.174	0.890	1.935	3
4	1.939	.5158	.1917	.3717	5.215	2.690	1.295	3.483	4
5	2.288	.4371	.1398	.3198	7.154	3.127	1.673	5.231	5
6	2.700	.3704	.1059	.2859	9.442	3.498	2.025	7.083	6
7	3.185	.3139	.0824	.2624	12.142	3.812	2.353	8.967	7
8	3.759	.2660	.0652	.2452	15.327	4.078	2.656	10.829	8
9	4.435	.2255	.0524	.2324	19.086	4.303	2.936	12.633	9
10	5.234	.1911	.0425	.2225	23.521	4.494	3.194	14.352	10
11	6.176	.1619	.0348	.2148	28.755	4.656	3.430	15.972	11
12	7.288	.1372	.0286	.2086	34.931	4.793	3.647	17.481	12
13	8.599	.1163	.0237	.2037	42.219	4.910	3.845	18.877	13
14	10.147	.0985	.0197	.1997	50.818	5.008	4.025	20.158	14
15	11.974	.0835	.0164	.1964	60.965	5.092	4.189	21.327	15
16	14.129	.0708	.0137	.1937	72.939	5.162	4.337	22.389	16
17	16.672	.0600	.0115	.1915	87.068	5.222	4.471	23.348	17
18	19.673	.0508	.00964	.1896	103.740	5.273	4.592	24.212	18
19	23.214	.0431	.00810	.1881	123.413	5.316	4.700	24.988	19
20	27.393	.0365	.00682	.1868	146.628	5.353	4.798	25.681	20

Payback Analysis

Payback Period Analysis

Payback period: **Estimated amount of time (n_p) for cash inflows to recover an initial investment (P) plus a stated return of return (i%)**

Types of payback analysis: **No-return** and **discounted** payback

1. **No-return payback** means rate of return is ZERO (i = 0%)
2. **Discounted payback** considers time value of money (i > 0%)

Caution: Payback period analysis is a good initial screening tool, rather than the primary method to justify a project or select an alternative

Payback Period Computation

Formula to determine payback period (n_p) varies with type of analysis.

NCF = Net Cash Flow per period t

No return, $i = 0\%$; NCF_t varies annually:	$0 = -P + \sum_{t=1}^{t=n_p} \text{NCF}_t$	**Eqn. 1**
No return, $i = 0\%$; annual uniform NCF:	$n_p = \frac{P}{\text{NCF}}$	**Eqn. 2**
Discounted, $i > 0\%$; NCF_t varies annually:	$0 = -P + \sum_{t=1}^{t=n_p} \text{NCF}_t(P/F, i, t)$	**Eqn. 3**
Discounted, $i > 0\%$; annual uniform NCF:	$0 = -P + \text{NCF}(P/A, i, n_p)$	**Eqn. 4**

Points to Remember About Payback Analysis

No-return payback neglects time value of money, so no return is expected for the investment made

No cash flows after the payback period are considered in the analysis. Return may be higher if these cash flows are expected to be positive.

Approach of payback analysis is different from PW, AW, ROR and B/C analysis. A different alternative may be selected using payback.

Rely on payback as a supplemental tool; use PW or AW at the MARR for a reliable decision

Discounted payback ($i > 0\%$) gives a good sense of the risk involved

Example 1: Payback Analysis

System	System 1	System 2
First cost, $	12,000	8,000
NCF, $ per year	3,000	1,000 (year 1-5) 3,000 (year 6-14)
Maximum life, years	7	14

Problem: Use (a) no-return payback, (b) discounted payback at 15%, and (c) PW analysis at 15% to select a system. Comment on the results.

System	System 1	System 2
First cost, $	12,000	8,000
NCF, $ per year	3,000	1,000 (year 1-5) 3,000 (year 6-14)
Maximum life, years	7	14

15%	Compound Interest Factors								15%
	Single Payment		Uniform Payment Series				Arithmetic Gradient		
n	Compound Amount Factor Find *F* Given *P* *F/P*	Present Worth Factor Find *P* Given *F* *P/F*	Sinking Fund Factor Find *A* Given *F* *A/F*	Capital Recovery Factor Find *A* Given *P* *A/P*	Compound Amount Factor Find *F* Given *A* *F/A*	Present Worth Factor Find *P* Given *A* *P/A*	Gradient Uniform Series Find *A* Given *G* *A/G*	Gradient Present Worth Find *P* Given *G* *P/G*	n
1	1.150	.8696	1.0000	1.1500	1.000	0.870	0	0	1
2	1.322	.7561	.4651	.6151	2.150	1.626	0.465	0.756	2
3	1.521	.6575	.2880	.4380	3.472	2.283	0.907	2.071	3
4	1.749	.5718	.2003	.3503	4.993	2.855	1.326	3.786	4
5	2.011	.4972	.1483	.2983	6.742	3.352	1.723	5.775	5
6	2.313	.4323	.1142	.2642	8.754	3.784	2.097	7.937	6
7	2.660	.3759	.0904	.2404	11.067	4.160	2.450	10.192	7
8	3.059	.3269	.0729	.2229	13.727	4.487	2.781	12.481	8
9	3.518	.2843	.0596	.2096	16.786	4.772	3.092	14.755	9
10	4.046	.2472	.0493	.1993	20.304	5.019	3.383	16.979	10
11	4.652	.2149	.0411	.1911	24.349	5.234	3.655	19.129	11
12	5.350	.1869	.0345	.1845	29.002	5.421	3.908	21.185	12
13	6.153	.1625	.0291	.1791	34.352	5.583	4.144	23.135	13
14	7.076	.1413	.0247	.1747	40.505	5.724	4.362	24.972	14
15	8.137	.1229	.0210	.1710	47.580	5.847	4.565	26.693	15
16	9.358	.1069	.0179	.1679	55.717	5.954	4.752	28.296	16
17	10.761	.0929	.0154	.1654	65.075	6.047	4.925	29.783	17
18	12.375	.0808	.0132	.1632	75.836	6.128	5.084	31.156	18
19	14.232	.0703	.0113	.1613	88.212	6.198	5.231	32.421	19
20	16.367	.0611	.00976	.1598	102.444	6.259	5.365	33.582	20

QUESTIONS?