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REPLACEMENT ANALYSIS

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Replacement analysis is the study of the planning, rationale and execution of the effective replacement of an existing asset (i.e. components, parts, vehicles, machinery) with a new asset(s). It involves determining the optimal time to replace existing equipment with new ones, considering factors beyond mere physical wear and tear. It distinguishes between the physical life and economic life of an asset, where the latter dictates replacement based on factors like repair costs and maintenance. The amount of time before an asset can no longer be used or its value reaches zero is referred to as its **physical life**. The **economic life** of an asset is the period of time when it is generating greater value than any possible alternatives. A project's economic life is always equal to or shorter than its physical life.

Replacement decisions require choosing between the current asset, known as the **defender**, and available alternatives, referred to as **challengers**. In various sectors, equipment has a limited lifespan, and over time, they may fail suddenly or wear out gradually, leading to decreased efficiency and affecting production or benefits. As equipment ages or reaches the wearing-out stage, higher operating and maintenance costs arise, prompting the consideration of complete replacement. Examples include transportation vehicles, industrial machines, and tires.

The various costs involved in replacement analysis are:

- The replacement cost of the item
- The consequential cost of failure
- The costs of the actual replacement

Replacement analysis aims to ensure efficient equipment functioning and determine optimal replacement times to minimize overall maintenance costs. Two primary replacement policies are:

i. Replacement of equipment/items that deteriorate or wear-out gradually; and
ii. Replacement of equipment/items that fail suddenly.

REPLACEMENT OF ITEMS THAT DETERIORATE

The efficiency of equipment or items subject to gradual deterioration diminishes over time, leading to progressive failure. This deterioration adversely affects efficiency, resulting in (i) a decrease in production capacity, (ii) escalating maintenance and operating costs, and (iii) a decline in the resale or salvage value of the item. Considering these effects, it becomes both reasonable and economical to replace deteriorating equipment or items with new ones. The decision to replace is often based on repair and maintenance costs, and two policies are considered:

a) Replacement of items that deteriorate but whose maintenance and repair costs increase with time, ignoring changes in the time value of money.

b) Replacement of items that deteriorate but whose maintenance and repair costs increase with time, considering changes in the time value of money.

a) Replacement of Items that Deteriorate and Experience Increasing Maintenance and Repair Costs

This involves minimizing the average annual cost of equipment when maintenance costs increase over time, assuming a constant time value of money.

☑ EXAMPLE 23.1

Historically, cost per year of operating an embroidery machine is as follows:

Year	1	2	3	4	5	6	7
Operating Cost ($)	570	590	1030	1310	1940	1990	2890

If the cost price is $12,000 and the scrap value is $2500, when should the machine be replaced?

SOLUTION**tips**

Let C = cost of the equipment
S = scrap value of the equipment at the end of t years
$C = 12{,}000$ $S = 2500$

Year	Running Cost ($)	Cumulative Running Cost ($)	Depression Cost Price ($)	Total Cost ($)	Average Cost ($)
n	X_1	$X_2 = \sum_0^n X_3$	$X_3 = C - S$	$X_4 = X_3 + X_2$	$X_5 = X_4/n$
1	570	570	9500	10070	10070.00
2	590	1160	9500	10660	5330.00
3	1030	2190	9500	11690	3896.67
4	1310	3500	9500	13000	3250.00
5	1940	5440	9500	14940	2988.00
6	1990	7430	9500	16930	**2821.67***
7	2890	10320	9500	19820	2831.43

The average cost is minimum in the sixth year. Thus, the machine should be replaced at the end of the sixth year.

☑ EXAMPLE 23.2

An owner of a printing machine, which costs $1000, estimates from past records that the maintenance costs and resale values per year are as follows:

Year	1	2	3	4	5	6	7	8	9	10
Maintenance Cost ($)	60	80	100	120	130	370	420	440	450	490
Resale Cost ($)	240	220	210	200	200	180	130	120	110	80

When should the machine be replaced?

SOLUTION**tips**

Year	Resale Value ($)	PRS value ($)	AM cost ($)	CM cost ($)	Total cost ($)	Average cost ($)
n	X_1	$X_2 = 1000 - X_1$	X_3	$X_4 = \sum_0^n X_3$	$X_5 = X_2 + X_4$	$X_6 = X_3/n$
1	240	760	60	60	820	820
2	220	780	80	140	920	460
3	210	790	100	240	1030	343.33
4	200	800	120	360	1160	290
5	200	800	130	490	1290	**258***
6	180	820	370	860	1680	280

7	130	870	420	1280	2150	307.14
8	120	880	440	1720	2600	325
9	110	890	450	2170	3060	340
10	80	920	490	2660	3580	358

AM = Annual maintenance; CM = Cumulative maintenance; PRS = Purchase price resale

The average cost is minimum in the 5^{th} year. Thus, the machine should be replaced by the end of the 5^{th} year.