Cost Estimation

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Cost Estimation & Economic Analysis

- Project cost estimation
- Cost indexes
- Net earning
- Interest and investment costs
- Income tax
- **Depreciation**

Income tax & Depreciation

- The profits generated by most chemical plants are subject to taxation.
- Taxes can have a significant impact on the cash flows from a project.
- The design engineer needs to have a basic understanding of taxation and tax allowances such as depreciation in order to make an economic evaluation of the project.
- The details of tax law can be complicated, and governments enact changes almost every year.
- Specialized knowledge about tax rules is not required for engineering design projects, which are usually compared on a relatively simple after-tax basis.
- The design engineer may occasionally need to consult a tax expert though, particularly when comparing projects in different countries with different tax law.
- Various types of tax allowance are permitted in the tax laws, the most common of which is depreciation.

Taxable income

- The taxable income of a plant = Total Gross Profit - Tax allowances
- Total Gross Profit = Total Revenue – Total Product Cost
- Payable Tax = Gross Profit * Tax rate
- Total Revenue is income from all sources
  - Product sales
  - Sales of assets and supplies
  - Royalties
  - Other revenue

Capital Gains Tax

- A capital gains tax is levied on profits made from the sale of capital assets, such as land, buildings, and equipment.
- Land is not depreciable.
- Profit on the sale of land = (Selling price) - (Purchase price) – (Costs of selling) –(Costs of improvements)
- For depreciable assets, such as buildings and equipment
- Profit = Selling price — (Costs of selling) - (Cost of Purchase - Depreciation).

- Consider an equipment: Purchase cost is $80,000 which has already had $50,000 of depreciation charged as an expense, and is sold for $45,000 with $2000 in selling expense—advertising and removal from service
- Capital gain = $45,000 — (80,000 — 50,000) — 2000 =
  = $13,000

Losses

- **Offsetting Gains:** If a company makes a loss in a year, it can use that loss to reduce its profits (gains) for that same year. This helps lower the amount of tax the company needs to pay, because taxes are based on profits.

- **Carrying Losses:**

•If a company has a **total loss** in a year (like losing money in its business), it can either:

- **Carry the loss back**: The company can use the loss to reduce profits from the previous **3 years**. This means it can get a refund of some taxes paid in those past years.
- **Carry the loss forward**: The company can also use the loss to reduce profits in the next **5 years**. This helps lower future tax bills.

Losses

- **Project-Specific Losses:** A project or business might be profitable overall, but it could show a loss in some individual years. In these cases, the company can decide whether to:

Depreciation

- The value of physical assets decrease with time and a business is allowed to take this into consideration when analysing costs and profits for a particular operation.

- The decrease in the value of assets.

- It may be due to several factors such as physical depreciation, technological advances, and economic changes, etc.,

- Depreciation, however, has a significant effect on corporate cash flow.

Depreciation: Classification

Physical Depreciation

- Wear and tear
- Corrosion
- Accidents,
- Deterioration due to age

Functional Depreciation

- Obsolescence due to technological advances
- Decrease in demand for the service rendered by the property
- Shifts in population
- Changes in requirements of public authority
- Inadequacy or insufficient capacity
- Abandonment of the enterprise

Depreciation: a Hypothetical expense

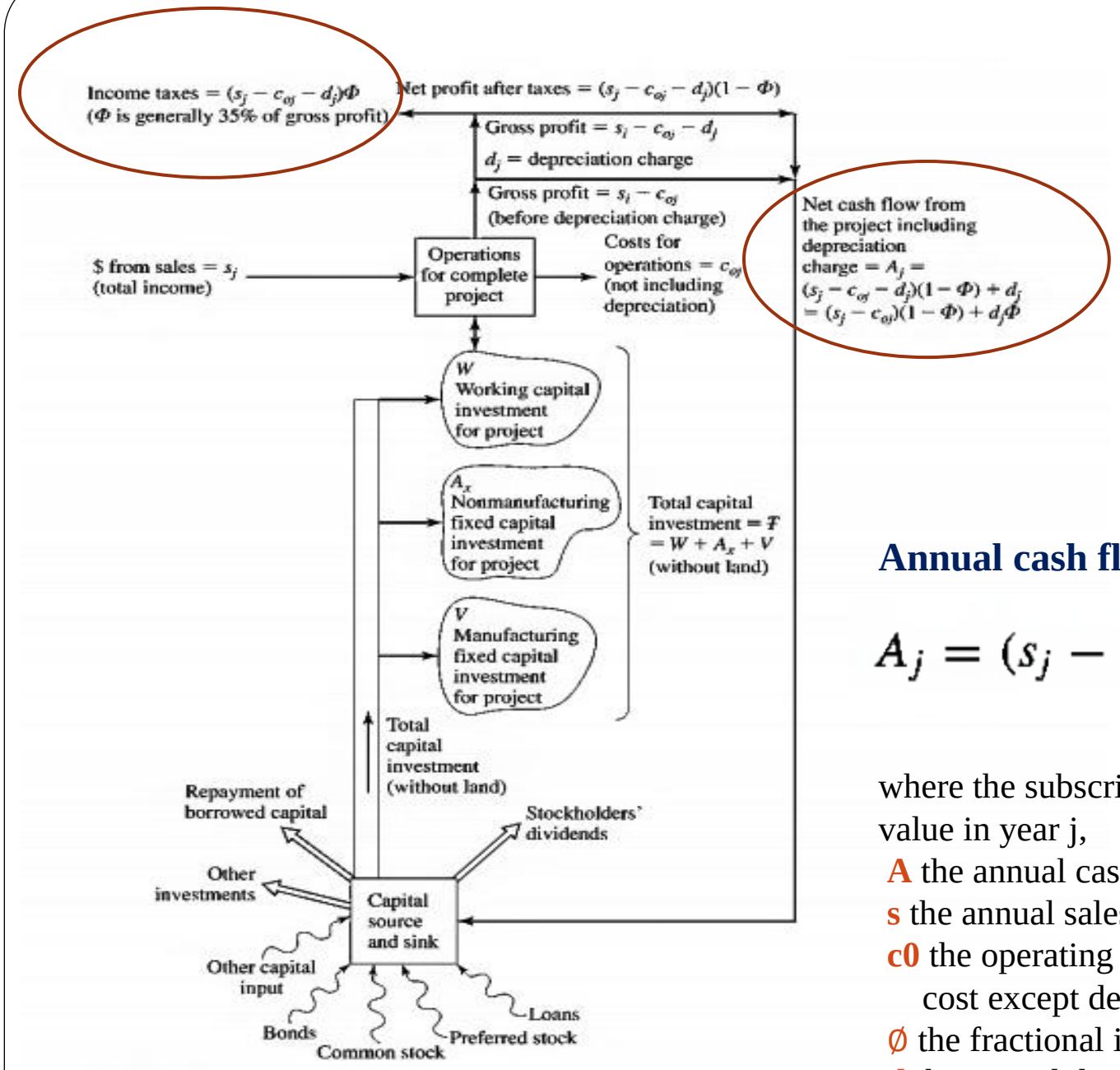
- In computing income taxes on the profits of an operation, Governments allow a deduction for a fraction of the initial cost of the plant as a "hypothetical expanse" to be subtracted from the actual gross profit for income tax calculations. This deduction is called Depreciation.

- The depreciation may be considered as a fund flow to allow eventual replacement of the plant or equipment of acknowledging that the plant has worn or becoming somewhat obsolete or less competitive with passage of time.

- Companies can calculate yearly depreciation for assets and deduct the depreciation from their gross income.

- Land is not allowed for depreciation.

- Depreciation is only calculated on business assets not personal assets.



Annual cash flow

$$A_j = (s_j - c_{oj})(1 - \Phi) + \Phi d_j$$

where the subscript j indicates an annual value in year j,

A the annual cash flow,

s the annual sales revenue,

c0 the operating cost (all of total product cost except depreciation),

Ø the fractional income tax rate, and

d the annual depreciation.

Depreciable Investments

Depreciable investments	Non-depreciable investments
All property with a limited useful life of more than 1 year that is used in a trade or business, or held for the production of income	Working capital and start-up costs
Improvements to the land such as grading and adding utility services	Land
Physical facilities, including such costs as design and engineering, shipping, and field erection	Inventories held for sale
The fixed-capital investment, not including land	The costs of maintenance and repairs

- The total amount of depreciation that may be charged is equal to the amount of the original investment in a property—**no more and no less**.
- Depreciation does not inflate or deflate.

Terms in Depreciation

- **Current value**: The current value of an asset is the value of the asset in its condition at the time of valuation.
- **Book value:** is the difference between the original cost of a property and all the depreciation charged up to a time.
- Over a period of time, the book value of the asset decreases until it is fully paid off or written off at which point depreciation can no longer be charged.
- **Market value:** The price that could be obtained for an asset if it were sold on the open market is designated the market value.
- It may be quite different from the book value and clearly is important for determining the true asset value of the company.

Terms in Depreciation

Salvage value refers to the estimated amount an asset is worth at the end of its useful life. This is the price you expect to get for the asset after it has been fully used or depreciated.

Scrap value: If the property is not useful, it can often be sold for material recovery. Income obtainable from this type of disposal is known as scrap value.

Service life: The period over which the use of a property is economically feasible is known as the service life of the property.

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Methods for Calculating Depreciation

There are several methods for calculating depreciation

- **Straight-line method**
- **Double-declining balance method**
- **Sum of digits method**
- **Modified accelerated cost recovery system (MACRS)**

Straight-line method

- In the straight-line method, the property value is assumed to decrease linearly with time over the recovery period.
- Thus the amount of depreciation in each year of the recovery period is

$$d = \frac{V - V_s}{N}$$

d = Annual depreciation, Rs./Year

V= Original investment in the property at the start of recovery period (Rs.)

V_s = Salvage value at the end of depreciable life (Rs.)

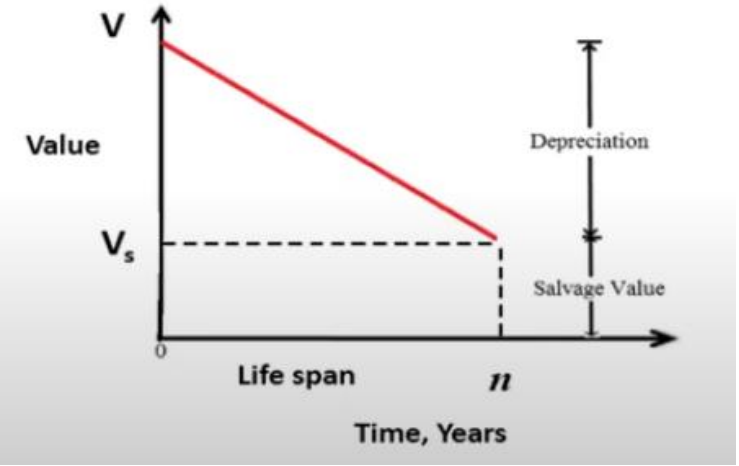
N = Length of the straight line recovery period (year)

Straight-line method

- For chemical plants the salvage value is often taken as zero, as the plant continues to operate for many years beyond the end of the depreciable life.

- Book value of the asset after m years of depreciation is

- $B_m = V - \sum_{i=1}^{m} d_i$



- When the book value is equal to the salvage value (or zero) then the asset is fully depreciated and no further depreciation charge can be taken.

Example 1: Straight line method

The cost of a heat exchange is Rs. 100,000. It has a useful life of 9 years. Its salvage value is 10000. Assuming straight line depreciation, what is the book value of the heat exchanger at the end of 5 th year.

Solution:

The annual depreciation is

$$d = \frac{V - V_S}{N} = \frac{100000 - 10000}{9} = \text{Rs. } 10{,}000 \text{ /year}$$

The book value of the heat exchanger after 5 years of depreciation,

$$B_5 = V - \sum_{i=1}^{5} d_i = 1{,}00{,}000 - 5(10{,}000) = \text{Rs. } 50{,}000$$

Straight-line method

End of year	Depreciation charged	Book value (Rs)
0	-	1,00,000
1	10,000	90,000
2	10,000	80,000
3	10,000	70,000
4	10,000	60,000
5	10,000	50,000
6	10,000	40,000
7	10,000	30,000
8	10,000	20,000
9	10,000	10,000
10	10,000	0

Value of depreciation is constant in straight line method

Declining Balance Method

- The Declining Balance Method is a way to calculate depreciation where the asset loses a larger portion of its value in the earlier years of its life and a smaller portion in the later years. This method assumes that the asset loses its value faster in the beginning.
- In this method, depreciation is calculated by multiplying the book value of the asset at the start of the year by a fixed percentage (called the depreciation rate).

Limitation:

- Unlike the straight-line method, the declining-balance method does not automatically take account of the salvage value of the asset.
- The book value at the end of the life of the asset may not be exactly equal to the salvage value of the asset.

Declining Balance Method

- Declining-balance depreciation (also called as fixed percentage method) models the loss in value of an asset over a period as a constant fraction of the asset's current book value.
- The fixed percentage factor remains constant throughout the service life of the asset.
- Therefore, the annual depreciated amount is different for each year.
- Depreciation = Book value at the beginning of the year x Depreciation rate
- Book value = Original Cost- Accumulated depreciation
  - $B_m = V - \sum_{i=1}^{m} d_i$
- The most common rate of depreciation is double the straight line rate. For this reason, this method is also referred as double-declining balance method.

Declining Balance Method

- In the declining-balance method, the annual depreciation charge is a fixed fraction (f_d) of the book value:

- Depreciation at the end of first year, $d_1 = V f_d$
- Book value at the end of first year, $B_1 = V - d_1 = V - Vf_d = V(1- f_d)$
- Depreciation at the end of second year, $d_2 = B_1 f_d = V(1- f_d)f_d$
- Book value at the end of second t year, $B_1 = B_1 - d_2 = V(1- f_d)-V(1- f_d)f_d = V(1- f_d)^2$

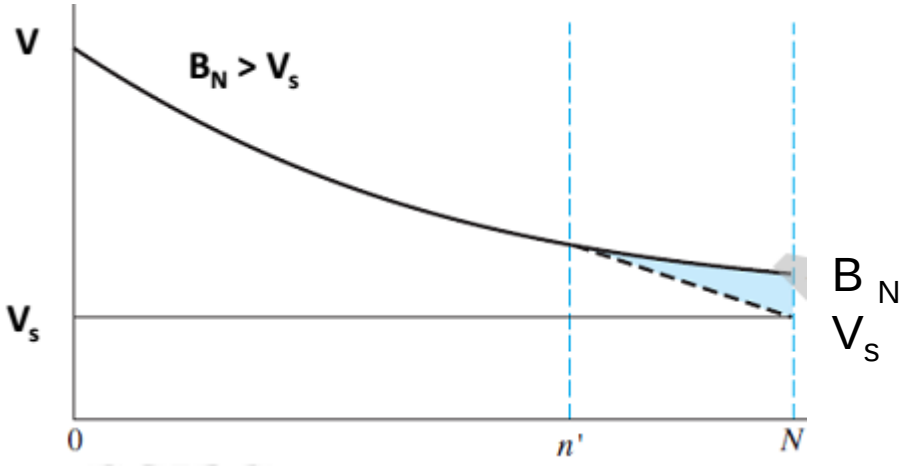
Similarly,

- Book value at the end of n th year, $B_n = V(1- f_d)^n$
- Depreciation at the end of n th year, $d_n = V(1- f_d)^{n-1}f_d$
- The fraction f_d must be equal to or less than 2/N, where N is the depreciable life in years.

Double Declining Balance Method

- Book value at the end of n years, $B_n = V(1- f_d)^n$
- Depreciation at the end of n years, $d_n = V(1- f_d)^{n-1} f_d$
- Admissible value for $f_d \leq \frac{2}{N}$
- When $f_d = \frac{2}{N}$, this method is known as Double Declining-Balance (DDB) depreciation.
- The DDB depreciation rate will be 200% (twice) of the straight-line rate.
- The book value for the DB method never goes to zero because the book value is always decreased by a fixed percentage.
- Since the DB depreciation may not reduce the book value to the salvage value at year N, it may be necessary to switch to straight-line depreciation in later years

- It is not allowed to depreciate the asset below their salvage value.



Example 1: A company has purchased an equipment at a cost of Rs. 1,00,000 with an estimated life of 8 years. The estimated salvage value of the equipment at the end of its lifetime is Rs. 20,000. Using declining balance method find its book value and depreciated amount for its service life at 20 % depreciation rate.

Solution:

$B_n = V(1- f_d)^n$

$d_n = V(1- f_d)^{n-1} f_d$

$f_d = 0.2$

For 8 th year

$d8 = \frac{20971.52-20000}{1}$

$=971.52$

End of the year	Depreciated amount, d_n ,(Rs)	Book Value, B_n
0	0	100000
1	20000	80000
2	16000	64000
3	12800	51200
4	10240	40960
5	8192	32768
6	6553.6	26214.4
7	5242.88	20971.52
8	~~4194.304~~ **971.52**	~~16777.22~~ **20000**

Example 2: A pump has an installed cost of Rs. 40,000 and a 10 year estimated life. The salvage value of the pump is zero at the end of 10 years. What is the pump value (in Rupees) after depreciation by the double declining balance method, at the end of 6 years? GATE 2007

Solution:

Double Declining-Balance depreciation method: $f_d = 2/N = 2/10 = 0.2$

$B_n = V(1- f_d)^n$ $B_6 = 40000(1- 0.2)^6 = 10485.76$ INR

$d_n = V(1- f_d)^{n-1} f$; $d = 40000(1-0.2)^5 \times 0.2 =$

Given:

- **Cost of the pump** = Rs. 40,000
- **Estimated life** = 10 years
- **Salvage value** = Rs. 0
- **Depreciation rate** = 2 × (1 / useful life) = 2 × (1 / 10) = 20%

Formula for Double Declining Balance Method:

Depreciation for the year = **Depreciation rate** × **Book value at the beginning of the year**

Year 1:

- Depreciation = 20% × Rs. 40,000 = Rs. 8,000
- Book value at the end of Year 1 = Rs. 40,000 - Rs. 8,000 = Rs. 32,000

Example 3: A process plant has a life of 7 years and its salvage value is 30%. For what minimum fixed- percentage factor will the depreciation amount for the second year, calculated by declining balance method be equal to that calculated by the straight line depreciation method? (GATE 2011)

Solution:

Straight line method, $d = \frac{V - V_s}{N} = \frac{V - 0.3V}{7} = 0.1\ V$

Declining balance method, $d_2 = V(1- f_d)\ f_d$

Therefore

$V(1- f_d)\ f_d = 0.1V$

f^2 -f+0.1 =0

Solving for f

F = 0.887 or 0.113

$f_d \leq \frac{2}{N} \leq 2/7 \leq 0.27$ → f =0.113

Sum-of-Years-Digits Method

- Sum-of-the-years digits (SOYD) depreciation is another accelerated cost recovery method for calculating depreciation that allows for more depreciation in the earlier years during the life of an asset.
- The rate of depreciation charge for the first year is assumed as the highest and then it decreases.
- The annual depreciation rate is computed by adding up all of the integers from 1 to N (depreciable life of plant/asset) and then taking a fraction of that each year.
- For example, if the plant's depreciable life is N = 5 years, then
  the sum-of-years digits is: 1 + 2 + 3 + 4 + 5 = 15.

  Sum of 1 2 ....N = N(N+1)/2
  The rates of depreciation for all the years are as follows:
- First Year: 5/15
- Second Year = 4/15
- Third Year = 3/15
- Fourth Year = 2/15
- Fifth Year = 1/15

Sum-of-Years-Digits Method

For any year, the depreciation is calculated by multiplying the corresponding rate of depreciation with (V– Vs)

$$\text{SOYD Depreciation} = \frac{Years\ Remaining}{Sum\ of\ the\ years\ digits} \text{ x } (V - V_s)$$

Depreciation in the m th year

$$Dm = \frac{N-m+1}{\frac{N(N+1)}{2}} (V - V_s) = 2\,\frac{(N-m+1)}{N(N+1)} (V - V_s)$$

Book Value in m-th year

$$Bm = (V - V_s)\,\frac{(N-m)(N-m+1)}{N(N+1)} + V_s$$

Sum-of-Years-Digits Method

- The sum-of-years-digits (SOYD) depreciation method also assumes that the book value of the asset decreases at a decreasing rate.
- This method is an arbitrary method for determining depreciation, but larger amounts are allowed to depreciate during the early life of the property.
- This method does allow the purchase price to decrease to zero at the end of the service life.

Example 1: A company has purchased an equipment at a cost of Rs. 1,00,000 with an estimated life of 8 years. The estimated salvage value of the equipment at the end of its lifetime is Rs. 20,000. Using Soyd method find its book value and depreciated amount for its service life at 20 % depreciation rate.

Solution:

SOYD = N(N+1)/2

= 8*9/2 = 36

$$Dm = \frac{N-m+1}{\frac{N(N+1)}{2}}(V\text{-}Vs)$$

$$D_1 = \frac{8}{36}\,x\,(80000)$$

$$= 17777.77$$

$$D_2 = \frac{7}{36}\,x\,(80000)$$

$$= 15555.55$$

End of the year	d	Depreciated amount (Rs)	Book Value
0		0	100000
1	8/36	17,777	82222.23
2	7/36	15555.55	66666.68
3	6/36	13333.33	53333.35
4	5/36	11111.11	42222.24
5	4/36	8888.88	33333.36
6	3/36	6666.66	26666.70
7	2/36	4444.44	22222.26
8	1/36	2222.22	20000

Modified accelerated cost recovery system (MACRS)

- The Modified Accelerated Cost Recovery System (MACRS) is the primary method used in the United States for depreciating assets for tax purposes. It allows businesses to recover the cost of capital investments over a specified lifespan using accelerated depreciation methods.

Key Features of MACRS:

1. Accelerated Depreciation:

•Assets depreciate faster in the early years, reducing taxable income sooner.

•Uses **Declining Balance (DB)** methods, often **200% (Double Declining) or 150% DB**, and switches to **Straight-Line (SL)** when beneficial.

Modified accelerated cost recovery system (MACRS)

Asset Classifications:

Assets under MACRS are grouped into different **property classes** based on their expected useful life. These classifications determine the recovery period (how long the asset can be depreciated) for each type of asset.

Depreciation Methods:

•**General Depreciation System (GDS)**: The most common method under MACRS. Typically uses **accelerated depreciation**, specifically the **Double Declining Balance** (DDB) method, but switches to **Straight-Line** once the depreciation slows down.

•**Alternative Depreciation System (ADS)**: This method is used for specific types of property (e.g., certain properties used in farming or long-term property) and usually applies the **Straight-Line method** over a longer period than GDS.

Modified accelerated cost recovery system (MACRS)

Property Classes & Useful Life:

Under GDS, assets are classified into property classes based on their useful life, and each class has its own depreciation schedule. Common classes include:

- **3-year property**: Certain property like racehorses or special equipment.
- **5-year property**: Computers, office equipment, cars, and trucks.
- **7-year property**: Office furniture, industrial equipment, etc.
- **27.5-year property**: Residential rental property.
- **39-year property**: Non-residential real property (commercial buildings).

Modified accelerated cost recovery system (MACRS)

Example: Company XYZ purchases a piece of machinery for Rs. 1,50,000. The machinery has a useful life of 5 years and a salvage value of Rs. 15,000. The company will use MACRS for tax purposes. We will assume that the machinery falls under the 5-year property class for depreciation, and the IRS depreciation table for a 5-year asset using the General Depreciation System (GDS) applies.

1. Depreciable Amount:

The **depreciable amount** is the cost of the machinery minus its estimated **salvage value**.

Depreciable Amount=Cost of Machinery−Salvage Value

Depreciable Amount=1,50,000−15,000=1,35,000

Modified accelerated cost recovery system (MACRS)

2. **MACRS Depreciation Rates for 5-Year Property**:

For a **5-year property**, the **MACRS** depreciation rates using the **half-year convention** (which is the standard method) are as follows:

Year	Depreciation Rate (%)
1	20%
2	32%
3	19.2%
4	11.52%
5	11.52%
6	5.76%

Year 1 (Depreciation = 20%):

$$\text{Depreciation in Year 1} = 20\% \times 1,35,000 = 27,000$$

Year 2 (Depreciation = 32%):

$$\text{Depreciation in Year 2} = 32\% \times 1,35,000 = 43,200$$

Year 3 (Depreciation = 19.2%):

$$\text{Depreciation in Year 3} = 19.2\% \times 1,35,000 = 25,920$$

Year 4 (Depreciation = 11.52%):

$$\text{Depreciation in Year 4} = 11.52\% \times 1,35,000 = 15,552$$

Year 5 (Depreciation = 11.52%):

$$\text{Depreciation in Year 5} = 11.52\% \times 1,35,000 = 15,552$$

Year 6 (Depreciation = 5.76%):

$$\text{Depreciation in Year 6} = 5.76\% \times 1,35,000 = 7,776$$

4. Calculate Book Value at the End of Each Year:

We will subtract the depreciation for each year from the initial **cost of Rs. 1,50,000** to find the **book value** at the end of each year.

Year	Depreciation (Rs.)	Accumulated Depreciation (Rs.)	Book Value (Rs.)
1	27,000	27,000	1,50,000 - 27,000 = 1,23,000
2	43,200	27,000 + 43,200 = 70,200	1,23,000 - 43,200 = 79,800
3	25,920	70,200 + 25,920 = 96,120	79,800 - 25,920 = 53,880
4	15,552	96,120 + 15,552 = 1,11,672	53,880 - 15,552 = 38,328
5	15,552	1,11,672 + 15,552 = 1,27,224	38,328 - 15,552 = 22,776
6	7,776	1,27,224 + 7,776 = 1,35,000	22,776 - 7,776 = 15,000 (Salvage Value)

General depreciation system
Applicable depreciation method: 200 or 150 percent
Declining balance switching to straight-line method
Applicable recovery periods: 3, 5, 7, 10, 15, 20 years
Applicable convention: half-year

Recovery year	Recovery period					
	3-year	5-year	7-year	10-year	15-year	20-year
	Depreciation rate, %					
1	33.33	20.00	14.29	10.00	5.00	3.750
2	44.45	32.00	24.49	18.00	9.50	7.219
3	14.81	19.20	17.49	14.40	8.55	6.677
4	7.41	11.52	12.49	11.52	7.70	6.177
5		11.52	8.93	9.22	6.93	5.713
6		5.76	8.92	7.37	6.23	5.285
7			8.93	6.55	5.90	4.888
8			4.46	6.55	5.90	4.522
9				6.56	5.91	4.462
10				6.55	5.90	4.461
11				3.28	5.91	4.462
12					5.90	4.461
13					5.91	4.462
14					5.90	4.461
15					5.91	4.462
16					2.95	4.461
17						4.462
18						4.461
19						4.462
20						4.461
21						2.231

†Source: *2000 U.S. Master Tax Guide.*

Other methods:

Units of Production method: Units-of-Production Depreciation is based on the number of units of production (output) and the useful life of an asset in terms of production (units, tons, feet, meters, cubic yards, cubic meters, hours, or mileage)

$$\textbf{Depreciation} = \frac{No.of\ units\ consumed\ or\ produced\ in\ n\ th\ year}{Total\ units\ (in\ life)} (V- V_S)$$

- Assume a Rs. 2,000,000 asset with neglegible salvage value.
- In its Lifetime it produces 2,400,000 units. For a monthly production of 12,000.
- Monthly depreciation = (12,000/2,400,000)*2,000,000 = Rs 10,000
- The depreciation calculation will fluctuate as the monthly production changes over the life of the asset.

Home work

A car is bought for Rs. 10,000,000 in 2020 and its salvage value is 1,00,000 in 2030. Tabulate the depreciation amount of the car for its useful life of 10 years using

1. Straight line method
2. Double declining method
3. Sum of digits methods.

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Thank you