CHEMICAL ENGINEERING DESIGN & SAFETY

CHE 4253

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Process Engineering Economics

2-Equipment Cost Estimation, Depreciation & Product Cost

EQUIPMENT COST (E)

Expressed as the cost of the equipment delivered to the site + the cost of installation. Sometimes comes separate.

Expressed as a function of equipment capacity.

$E = a\ CI^b$

Sometimes $E = c + a\ CI^b$

CI: equipment capacity indicator (Areas, diameters, number of trays, power)

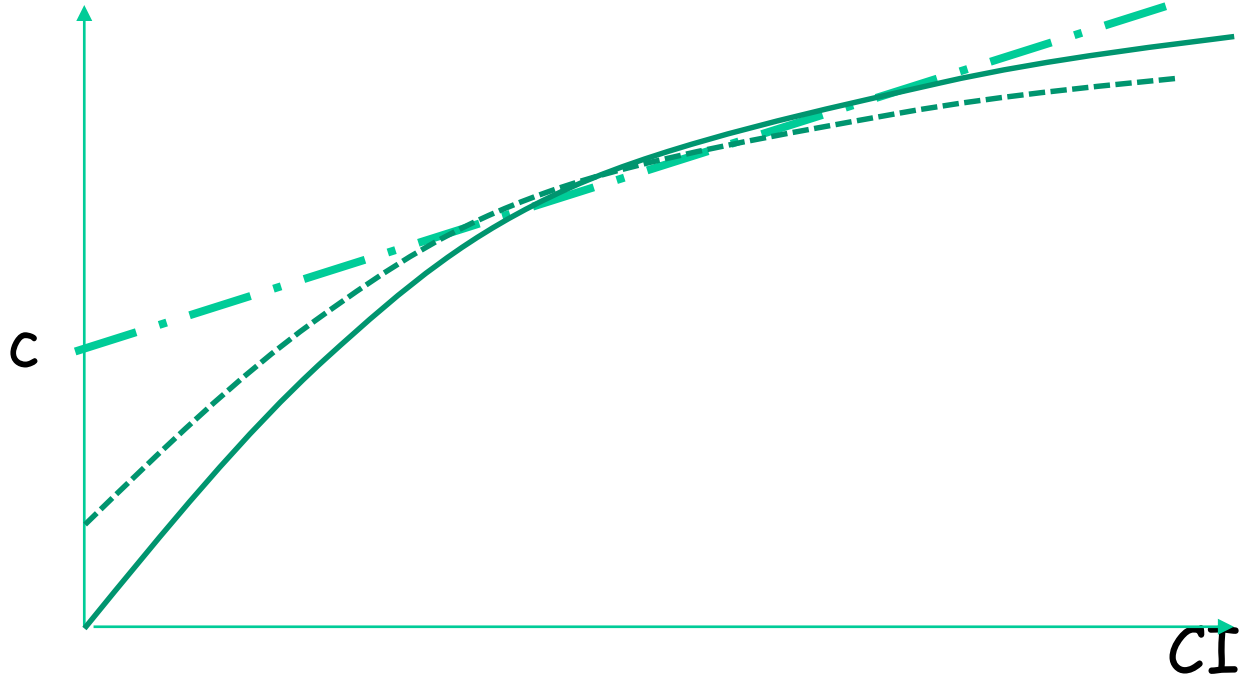
a: Cost coefficient b: Scaling c: Fixed cost

EQUIPMENT COST (E)

Expressed as a function of equipment capacity

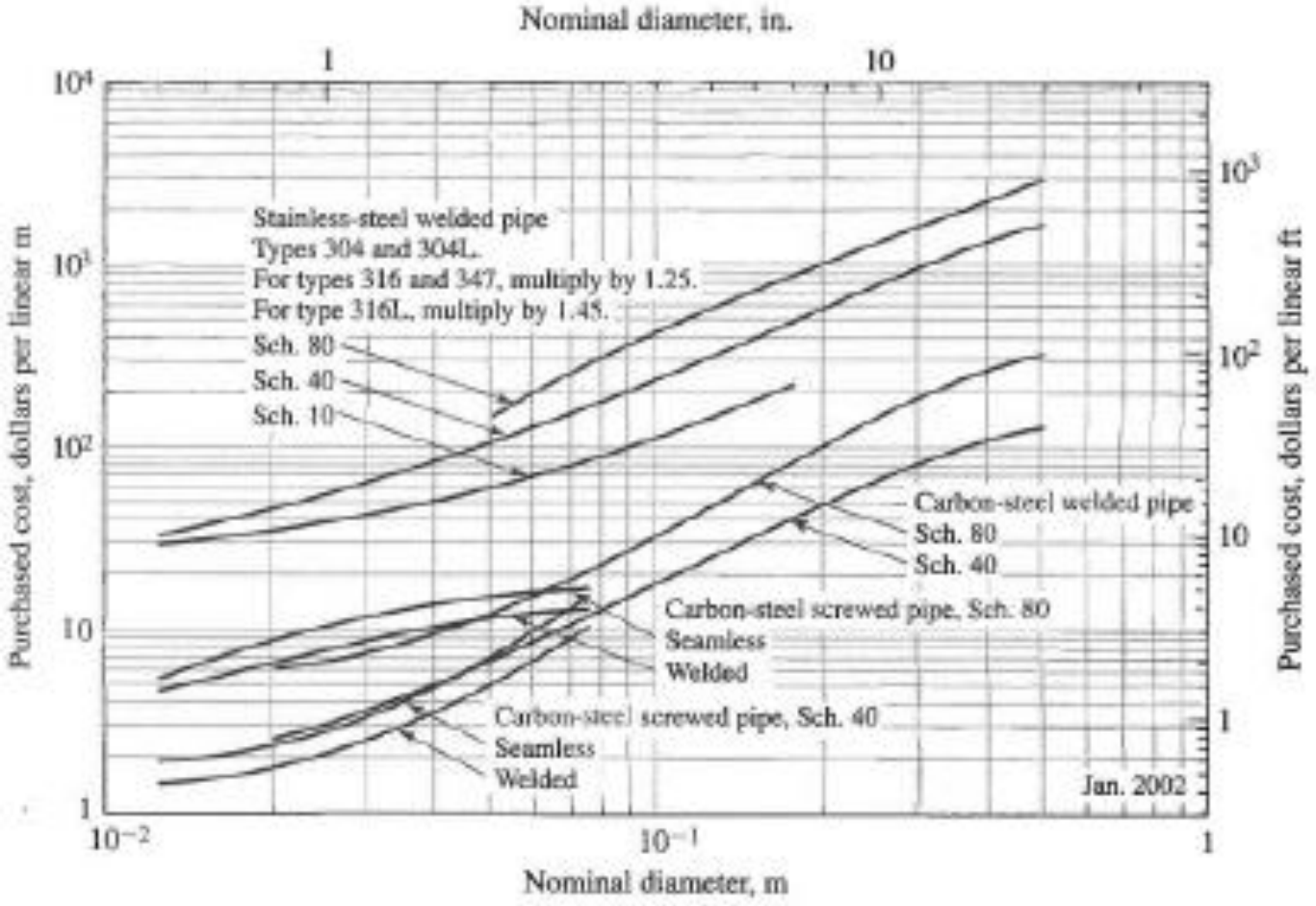
$E = a\ CI^b$

$E = c + a\ CI^b$



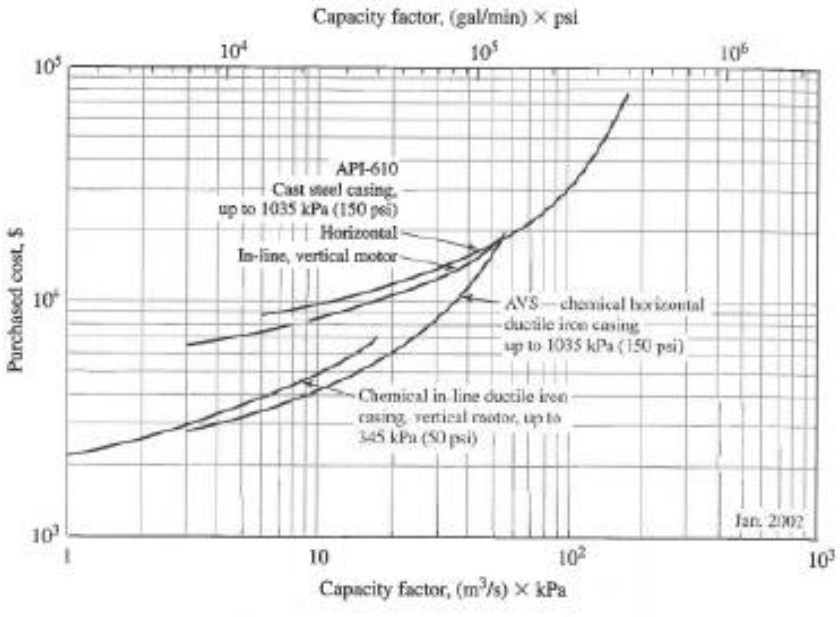
EQUIPMENT COST (E)

PIPING:

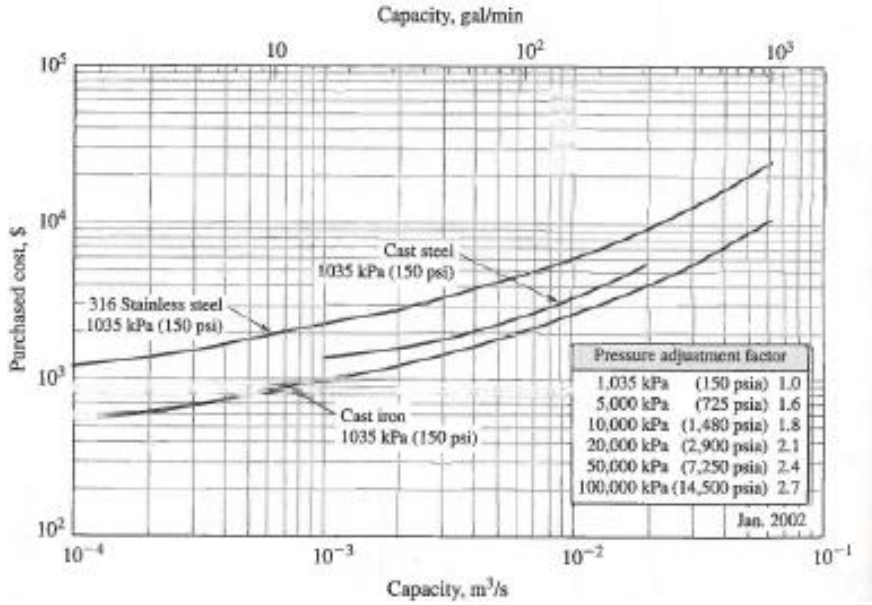


EQUIPMENT COST (E)

PUMPS:



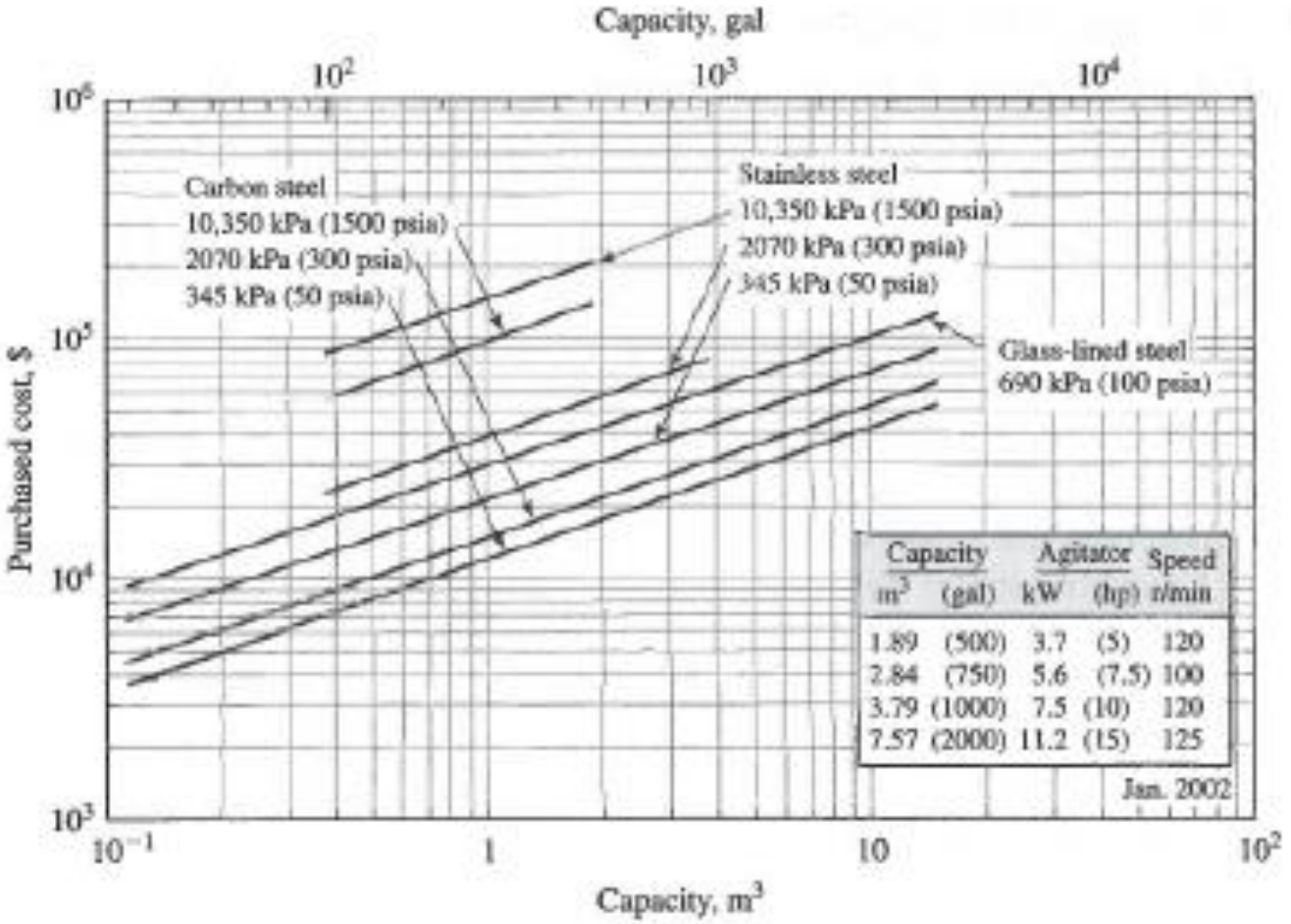
Centrifugal



Reciprocating

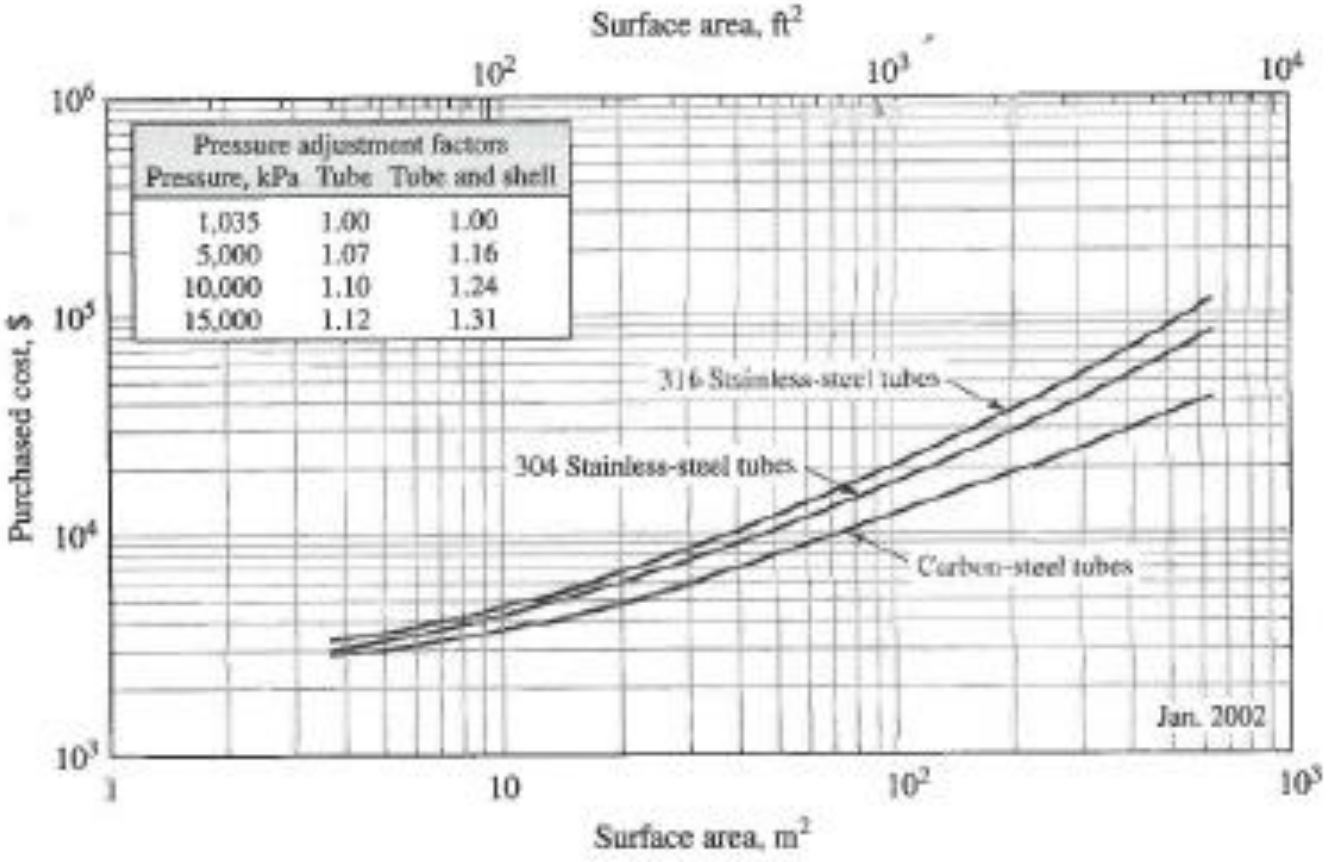
EQUIPMENT COST (E)

REACTORS:



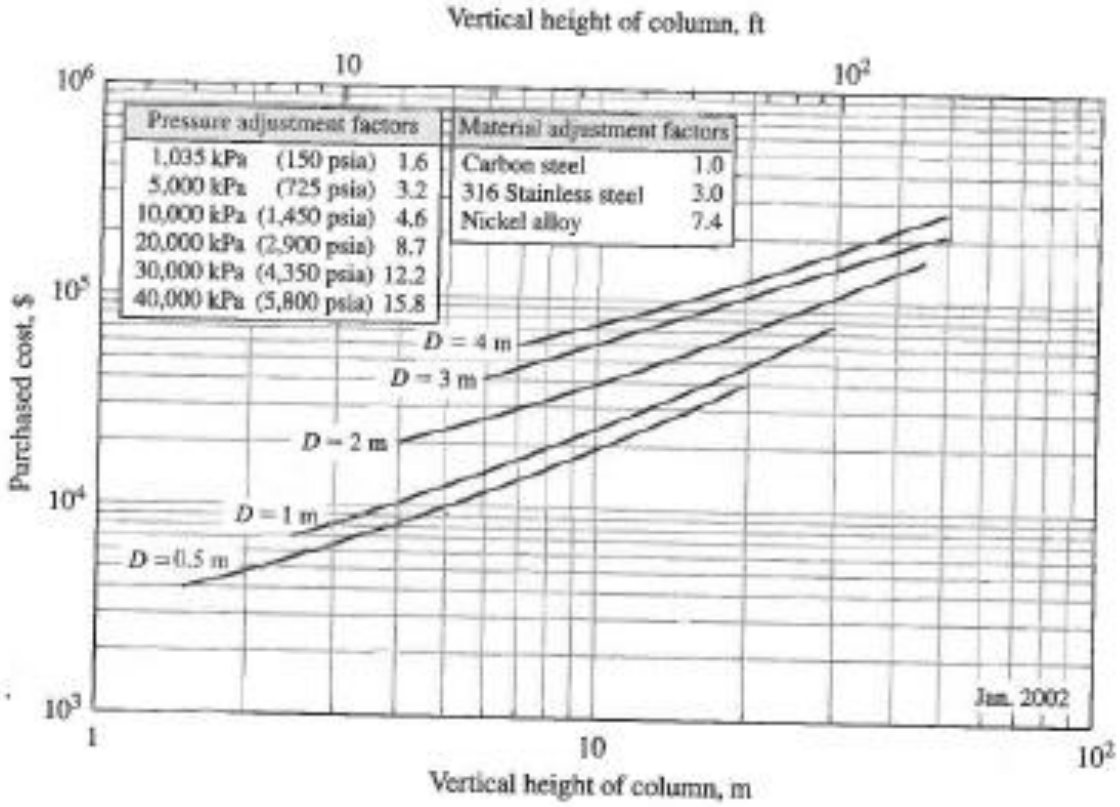
EQUIPMENT COST (E)

HEAT EXCHANGERS



EQUIPMENT COST (E)

COLUMNS



EQUIPMENT COST (E)

Exponent b in $E = a C_i^b$

Table 6-4 Typical exponents for equipment cost as a function of capacity

Equipment	Size range	Exponent
Blender, double cone rotary, carbon steel (c.s.)	1.4–7.1 m^3 (50–250 ft^3)	0.49
Blower, centrifugal	0.5–4.7 m^3/s (10^3–10^4 ft^3/min)	0.59
Centrifuge, solid bowl, c.s.	7.5–75 kW (10–10^2 hp) drive	0.67
Crystallizer, vacuum batch, c.s.	15–200 m^3 (500–7000 ft^3)	0.37
Compressor, reciprocating, air-cooled, two-stage, 1035-kPa discharge	0.005–0.19 m^3 (10–400 ft^3/min)	0.69
Compressor, rotary, single-stage, sliding vane, 1035-kPa discharge	0.05–0.5 m^3/s (10^2–10^3 ft^3/min)	0.79
Dryer, drum, single vacuum	1–10 m^2 (10–10^2 ft^2)	0.76
Dryer, drum, single atmospheric	1–10 m^2 (10–10^2 ft^2)	0.40
Evaporator (installed), horizontal tank	10–1000 m^2 (10^2–10^4 ft^2)	0.54
Fan, centrifugal	0.5–5 m^3/s (10^3–10^4 ft^3/min)	0.44
Fan, centrifugal	10–35 m^3/s (2×10^4–7×10^4 ft^3/min)	1.17
Heat exchanger, shell-and-tube, floating head, c.s.	10–40 m^2 (100–400 ft^2)	0.60
Heat exchanger, shell-and-tube, fixed sheet, c.s.	10–40 m^2 (100–400 ft^2)	0.44
Kettle, cast-iron, jacketed	1–3 m^3 (250–800 gal)	0.27
Kettle, glass-lined, jacketed	0.8–3 m^3 (200–800 gal)	0.31
Motor, squirrel cage, induction, 440-V, explosion-proof	4–15 kW (5–20 hp)	0.69
Motor, squirrel cage, induction, 440-V, explosion-proof	15–150 kW (20–200 hp)	0.99
Pump, reciprocating, horizontal cast-iron (includes motor)	1×10^{-4}–6×10^{-3} m^3/s (2–100 gpm)	0.34
Pump, centrifugal, horizontal, cast steel (includes motor)	4–40 m^3/s·kPa (10^4–10^5 gpm·psi)	0.33
Reactor, glass-lined, jacketed (without drive)	0.2–2.2 m^3 (50–600 gal)	0.54
Reactor, stainless steel, 2070-kPa	0.4–4.0 m^3 (10^2–10^3 gal)	0.56
Separator, centrifugal, c.s.	1.5–7 m^3 (50–250 ft^3)	0.49
Tank, flat head, c.s.	0.4–40 m^3 (10^2–10^4 gal)	0.57
Tank, c.s., glass-lined	0.4–4.0 m^3 (10^2–10^3 gal)	0.49
Tower, c.s.	5×10^2–10^6 kg (10^3–2×10^6 lb)	0.62
Tray, bubble cap, c.s.	1–3 m (3–10 ft) diameter	1.20
Tray, sieve, c.s.	1–3 m (3–10 ft) diameter	0.86

DEPRECIATION

Reduction in value due to any causes.

Example: Pump

Cost :	C_V= \$12,000
Scrap value :	V_S= \$2,000
Depreciation :	$C_V - V_S$ = \$10,000

For engineers, depreciation is considered as a cost for using the equipment.

DEPRECIATION

Types Of Depreciation

Physical: Wear and Tear, corrosion, accidents, age deterioration.

Functional: All other causes.

Obsolescence: Due to technological advances.

Depletion: Loss due to materials consumed. Applicable to Natural Resources (timber, mineral, oil deposits)

IRS: "A reasonable allowance for the exhaustion, wear and tear of property used in the trade or business including a reasonable allowance for obsolescence"

DEPRECIATION

Methods To Calculate Depreciation

1. *Straight Line Depreciation* :

Value decreases linearly in time.

$$D = (V - V_S)/n$$

D: Depreciation ($/year)
V : Original value
V_S: Salvage value.
n : Service life

Book Value :

$$V_a = V - a\,D$$

a : number of years of use.

Methods To Calculate Depreciation

2. *Multiple Straight Line Depreciation:*

Re-estimates the service life and salvage value at the end of every accounting period.

3. *Declining balance or Fixed % Method:*

Depreciation (D) is a fixed % of the property value at the beginning of the year.

Let f be the fixed % factor.

End of first year : $D_1 = V f$

$V_a = V - V f = V(1-f)$, $a = 1$

End of 2nd year : $D_2 = V(1-f) f$

$V_a = V(1-f)^2$, $a = 2$

Methods To Calculate Depreciation

3. *Declining balance or Fixed % Method:*

End of nth year : $D_n = V(1-f)^{n-1} f$

$V_a = V(1-f)^n = V_S$

==> $f = 1 - \left(\frac{V_S}{V}\right)^{1/n}$ (Matheson Formula)

Emphasis on salvage value. Not used. What if V_S=0 ?

Methods To Calculate Depreciation

4. *Double Declining Method:*

Tax laws allow for depreciation up to twice the value calculated from the straight line method.

$$f = 2/n$$

Consider n=10. Then f=2/10

After 5 years:

$$V_a = V(1-f)^5$$

and $(V_a / V) = (1-0.2)^5 \sim 0.32$

Approximately 2/3 is written off after 1/2 life if n=10.

Methods To Calculate Depreciation

4. *Double Declining Method:*

Book value as a percentage at half life:

n	$(1-2/n)^{n/2}$
4	0.25
6	0.29
8	0.31
10	0.32
20	0.35

5. *Combination Method*

The Combination Method assumes
first half-life : Double declining
Second half-life : Straight line

Methods To Calculate Depreciation

6. *Modified Accelerated Cost Recovery System (MACRS):*

It is essentially a combination method allowed by the IRS.

Uses double declining initially, and then switches to straight line.

When does the switch happen? When f for straight line is higher than f for double declining! (This is the IRS!)

Half year convention: In the first year only half of the double declining method depreciation is allowed. As a result, the process is depreciated half a year after its economic life!

(This is the IRS!)

MACRS- Example (see Table 9.2, in TBW&S):

PRODUCT COST

RECIPE

Raw materials	
Operating labor	
Operating supervision	
Utilities	
Electricity	
Fuel	
Refrigeration	
Steam	
Waste treatment and disposal	
Water, process	
Water, cooling	
Maintenance and repairs	
Operating supplies	
Laboratory charges	
Royalties (if not on lump-sum basis)	
Catalysts and solvents	
	Subtotal: Variable production costs
Depreciation	
Taxes (property)	
Financing (interest)	
Insurance	
Rent	
	Subtotal: Fixed charges
Medical	
Safety and protection	
General plant overhead	
Payroll overhead	
Packaging	
Restaurant	
Recreation	
Salvage	
Control laboratories	
Plant superintendence	
Storage facilities	
	Subtotal: Plant overhead costs
	Total of above = Manufacturing costs
Executive salaries	
Clerical wages	
Engineering	
Legal costs	
Office maintenance	
Communications	
	Subtotal: Administrative expenses
Sales offices	
Sales personnel expenses	
Shipping	
Advertising	
Technical sales service	
	Subtotal: Distribution and marketing expenses
Research and development	
	Total of administrative, distribution and marketing, R&D = General expenses
	Total of all above = Total product cost

Careful with
- Utilities
- Depreciation
- Not all items apply

PRODUCT COST

RECIPE

Title: Date:

Product: Capacity, kg/h:
Operating time, h/yr: Capacity, kg/s:
Capacity, kg/yr: Fixed Capital Investment (FCI)

	Suggested factor	User variables: Rate or quantity per year	User variables: Cost per rate or quantity unit		Calculated values, $M
Raw materials					
1					
2					
3					
4				Total	
Operating labor†					
Operating supervision	0.15	of operating labor			
Utilities†					
Water					
Cooling					
Process					
Electricity					
Fuel					
Refrigeration					
Steam					
Waste treatment and disposal					
Maintenance and repairs	0.07	of FCI			
Operating supplies	0.15	of maintenance and repairs			
Laboratory charges	0.15	of operating labor			
Royalties (if not on lump-sum basis)	0.04	of TPC without depreciation			
Catalysts and solvents					
				Total variable production costs	
Depreciation—calculated separately below					
Taxes (property)	0.02	of FCI			
Financing (interest)	0.00	of FCI			
Insurance	0.01	of FCI			
Rent	0.00	of FCI			
				Fixed charges (without depreciation)	
				Plant overhead costs	
				Administrative costs	
				Distribution + marketing costs	
				Research and development	
				General expenses	
				Total product cost (without depreciation)	