

ENGINEERING ECONOMY

COST CONCEPTS AND DESIGN ECONOMICS

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COST ESTIMATING

Used to describe the process by which the present and future cost consequences of engineering designs are forecast

COST ESTIMATING USED TO

- Provide information used in setting a selling price for quoting, bidding, or evaluating contracts
- Determine whether a proposed product can be made and distributed at a profit (EG: $\text{price} = \text{cost} + \text{profit}$)
- Evaluate how much capital can be justified for process changes or other improvements
- Establish benchmarks for productivity improvement programs

COST ESTIMATING APPROACHES

Top-down Approach
Bottom-up Approach

TOP-DOWN APPROACH

- Uses historical data from similar engineering projects
- Used to estimate costs, revenues, and other parameters for current project
- Modifies original data for changes in inflation / deflation, activity level, weight, energy consumption, size, etc...
- Best use is early in estimating process

BOTTOM-UP APPROACH

- More detailed cost-estimating method
- Attempts to break down project into small, manageable units and estimate costs, etc....
- Smaller unit costs added together with other types of costs to obtain overall cost estimate
- Works best when detail concerning desired output defined and clarified

CASH COST VERSUS BOOK COST

- Cash cost is a cost that involves payment in cash and results in cash flow;
- Book cost or noncash cost is a payment that does not involve cash transaction; book costs represent the recovery of past expenditures over a fixed period of time;
- Depreciation is the most common example of book cost; depreciation is what is charged for the use of assets, such as plant and equipment; depreciation is not a cash flow;

SUNK COST AND OPPORTUNITY COST

- A sunk cost is one that has occurred in the past and has no relevance to estimates of future costs and revenues related to an alternative course of action;
- An opportunity cost is the cost of the best rejected
- (i.e., foregone) opportunity and is hidden or implied;

LIFE-CYCLE COST

- **Life-cycle cost is the summation of all costs, both recurring and nonrecurring, related to a product, structure, system, or service during its life span.**
- **Life cycle begins with the identification of the economic need or want (the requirement) and ends with the retirement and disposal activities.**

PHASES OF THE LIFE CYCLE

PHASE	STEP	COST
Acquisition	Needs Assessment	Rising at increasing rate
	Conceptual design	Rising at increasing rate
	Detailed Design	Rising at decreasing rate
Operation	Production/Construction	Rising at decreasing rate
	Operation/Customer Use	Constant
	Retirement/Disposal	Constant

CAPITAL AND INVESTMENT

- Investment Cost or capital investment is the capital (money) required for most activities of the acquisition phase;
- Working Capital refers to the funds required for current assets needed for start-up and subsequent support of operation activities;
- Operation and Maintenance Cost includes many of the recurring annual expense items associated with the operation phase of the life cycle;
- Disposal Cost includes non-recurring costs of shutting down the operation;

FIXED, VARIABLE, AND INCREMENTAL COSTS

- Fixed costs are those unaffected by changes in activity level over a feasible range of operations for the capacity or capability available.
- Typical fixed costs include insurance and taxes on facilities, general management and administrative salaries, license fees, and interest costs on borrowed capital.
- When large changes in usage of resources occur, or when plant expansion or shutdown is involved fixed costs will be affected.

FIXED, VARIABLE AND INCREMENTAL COSTS

- Variable costs are those associated with an operation that vary in total with the quantity of output or other measures of activity level.
- Example of variable costs include : costs of material and labor used in a product or service, because they vary in total with the number of output units -- even though costs per unit remain the same.

RECURRING AND NONRECURRING COSTS

- Recurring costs are repetitive and occur when a firm produces similar goods and services on a continuing basis.
- Variable costs are recurring costs because they repeat with each unit of output .
- A fixed cost that is paid on a repeatable basis is also a recurring cost:
 - Office space rental

RECURRING AND NONRECURRING COSTS

- **Nonrecurring costs are those that are not repetitive, even though the total expenditure may be cumulative over a relatively short period of time;**
- **Typically involve developing or establishing a capability or capacity to operate;**
- **Examples are purchase cost for real estate upon which a plant will be built, and the construction costs of the plant itself;**

DIRECT, INDIRECT AND OVERHEAD COSTS

- Direct costs can be reasonably measured and allocated to a specific output or work activity -- labor and material directly allocated with a product, service or construction activity;
- Indirect costs are difficult to allocate to a specific output or activity -- costs of common tools, general supplies, and equipment maintenance ;

DIRECT, INDIRECT AND OVERHEAD COSTS

- Overhead consists of plant operating costs that are not direct labor or material costs
 - indirect costs, overhead and burden are the same;
- Prime Cost is a common method of allocating overhead costs among products, services and activities in proportion the sum of direct labor and materials cost ;

STANDARD COSTS

Representative costs per unit of output that are established in advance of actual production and service delivery;

<u>Standard Cost Element</u>	<u>Sources of Data</u>
Direct Labor	Process routing sheets, + standard times, standard labor rates;
Direct Material	Material quantities per + unit, standard unit materials cost;
Factory Overhead Costs	Total factory overhead costs allocated based on prime costs;

SOME STANDARD COST USES

- **Estimating future manufacturing or service delivery costs;**
- **Measuring operating performance by comparing actual cost per unit with the standard unit cost;**
- **Preparing bids on products or services requested by customers;**
- **Establishing the value of work-in-process and finished inventories;**

FIXED, VARIABLE AND INCREMENTAL COSTS

incremental cost is the additional cost that results from increasing the output of a system by one (or more) units.

Incremental cost is often associated with “go / no go” decisions that involve a limited change in output or activity level.

EXAMPLE

the incremental cost of driving an automobile might be \$0.27 / mile. This cost depends on:

- mileage driven;
- mileage expected to drive;
- age of car;

CONSUMER GOODS AND PRODUCER GOODS AND SERVICES

Consumer goods and services are those that are directly used by people to satisfy their wants;

Producer goods and services are those used in the production of consumer goods and services: machine tools, factory buildings, buses and farm machinery are examples;

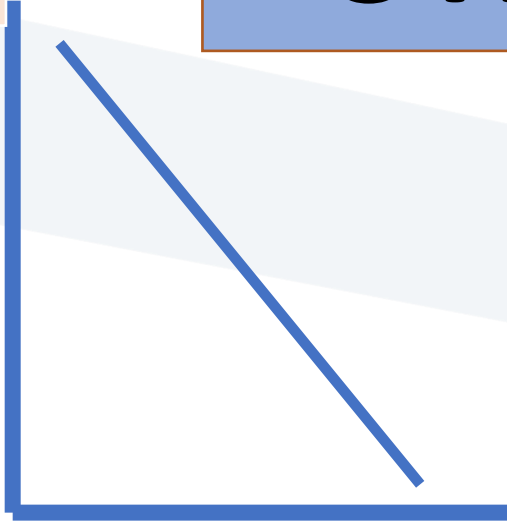
UTILITY AND DEMAND

Utility is a measure of the value which consumers of a product or service place on that product or service;

Demand is a reflection of this measure of value, and is represented by price per quantity of output;

UTILITY AND DEMAND

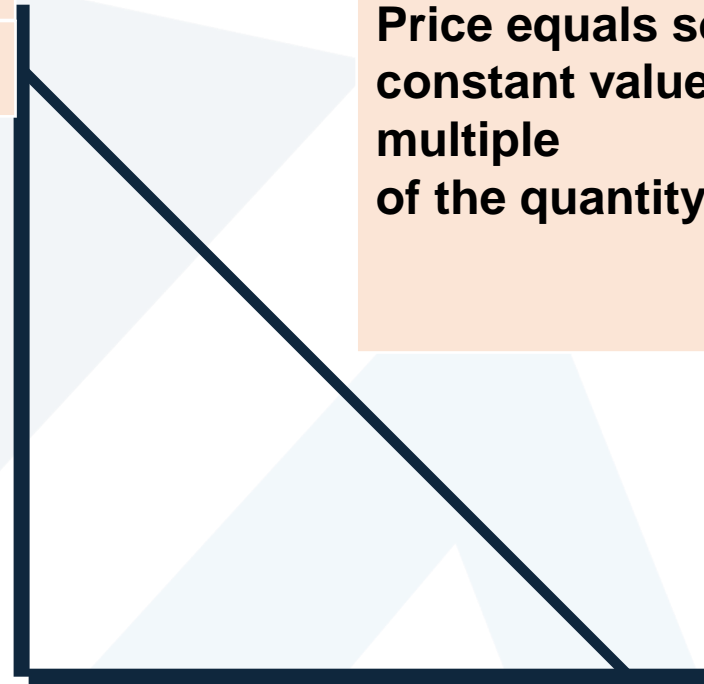
PRICE



QUANTITY (OUTPUT)

PRICE

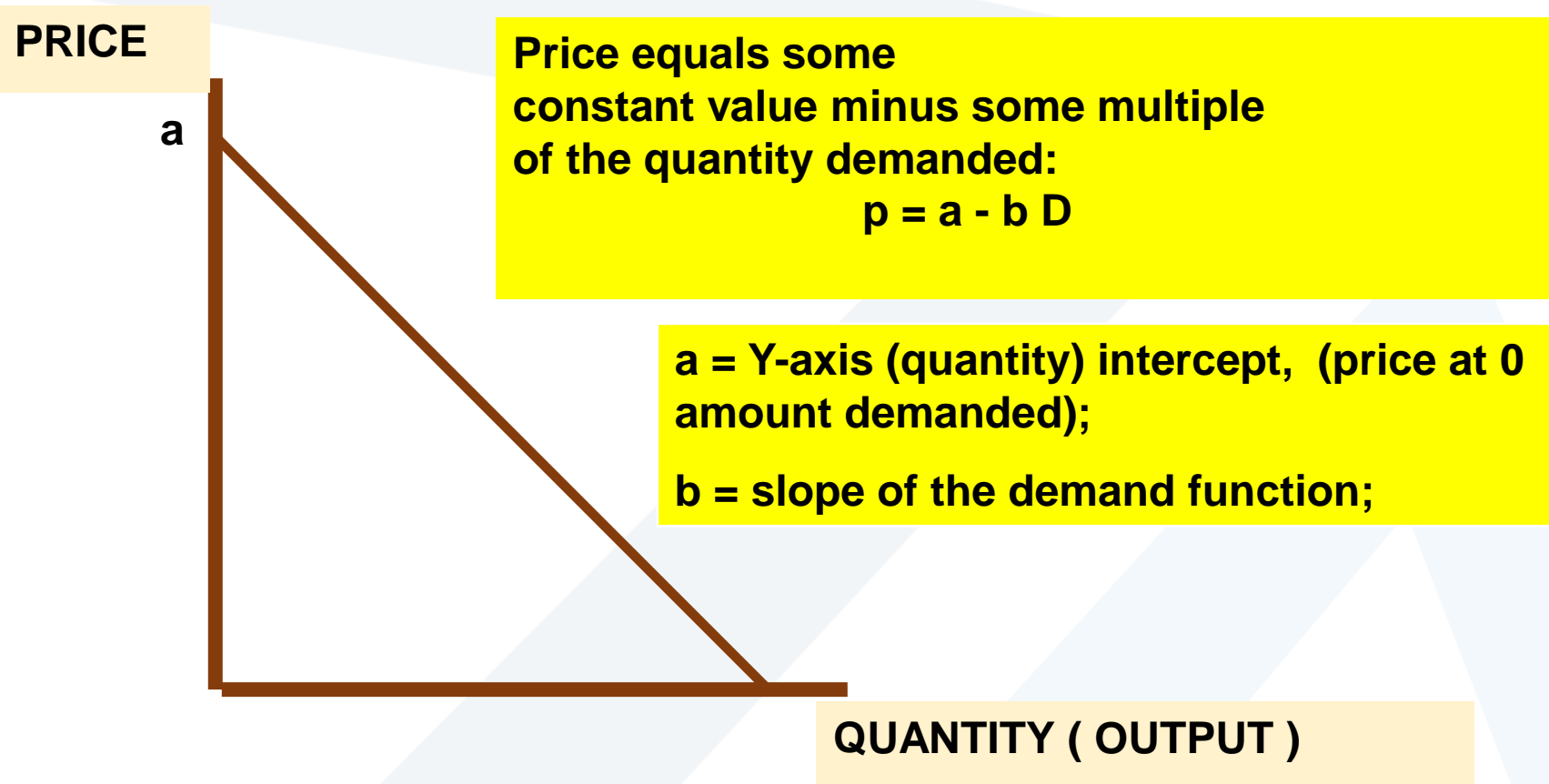
a



Price equals some constant value minus some multiple of the quantity demanded:
 $p = a - b D$

QUANTITY (OUTPUT)

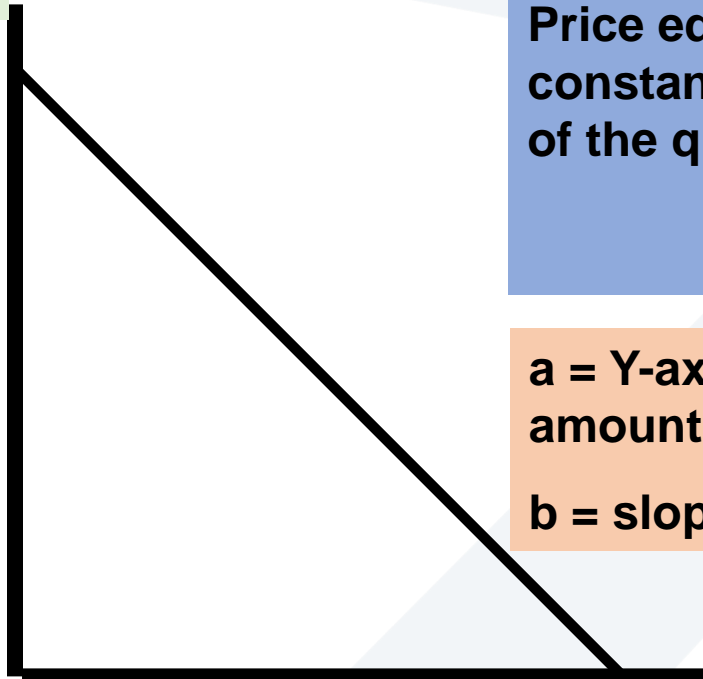
UTILITY AND DEMAND



UTILITY AND DEMAND

PRICE

a



Price equals some constant value minus some multiple of the quantity demanded:

$$p = a - b D$$

a = Y-axis (quantity) intercept, (price at 0 amount demanded);

b = slope of the demand function;

$$D = (a - p) / b$$

QUANTITY (OUTPUT)

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PRICE

QUANTITY (OUTPUT)

$$\text{Total Revenue} = p \times D$$

$$= (a - bD) \times D$$

QUANTITY (OUTPUT)

PRICE

a

$\epsilon > 1$

Price equals some constant value minus some multiple of the quantity demanded:

$$p = a - b D$$

$\epsilon = 1$

a = Y-axis (quantity) intercept, (price at 0 amount demanded);

b = slope of the demand function;

$\epsilon < 1$

$$D = (a - p) / b$$

PRICE

MR=0

QUANTITY (OUTPUT)

$$MR = dTR / dD = a - 2bD = 0$$

Total Revenue = p x D

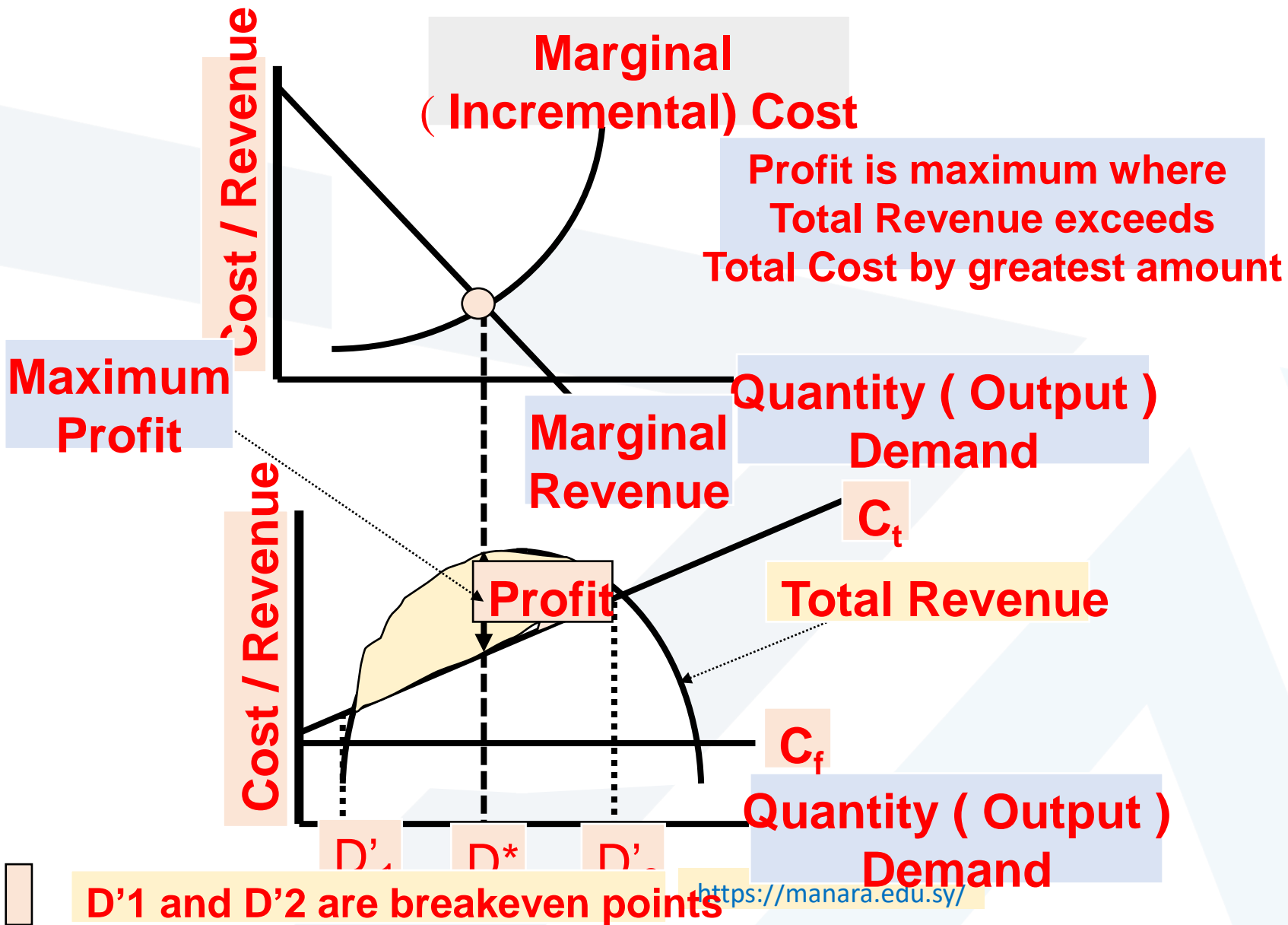
TR = Max

$$\text{Total Revenue} = p \times D$$

$$= (a - bD) \times D$$

$$= aD - bD^2$$

QUANTITY (OUTPUT)



PROFIT MAXIMIZATION

D^*

- Occurs where total revenue exceeds total cost by the greatest amount;
- Occurs where marginal cost = marginal revenue;
- Occurs where $dTR/dD = dC_t/dD$;
- $D^* = [a - b (C_v)] / 2$

BREAKEVEN POINT

D'_1 and D'_2

D'_1 and D'_2

- Occurs where $TR = C_t$
- $(aD - D^2) / b = C_f + (C_v) D$
- $- D^2 / b + [(a / b) - C_v] D - C_f$
- Using the quadratic formula: $D' =$
 $- [(a / b) - C_v] \pm \{ [(a / b) - C_v]^2 - (4 / b) (- C_f) \}^{1/2}$

COST-DRIVEN DESIGN OPTIMIZATION

- Must maintain a life-cycle design perspective
- Ensures engineers consider:
- Initial investment costs
- Operation and maintenance expenses
- Other annual expenses in later years
- Environmental and social consequences over design life

DESIGN FOR THE ENVIRONMENT (DFE)

- This green-engineering approach has the following goals:
- Prevention of waste
- Improved materials selection
- Reuse and recycling of resources

COST-DRIVEN DESIGN OPTIMIZATION PROBLEM TASKS

1. Determine optimal value for certain alternative's design variable
2. Select the best alternative, each with its own unique value for the design variable

COST-DRIVEN DESIGN OPTIMIZATION PROBLEM COST TYPES

1. Fixed cost(s)
2. Cost(s) that vary *directly* with the design variable
3. Cost(s) that vary *indirectly* with the design variable

Simplified Format of Cost Model With One Design Variable

$$\text{Cost} = aX + (b / X) + k$$

- a is a parameter that represents directly varying cost(s)
- b is a parameter that represents indirectly varying cost(s)
- k is a parameter that represents the faced cost(s)
- X represents the design variable in question

(In a particular problem, the parameters a, b and k may actually represent the sum of a group of costs in that category, and the design variable may be raised to some power for either directly or indirectly varying costs.)

GENERAL APPROACH FOR OPTIMIZING A DESIGN WITH RESPECT TO COST

1. Identify primary cost-driving design variable
2. Write an expression for the cost model in terms of the design variable
3. Set first derivative of cost model with respect to continuous design variable equal to 0. (For discrete design variables, compute cost model for each discrete value over selected range).
4. Solve equation in step 3 for optimum value of continuous design variables
5. For continuous design variables, use the second derivative of the cost model with respect to the design variable to determine whether optimum corresponds to global maximum or minimum.

PRESENT ECONOMY STUDIES

When alternatives for accomplishing a task are compared for one year or less (i.e., influence of time on money is irrelevant)

Rules for Selecting Preferred Alternative

Rule 1 – When revenues and other economic benefits are present and vary among alternatives, choose alternative that maximizes overall profitability based on the number of defect-free units of output

Rule 2 – When revenues and economic benefits are not present or are constant among alternatives, consider only costs and select alternative that minimizes total cost per defect-free output

PRESENT ECONOMY STUDIES

Total Cost in Material Selection

In many cases, selection of among materials cannot be based solely on costs of materials. Frequently, change in materials affect design, processing, and shipping costs.

Alternative Machine Speeds

Machines can frequently be operated at different speeds, resulting in different rates of product output. However, this usually results in different frequencies of machine downtime. Such situations lead to present economy studies to determine preferred operating speed.

PRESENT ECONOMY STUDIES

Make Versus Purchase (Outsourcing) Studies

A company may choose to produce an item in house, rather than purchase from a supplier at a price lower than production costs if:

1. direct, indirect or overhead costs are incurred regardless of whether the item is purchased from an outside supplier, and
2. The incremental cost of producing the item in the short run is less than the supplier's price

The relevant short-run costs of the make versus purchase decisions are the incremental costs incurred and the opportunity costs of resources

PRESENT ECONOMY STUDIES

Make Versus Purchase (Outsourcing) Studies

Opportunity costs may become significant when in-house manufacture of an item causes other production opportunities to be foregone (E.G., insufficient capacity)

In the long run, capital investments in additional manufacturing plant and capacity are often feasible alternatives to outsourcing.