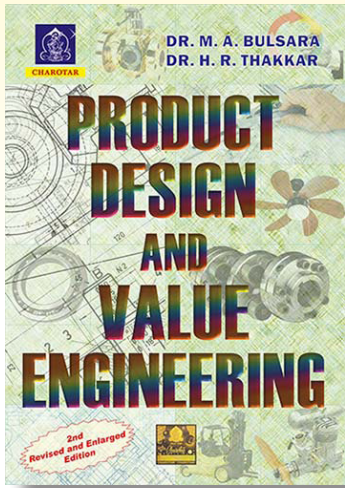


# PRODUCT DESIGN AND VALUE ENGINEERING



REVISED  
& ENLARGED

By

Dr. M. A. Bulsara and Dr. H. R. Thakkar

Edition : 2<sup>nd</sup> Revised and Enlarged Edition : 2015  
ISBN : 9789385039140  
Binding : Paperback  
Pages : 280 + 16 = 296  
Size (mm) : 240 × 12 × 170  
Weight : 365 g



₹ 225.00 BUY

## ABOUT THE BOOK

The text-book aims at presenting the topics of *Product Design and Value Engineering* in a simple manner. Each topic of the book has been arranged in such a way that reader is empowered with in-depth knowledge in the subject.

This is thoroughly revised and extensively enlarged edition. One new chapter on Product Design has been added. Some of the topics relevant to the subject have been added and few have also been described elaborately.

First six chapters contain topics on Product Design and Product Development. Product Design and Product development is a challenging task and can be learnt through experience. Many good universities have incorporated this course to introduce the challenges and difficulties in product development process, to the students. A product can be developed at lowest possible cost if the process is planned systematically. Initial few chapters of the book cover systematic procedure for "Product Development" in detail, supported with relevant examples.

Subsequent five chapters of the book cover the Value Engineering concept. Value Engineering approach is used to eliminate the unnecessary cost from the product. The implementation of Value Engineering concept has been elaborately described as value engineering job plan along with value engineering project selection, FAST diagram and Life Cycle Cost with relevant case studies.

Last chapter deals with practical aspects of manufacturing, affecting the design considerations.

*The salient features of this book are:*

- \***Lucid description of Product Development process and Value Engineering Concept.**
- \***Illustrative examples within the text.**
- \***Comprehensive summary at the end of each chapter.**
- \***Exercise at the end of each chapter.**
- \***Solved sample papers (GTU).**
- \***Case studies of various products to illustrate product development process.**
- \***Value Engineering Training programme course.**
- \***Illustrative engineering drawings to understand design for manufacture.**

The book covers major syllabus of the subject Product Design and Value Engineering (Subject code 171904 for B.E. Semester VII of Mechanical Engineering branch) prescribed by Gujarat Technical University (GTU) and other Indian Universities. The book will also be of immense help to the practicing engineers.

## CONTENT

- 1: PRODUCT DESIGN
  - 2: PRODUCT DEVELOPMENT: A PREAMBLE
  - 3: PRODUCTS AND PRODUCT DEVELOPMENT PROCESSES
  - 4: PRODUCT DEVELOPMENT PLAN
  - 5: IDENTIFYING CUSTOMER NEEDS
  - 6: DECIDING PRODUCT SPECIFICATIONS
  - 7: VALUE ENGINEERING: AN OVERVIEW
  - 8: VALUE ENGINEERING JOB PLAN
  - 9: VALUE ENGINEERING: PROJECT SELECTION AND VALUE STANDARD
  - 10: FAST DIAGRAM AND LIFE CYCLE COST
  - 11: INITIATING VALUE ENGINEERING PROGRAM
  - 12: DESIGN FOR MANUFACTURE
- ANNEXURE I : TYPICAL TRAINING PROGRAM FOR A 40-HOUR VALUE ENGINEERING TRAINING WORKSHOP COURSE
- ANNEXURE II : CASE STUDY: MARKET PULL PRODUCT \ DEVELOPMENT OF BICYCLE
- ANNEXURE III : PAPER SOLUTION OF PREVIOUS GTU EXAMINATIONS
- INDEX

Catalogue Checklist

**PRODUCT DESIGN AND VALUE ENGINEERING**  
**DETAILED CONTENTS**

**Chapter 1 PRODUCT DESIGN**

- 1-1. Introduction
- 1-2. Objective of product design
  - (1) Functionality
  - (2) Nature, characteristics of form
  - (3) Expressiveness
  - (4) User-object interaction
  - (5) Reliability, durability and maintainability
- 1-3. Types of Design
  - (1) Engineering Design
  - (2) Original design
  - (3) Adaptive design
  - (4) Redesign
  - (5) Selection design
  - (6) Industrial design
- 1-4. Phases in product design
  - 1-4-1. Concept design
  - 1-4-2. System level design
  - 1-4-3. Detailed design
- 1-5. Tools and Techniques for product design and development
  - 1-5-1. Concurrent engineering
  - 1-5-2. Quality Function Deployment
  - 1-5-3. Design for X
    - (1) Design for Manufacture
    - (2) Design for Assembly
    - (3) Design for Maintenance
    - (4) Design for Reliability
    - (5) Design for Stiffness
    - (6) Design for Rigidity
    - (7) Design for Aesthetics
    - (8) Design for Ergonomics
  - 1-5-4. Failure Modes and Effects Analysis (FMEA)
    - Step 1: Identify components and associated functions
    - Step 2: Identify failure modes
    - Step 3: Identify effects of the failure modes
    - Step 4: Identify cause(s) of the failure mode
  - 1-5-5. Computational techniques and tools
    - 1-5-5-1. Computer aided design (CAD)
    - 1-5-5-2. Finite Element Analysis (FEA)
    - 1-5-5-3. Computer aided systems
    - 1-5-5-4. Engineering / product data management system
    - 1-5-5-5. Knowledge based engineering
    - 1-5-5-6. Rapid prototyping
      - Laminated Object Manufacture (LOM)
  - 1-6. Importance of product design
  - 1-7. Overview
    - (1) Concurrent Engineering
    - (2) Quality Function Deployment
    - (3) Failure Mode and Effect Analysis
    - (4) Computer Aided design
    - (5) Finite Element Analysis
    - (6) Computer Aided Systems
  - Rapid Prototyping
  - Exercise 1

**Chapter 2 PRODUCT DEVELOPMENT: A PREAMBLE**

- 2-1. Introduction
- 2-2. Reasons for Product Development
- 2-3. Factors Affecting Product Development
  - (1) Changing needs of customer
  - (2) Technological advancement
  - (3) Economic development of country
  - (4) Competition in market
  - (5) Changes in government policies
- 2-4. Characteristics of successful product development
  - (1) Product function
  - (2) Product quality
  - (3) Product cost
  - (4) Development time
  - (5) Development cost
  - (6) Development capability
- 2-5. Design and Development of Product: A Team Work

- 2-6. Duration and Cost of Product Development
- 2-7. Challenges of Product Development
  - (1) Creativity
  - (2) Cost
  - (3) Ever changing customer needs
  - (4) Economics
  - (5) Time constraint
  - (6) Target customer segment
  - (7) Team selection
- 2-8. Evaluation of Product Development Process
- 2-9. Overview
- Exercise 2

**Chapter 3 PRODUCTS AND PRODUCT DEVELOPMENT PROCESSES**

- 3-1. Introduction
- 3-2. Product classification
  - (1) Based on users
  - (2) Based on engineering sciences
  - (3) Based on infrastructure available with organization
  - (4) Based on the technological requirement for product manufacturing
  - (5) Process intensive product
  - (6) Customized product
  - (7) High risk product
  - (8) Quick build product
  - (9) Complex product
- 3-3. Product Development Processes
- 3-4. A typical (generic) product development process
  - (1) Planning
  - (2) Concept development
  - (3) System level design
  - (4) Detailed design
  - (5) Prototype building / model simulation
  - (6) Prototype / simulated model testing
  - (7) Revisions and improvement
  - (8) Production
- 3-5. Advantages of systematic product development process
  - (1) Planning
  - (2) Coordination
  - (3) Time management
  - (4) Financial management
  - (5) Process monitoring
  - (6) Quality
- 3-6. Concept development (The front end process)
  - 3-6-1. Concept development activities
    - (1) Identifying customer needs
    - (2) Establishing target specifications
    - (3) Concept generation
    - (4) Concept selection
    - (5) Concept testing
    - (6) Finalizing concept and specifications
    - (7) Comparison with competitive products
    - (8) Economic analysis
    - (9) Modelling and prototyping
  - 3-6-2. Concept generation (development) techniques
    - 3-6-2-1. Brainstorming
    - 3-6-2-2. Brain Writing
      - (1) Brain Writing Pool
      - (2) Brain writing worksheet
    - 3-6-2-3. The Idea Game
    - 3-6-2-4. Morphological analysis
    - 3-6-2-5. Forced relationships
    - 3-6-2-6. Systems approach
    - 3-6-2-7. Varied perspectives
      - (1) White Hat
      - (2) Red Hat
      - (3) Black Hat
      - (4) Yellow Hat
      - (5) Green Hat
      - (6) Blue Hat
    - 3-6-2-8. Archival analysis
    - 3-6-2-9. Inventive Templates
    - 3-6-2-10. Synectics
      - (1) Deferment
      - (2) Autonomy of object
      - (3) Use of commonplace

**PRODUCT DESIGN AND VALUE ENGINEERING**  
**DETAILED CONTENTS**

- (4) Involvement/Detachment
  - (5) Use of metaphor
  - 3-7. Product development organization
  - 3-7-1. Structure of typical engineering organization
    - (1) Design, research and development department (What to produce?)
    - (2) Planning department (How to produce?)
    - (3) Manufacturing department (Produce)
    - (4) Inspection and quality control department (Quality Control)
    - (5) Purchase department (Procurement of raw material)
    - (6) Tool design department (Jig, fixture design)
    - (7) Servicing department (After sales services)
    - (8) Administration department (Managing human resource)
    - (9) Sales and Marketing Department (How much to produce?)
  - 3-7-2. Structure of Product development organizations
    - (1) Project oriented structure
    - (2) Function oriented structure
    - (3) Hybrid (matrix) structure organization
    - (4) Selecting an organization structure
    - (5) Requirement of cross-functional expertise
    - (6) Requirement of cutting-edge (advanced) functional expertise
    - (7) Utilization of experts for complete duration of project
    - (8) Project completion schedule
    - (9) Case study
    - (10) AMF development process
    - (11) The AMF organization structure
  - 3-8. Overview
    - (1) Brainstorming
    - (2) Brain writing
    - (3) The idea game
    - (4) Morphological analysis
    - (5) Forced relationship
    - (6) A systems approach
    - (7) Varied perspective
    - (8) Archival analysis
    - (9) Inventive templates
    - (10) Synectics
- Exercise 3

**Chapter 4 PRODUCT DEVELOPMENT PLAN**

- 4-1. Introduction
- 4-2. Product Life Cycle
- 4-3. New Product Development – NPD
- 4-3-1. New Product Development Funnel
- 4-3-2. Empathic design
- 4-4. Appropriate time for introducing new product
- 4-5. Planning the product development process
- 4-5-1. Proposing organization goal
- 4-5-2. Identify potential products
  - (1) Employees of the organization
  - (2) Senior officers of the organization
  - (3) Sales and marketing staff
  - (4) Magazines
  - (5) Competitors' product brochure
  - (6) Customer reviews
  - (7) Research and development organization
  - (8) Thrust areas identified by government
  - (9) Educational institutes
  - (10) Hiring specialist
  - (11) Crisis of natural resources
  - (12) Changing life style
- 4-5-3. Selection and Evaluation of project (product)
- 4-5-3-1. Selection of project (product)
  - (1) Technology consideration
  - (2) Technological development cycle
  - (3) Infrastructure consideration
  - (4) Market segment
  - (5) Demand
- 4-5-3-2. Evaluation of project (product)
  - (1) Project rating
  - (2) Ranking
  - (3) Simulated outcome
  - (4) Strategic cluster
  - (5) Interactive decision
- 4-5-4. Resource allocation

- 4-5-5. Deciding product dev. goals
  - 4-5-6. Review of product planning
  - 4-6. Overview
- Exercise 4

**Chapter 5 IDENTIFYING CUSTOMER NEEDS**

- 5-1. Introduction
    - (1) Product name
    - (2) Basic Function
    - (3) Outstanding features
    - (4) Business goal
    - (5) Financial constraint
    - (6) Market segment
    - (7) Customers
    - (8) Major constraints
    - (9) Expected selling price
    - (10) Time frame to introduce the product
    - (11) Use of existing resources and technology
  - 5-2. Gather information from customer
    - (1) Selection of customer
    - (2) Methods for gathering customer needs
    - (3) Eliciting customer needs
    - (4) Documentation of customer needs
      - (1) Audio recording
      - (2) Video Recording
      - (3) Text writing
  - 5-3. Interpretation of raw data
  - 5-4. Arrange customer needs based on hierarchy
  - 5-5. Establish significance of customers needs
  - 5-6. Trade-off in deciding importance of the needs
  - 5-7. Quality Function Deployment
    - (1) QFD and house of quality (HoQ)
    - (2) Steps in preparing of House of Quality (QFD)
- Case study 1  
QFD analysis for a Clothes Drying Stand  
Case study description
- (1) Enlist the customer needs
    - (i) Aesthetic and Ergonomic requirements
    - (ii) Performance requirements
  - (2) List the "Parameters affecting customer needs" (How these customer needs can be achieved?)
    - (i) Material selection
    - (ii) Manufacturing processes
  - (3) Develop a relationship matrix between what and how?:
  - (4) Develop an interrelationship matrix (Relation between hows?)
  - (5) Make competitive assessment of design attributes. (Rating of factors affecting design)
  - (6) These priorities indicate the direction / action to improve the products
- Case study 2  
QFD analysis for a ceiling fan
- 5-8. Advantages of QFD
  - 5-9. Review and Revision
  - 5-10. Overview
    - (1) Establishing the mission statement
    - (2) Gather information from customers
    - (3) Interpretation of raw data
    - (4) Trade-off in deciding importance of needs
    - (5) Review and revisions

Exercise 5

**Chapter 6 DECIDING PRODUCT SPECIFICATIONS**

- 6-1. Introduction
  - 6-1. Product Specification
  - 6-2. Establishing target specifications
    - (1) Prepare a list of measurable
    - (2) Collect competitors' data (Benchmarking)
    - (3) Set the range of target values
  - 6-3. Setting the final specifications
    - (1) Develop different concepts of design
    - (2) Calculate cost of product for alternative design
    - (3) Strike out final specification based on trade-off
  - 6-4. Review and Revisions
  - 6-5. Overview
- Exercise 6



**PRODUCT DESIGN AND VALUE ENGINEERING**  
**DETAILED CONTENTS**

**Chapter 7 VALUE ENGINEERING: AN OVERVIEW**

- 7-1. Introduction
- 7-2. Cost reduction techniques
  - (1) Operation research
  - (2) Time and motion study
  - (3) Use of mass production techniques
  - (4) Standardization
  - (5) Make-buy decision
  - (6) Simplification
- 7-3. Definition of Value Engineering
- 7-4. What is value?
  - (1) Use value
  - (2) Esteem value
  - (3) Exchange value
  - (4) Cost value
- 7-5. Value Engineering Programme (VEP)
  - (1) Selecting a product or service for study
  - (2) Obtaining and recording information
  - (3) Analyzing the information and evaluating the product
  - (4) Working out alternatives
  - (5) Selecting the least cost alternative
  - (6) Recommendation
  - (7) Implementation
- 7-6. Advantages of value engineering
- 7-7. Reasons for unnecessary cost
- 7-8. Objectives / Reasons for value analysis
- 7-9. Concept of value engineering
  - (1) What is the product? (Selection of product)
  - (2) What must it do? (Evaluation of function)
  - (3) What does it cost? (Evaluation of cost)
  - (4) What is it's worth? (Evaluation of worth)
  - (5) What else would work? (Working out alternatives)
  - (6) What does it cost? (Evaluation of cost of alternatives)
- 7-10. Areas of application value engineering
- 7-11. Overview  
Exercise 7

**Chapter 8 VALUE ENGINEERING JOB PLAN**

- 8-1. Introduction to value engineering job plan
- 8-2. Orientation phase
- 8-3. Information phase
- 8-4. Function phase
- 8-4-1. Evaluation of function
  - (1) Express function in two words
  - (2) Quantify noun
  - (3) Choose broad verbs
  - (4) Categorize function
  - (5) Emphasize on aesthetics
- 8-5. Creation Phase
  - (1) Brain storming
  - (2) Blast, Create and Refine
  - (3) Check list
  - (4) Morphological analysis
  - (5) Delphi method
  - (6) Attribute listing
  - (7) FAST Diagram
- 8-6. Evaluation phase
  - (1) Number of components in assembly
  - (2) Number of features on component
  - (3) Design features to be machined in single set-up
  - (4) Use of symmetry
  - (5) Ease of assembly
  - (6) Ease of manufacture
  - (7) Use of standardized parts
  - (8) Service and maintenance of equipment
  - (9) Availability of vendor and their reliability
- 8-7. Investigation Phase (Development phase)
- 8-8. Recommendation (Presentation) and Implementation Phase
- 8-9. Overview  
Exercise 8

**Chapter 9 VALUE ENGINEERING: PROJECT SELECTION AND VALUE STANDARD**

- 9-1. Value Engineering (VE) Project selection
- 9-2. Methods used for VE project selection
  - (1) Felt need

- (2) Review by steering committee
- (3) Suggestion schemes
- (4) Seminars / brain storming
- (5) Relative ranking
- (6) Why-Why analysis
- (7) Assessment of Value index
- 9-3. When to apply value engineering methodology
  - (1) Application of VE during Product Dev. Process
  - (2) Application of Value Engineering during Product Life Cycle
- 9-4. Value standard
  - (1) Information Phase
  - (2) Function Analysis Phase
  - (3) Creation Phase
  - (4) Evaluation Phase
  - (5) Development Phase
  - (6) Presentation Phase
- 9-5. Overview  
Exercise 9

**Chapter 10 FAST DIAGRAM AND LIFE CYCLE COST**

- 10-1. Introduction
- 10-2. Uses of FAST diagram
- 10-3. Types of FAST diagram
- 10-4. Technically oriented FAST diagram
  - 10-4-1. Layout of FAST diagram
- 10-5. Case study (technically oriented FAST diagram)
  - 10-5-1. Case Study 1: O.H.P.
  - 10-5-2. Case Study 2: Lathe Machine
  - 10-5-3. Case study 3: Air conditioner
- 10-6. Tips for preparing FAST dia.
- 10-7. Customer (Task) oriented FAST diagram
- 10-8. Life Cycle Cost (LCC)
  - (1) Development cost
  - (2) Direct Material Cost
  - (3) Direct Labour Cost
  - (4) General expenses
  - (5) Factory expenses
  - (6) Sales expenses
  - (7) Maintenance and repair cost during service life
- 10-8-1. Time Value of Money
- 10-8-2. Evaluation of life cycle cost
- 10-9. Overview  
Exercise 10

**Chapter 11 INITIATING VALUE ENGINEERING PROGRAM**

- 11-1. VE training Prg.: Introduction
- 11-2. Implementation of VE training program
  - (1) Training coordinator
  - (2) Training plan
  - (3) Training capability
- 11-3. Categories of training
  - (1) Limited training (Level I)
  - (2) Intensive training (Level II)
  - (3) On the job training
  - (4) Training by rotational job assignment
  - (5) Contractual training
  - (6) Informal training
- 11-4. Workshop / Seminar
  - (1) Priority of Attendance
  - (2) Duration and Session Schedule
  - (3) Participants
  - (4) Team Organization and Responsibility
  - (5) Workshop Projects
  - (6) Workshop Leadership
  - (7) Vendors
  - (8) Curriculum
- 11-5. Career development for VE specialities
- 11-6. Value Engineering Team
  - 11-6-1. Value Engineering Team Leader
  - 11-6-2. Value Engineering Project manager
  - 11-6-3. Full-time VE Team Members
  - 11-6-4. Part-time VE Team Members
- 11-7. VE Coordinator / Facilitator

- 11-8. VE Level of Effort
- 11-9. Definitions
- (1) Value Engineering (VE)
  - (2) Value Analysis (VA)
  - (3) Project Cost
  - (4) Worth
  - (5) Value
  - (6) Function
  - (7) Basic Function
  - (8) Secondary function
  - (9) Higher order function
  - (10) Required secondary function
  - (11) Assumed functions
  - (12) Supporting functions
  - (13) Function Analysis
  - (14) FAST diagram
  - (15) VE Job Plan
  - (16) VE Project
  - (17) Life cycle cost
- 11-10. Overview  
Exercise 11
- Chapter 12 DESIGN FOR MANUFACTURE**
- 12-1. Introduction
- 12-2. Capability and capacity of machine
- 12-3. Advantages of design for manufacture
- 12-4. Common Manufacturing processes
- 12-5. Design guidelines for sheet metal work
- (1) Width to thickness ratio for punching
  - (2) Accuracy of punched hole
  - (3) Bending of sheet
  - (4) Height to thickness ratio
  - (5) Placement of hole
  - (6) Relieving the Bend
  - (7) Bending in perpendicular directions
  - (8) Reduce wastage
  - (9) Limitation of roll bending
  - (10) Grain orientation and bending
- 12-6. Design guidelines for machined part
- (1) Design for reduced setups
  - (2) Design shape according to standard cutters
  - (3) Avoid deep hole drilling
  - (4) Drill can produce only straight holes
  - (5) Drilling on inclined surface
  - (6) Depth of blind hole for post drilling operation
  - (7) Placement of hole
  - (8) Design section to resist cutting and/or clamping force
  - (9) Chamfers are preferred over fillet
  - (10) Clamping of work piece
  - (11) Provide free space for drill jig
  - (12) Avoid machining if possible
  - (13) Avoid machining in narrow space
  - (14) Provide relief for tool
- 12-7. Design guidelines for cast components
- (1) Prevent hot spot at sharp corners
  - (2) Provide draft in pattern
  - (3) Maintain uniform thickness of cross-section
  - (4) Design junction to avoid hot spot
  - (5) Material distribution
  - (6) Web design in pulley
  - (7) Relative size of section
  - (8) Avoid sharp corners
  - (9) Cored holes
  - (10) Spacing of ribs
  - (11) Avoid solid hub
  - (12) Design for straight parting line
  - (13) Avoid abrupt changes in cross-section
- 12-8. Design guidelines for welded joints
- 12-9. Design guidelines for injection moulded components
- (1) Optimize the section thickness
  - (2) Provide suitable draft
  - (3) Avoid sharp corners
  - (4) Avoid abrupt changes in cross-section
  - (5) Design bosses carefully
- 12-10. Design guidelines for Plastic part
- 12-10-1. Types of plastics and properties
- 12-10-2. Design factors to improve mouldability
- 12-10-3. Failure of plastic parts
- (1) Mechanical failure
  - (2) Thermal failures
  - (3) Environmental failures
- 12-10-4. Design consideration for Plastic parts
- (1) Shrinkage
  - (2) Uniform wall thickness
  - (3) Reducing sink marks
  - (4) Radius all corners
  - (5) Holes
  - (6) Reinforcement features
  - (7) Gate location
  - (8) Ejector pin marks
- 12-10-5. Engineering applications of plastic parts
- 12-11. Design guidelines for Rubber part
- 12-11-1. Properties of Natural Rubber
- 12-11-2. Types and properties of rubber
- 12-11-3. Manufacturing of Rubber Products
- 12-11-4. Design consideration of Rubber Parts
- (1) Wall thickness
  - (2) Holes
  - (3) Undercuts
  - (4) Screwed threads
  - (5) Inserts
  - (6) Draft
  - (7) Corners (Radii and fillets)
  - (8) Flash
  - (9) Parting line
  - (10) Distortion in rubber
  - (11) Wobble and eccentricity
- 12-12. Design guidelines for Ceramics and Glass parts
- 12-12-1. Properties of ceramics
- (1) Chemical properties
  - (2) Mechanical properties
  - (3) Physical properties ceramics and glass
  - (4) Thermal properties
  - (5) Electrical properties
  - (6) Magnetic properties
- 12-12-2. Manufacturing of Ceramic components
- (1) Moulding
  - (2) Densification
  - (3) Applications of ceramics
- 12-12-3. Design aspects of Ceramics
- (1) Tolerance dimensions as loosely as possible
  - (2) Limit component thickness
  - (3) Avoid features which cause stress concentrations, such as sharp edges and corners, sudden changes in cross-sectional area and small contact points
  - (4) Keep the component form as simple as possible
  - (5) Keep wall thickness as uniform as possible
  - (6) Avoid unnecessary diamond grinding
  - (7) Use modular design
- 12-13. Overview  
Exercise
- Annexure I : TYPICAL TRAINING PROGRAM FOR A 40-HOUR VALUE ENGINEERING TRAINING WORKSHOP COURSE**
- Annexure II : CASE STUDY: MARKET PULL PRODUCT \ DEVELOPMENT OF BICYCLE**
- Annexure III : PAPER SOLUTIONS OF PREVIOUS GTU EXAMINATIONS**
- Index**