Chapter 1

Generic Product Development Process

0. **Planning:** Identify the need for a new product or improvement of an existing product
1. **Concept Development:** Generate and evaluate ideas for new products or improvements
2. **System-Level Design:** Define the architecture and components of the product
3. **Detail Design:** Create detailed specifications for each component and subsystem
4. **Testing and Refinement:** Test the product and make necessary adjustments
5. **Production Ramp-Up:** Prepare for full-scale production and launch the product

Chapter 2

Opportunity Identification

- The 5-steps of in Planning Process:
  - **Identify opportunities**
  - Evaluate and prioritize projects
  - Allocate resources and plan timing
  - Complete pre-project planning
  - Reflect on the results and the process

2.1 Opportunity

- Definition: An idea for a new product, a hypothesis about how value might be created
- Ansoff's Growth Matrix:

	Current Products	**New Products**
Current Markets	Market Penetration strategy	Product Development strategy
New Markets	Market Development strategy	Diversification strategy

  - Market Penetration Strategy: Focus on increasing sales of existing products in existing markets
  - Product Development Strategy: Focus on developing new products for existing markets

  - Market Development Strategy: Focus on entering new markets with existing products
  - Diversification Strategy: Focus on developing new products for new markets
  - Risk: Current < New, Product development > Market penetration

- Opportunity tournaments: A structured process for generating and evaluating new product ideas
  - Advantages:
    * Generate a large number of ideas
    * Seek high quality of opportunities generated
    * Create high variance in the quality of opportunities

2.2 Opportunity Identification

- Ulrich and Eppinger's 6-step process:
  1. Establish a charter
  2. Generate and sense many opportunities
  3. Screen opportunities
  4. Develop promising opportunities
  5. Select exceptional opportunities
  6. Reflect on the results and process

Step 1: Establish a Charter

- Charter: Articulate the goals and establish the boundary conditions for an innovation effort
- Charter $\approx$ Mission statement for a new product
- Requires:
  - Resolving a tension between leaving the innovation problem unconstrained
  - Specifying a direction that is likely to meet the goals of the team and organization
- Recommended:
  - The innovation charter be broad. Benefit is that opportunities that may otherwise have never been considered will challenge the team's assumptions about what kinds of opportunities it should pursue

Step 2: Generate and Sense Many Opportunities

- Opportunities from various sources:
  - Internal sources: Employees, R&D, existing products
  - External sources: Customers, competitors, market trends, technology advancements
- Techniques for Generating Opportunities:
  - Follow a Personal Passion
  - Compile Bug Lists
  - Pull Opportunities from Capabilities
  - Study Customers (Find latent needs)
  - Consider Implications of Trends
  - Imitate, but Better
  - Mine Your Sources (Mainly external sources)
    - Lead users
    - Representation in social networks
    - Universities and government laboratories
    - Online idea submission

Step 3: Screen Opportunities

- Goal: To eliminate opportunities that are highly unlikely to result in the creation of value and to focus attention on the opportunities worthy of further investigation
- **Not** to pick the single best opportunity
- Two methods for screening opportunities:
  - Web-based surveys
  - Workshops with "multivoting"

Step 4: Develop Promising Opportunities

- Goal: To resolve the greatest uncertainty surrounding each one at the lowest cost in time and money
- Determine:
  - The major uncertainties regarding the success of each opportunity

  - The tasks you could take to resolve the uncertainties
  - The approximate cost of each task
- Invest modest levels of resources in developing a few of them
- Additional tasks (customer interviews, testing of existing products, etc.)

Step 5: Select Exceptional Opportunities

- Method: RWW (Real, Win, Worth it)
  - Real: Is there a real market and a real product?
  - Win: Can we win? Can our product or service be competitive? Can we succeed as a company?
  - Worth it: Is it worth doing? Is the return adequate and the risk acceptable?

Step 6: Reflect on the Results and the Process

- How many of the opportunities identified came from internal sources versus external sources?
- Did we consider dozens or hundreds of opportunities?
- Was the innovation charter too narrowly focused?
- Were our filtering criteria biased, or largely based on the best possible estimates of eventual product success?
- Are the resulting opportunities exciting to the team?

2.3 R&D

- R&D: Reasearch and Development
- Main activities
  1. Discovering and developing new technologies
  2. Improving understanding of the technology in existing products
  3. Improving and strengthening understanding of technologies used in manufacturing
  4. Understanding research results from universities and other research institutions

Chapter 3

Product Planning

- An activity that considers both the current product line and the potential portfolio of projects that an organization might pursue

3.1 Product Planning Process

- Product plan: Identifies the portfolio of products to be developed by the organization and the timing of their introduction to the market
- Inefficiencies (no good product plan):
  - Inadequate coverage of target markets with competitive products
  - Poor timing of market introductions of products
  - Mismatches between aggregate development capacity and the number of projects pursued
  - Poor distribution of resources, with some projects overstaffed and others understaffed
  - Initiation and subsequent cancellation of ill-conceived projects
  - Frequent changes in the directions of projects

3.1.1 Types of Product Plans

- New Product Platforms: A set of products that share a common architecture and components, allowing for economies of scale and scope
- Derivatives of existing product platforms: Products that are based on existing platforms but have modifications or enhancements
- Incremental improvements to existing products: Small enhancements or modifications to existing products to improve performance, quality, or features

- Fundamentally new products: Products that are significantly different from existing offerings and may require new technologies or processes

3.2 Process

1. Identify Opportunities
2. Evaluate and Prioritize Projects
3. Allocate Resources and Plan Timing
4. Complete Pre-Project Planning
5. Reflect on the Results and the Process

3.2.1 Step 1: Identify Opportunities

- Opportunity funnel
- Recommend: each promising opportunity be described in a short, coherent statement and that this information be collected in a database

3.2.2 Step 2: Evaluate and Prioritize Projects

- To select the most promising projects to pursue
- Basic perspectives:
  - Competitive strategy
  - Market segmentation
  - Technological trajectories
  - Project platform

Competitive Strategy

- Defines a basic approach to markets and products with respect to competitors
  - Technology leadership
  - Cost leadership
  - Customer focus
  - Imitate

Market Segmentation

- Allows the firm to consider the actions of competitors and the strength of the firm's existing products with respect to each well-defined group of customers
- Can assess which product opportunities best address weaknesses in its own product line and which exploit weaknesses in the offerings of competitors

Technological Trajectories

- Key: When to adopt a new basic technology in a product line
- Conceptual tool: Technology S-Curve

Project Platform Planning

- The set of assets shared across a set of products
- Effective platform $\xrightarrow[Rapidly]{Easily}$ A variety of derivative products
- Key Strategy: Whether any project will develop a derivative product from an existing platform or develop an entirely new platform
- Technology roadmap:

Evaluating Fundamentally New Product Opportunities

- Market size (units/year×average price)
- Market growth rate (percent per year)
- Competitive intensity (range of competitors and their strengths)
- Depth of the firm's existing knowledge of the market
- Depth of the firm's existing knowledge of the technology
- Fit with the firm's other products
- Fit with the firm's core assets and capabilities
- Potential for patents, trade secrets, or other barriers to competition
- Existence of a product champion within the firm

Balancing the Portfolio

- Two specific dimensions:
  - The extent to which the project involves a change in the product line
  - The extent to which the project involves a change in production processes
- Advantage:
  - Be useful to illuminate imbalances in the portfolio of projects under consideration
  - In assessing the consistency between a portfolio of projects and the competitive strategy

3.2.3 Step 3: Allocate Resources and Plan Timing

Allocate Resources

- Aggregate Planning: Helps an organization make efficient use of its resources by pursuing only those projects that can reasonably be completed with the allocated resources
- Primary resource to be managed: The effort of the development staff (person-hours or person-months)
- Capacity utilization: 80% to 90%

Project Timing

- Timing of product introductions
- Technology readiness
- Market readiness
- Competition

The Product Plan

- The set of projects approved by the planning process, sequenced in time
- May include:
  - A mix of fundamentally new products
  - Platform projects
  - Derivative projects of varying size

3.2.4 Step 4: Complete Pre-Project Planning

- By: Core team
- Product vision statement: A brief description of the product and its intended market

Mission Statement

- Brief (one sentence) description of the product
- Benefit proposition
- Key business goals
- Target market(s) for the product
- Assumptions and constraints that guide the development effort
- Stakeholders

Assumptions and Constraints

- Considers the strategies of several functional areas within the firm
- Consider:
  - Manufacturing
  - Service
  - Environment

3.2.5 Step 5: Reflect on the Results and the Process

- Is the opportunity funnel collecting an exciting and diverse set of product opportunities?
- Does the product plan support the competitive strategy of the firm?
- Does the product plan address the most important current opportunities facing the firm?
- Are the total resources allocated to product development sufficient to pursue the firm's competitive strategy?
- Have creative ways of leveraging finite resources been considered, such as the use of product platforms, joint ventures, and partnerships with suppliers?
- ...

Chapter 4

Concept Development

1. **Identify Customer Needs**
2. **Establish Target Specifications**
3. **Generate Product Concepts**
4. **Select Product Concepts**
5. **Test Product Concepts**
6. **Set Final Specifications**
7. **Plan Downstream Development**

4.1 Specifications

- Customer needs → "Language of the customer"
- Specifications → "Language of the engineer"
- Specifications: an unambiguous agreement on what the team will attempt to achieve to satisfy the customer needs
- Include: Metric, Value

4.2 Establishing Target Specifications

- Target specifications: The goals of the development team, describing a product that the team believes would succeed in the marketplace

- 4 steps:
  - Prepare the list of metrics
  - Collect competitive benchmarking information
  - Set ideal and marginally acceptable target values
  - Reflect on the results and the process

4.3 Concept Generation

4.3.1 The Activity of Concept Generation

- Concept generation: An approximate description of the technology, working principles, and form of the product
- Form (with a brief textual description):
  - Sketch
  - rough three-dimensional model

4.3.2 Structured Approaches

- 5 steps:
  1. Clarify the problem
  2. Search externally
  3. Search internally
  4. Explore systematically
  5. Reflect on the results and the process

4.4 Concept Selection

- Concept selection: The process of evaluating concepts with respect to customer needs and other criteria, comparing the relative strengths and weaknesses of the concepts, and selecting one or more concepts for further investigation, testing, or development
- 5 stages:
  1. Initial Screen
     - Technical

  - Research direction and balance
  - Competitive rationale
  - Patentability
  - Stability of the market
  - Integration and synergy
  - Market
  - Channel fit
  - Manufacturing
  - Financial
  - Strategic fit
2. Customer Screen
3. Technical Screen
4. Final Screen
5. Business Analysis

4.5 Concept Testing

- 7 steps:

1. Define the purpose of the concept test
2. Choose a survey population
3. Select a survey format
4. Communicate the concept
5. Measure customer response
6. Interpret the results
7. Reflect on the results and the process

4.6 Setting Final Specifications

- Final specifications: Revised target specifications after product concept selection
- 5 steps:
  - Develop technical models of the product
  - Develop a cost model of the product

  - Refine the specifications, making trade-offs where necessary
  - Flow down the specifications as appropriate
  - Reflect on the results and the process

4.7 Output – The Contract book

- Mission statement
- Customer needs
- Details of the selected concept
- The product specifications
- The economic analysis of the product
- The development schedule
- The project staffing
- The budget

4.8 Ongoing Activities

- Economic analysis
- Benchmarking
- Modeling

Chapter 5

System-Level Design

5.1 Product Architecture

- Production Architecture: The assignment of the functional elements of a product to the physical building blocks of the product
  - Functional elements
  - Physical elements (chunk)
- Types:
  - Modular Architecture
    - Chunks implement one or a few functional elements in their entirety
    - The interactions between chunks are well defined and are generally fundamental to the primary functions of the product
  - Integral Architecture
    - Functional elements of the product are implemented using more than one chunk
    - A single chunk implements many functional elements
    - The interactions between chunks are ill defined and may be incidental to the primary functions of the products

5.2 Modular Architecture

- Type:
  - Slot-modular architecture
  - Bus-modular architecture
  - Sectional-modular architecture

5.3 Implications of Architecture

- Product Change
  - Upgrade
  - Add-ons
  - Adaptation
  - Wear
  - Consumption
  - Flexibility in use
  - Reuse
- Product Variety
- Component Standardization
- Product Performance
- Manufacturability
- Product Development Management

5.4 Establish the Architecture

1. Create a schematic of the product
2. Cluster the elements of the schematic
   - Geometric integration and precision
   - Function sharing
   - Capabilities of vendors
   - Similarity of design or production technology
   - Localization of change
   - Accommodating variety
   - Enabling standardization
   - Portability of the interfaces
3. Create a rough geometric layout
4. Identify the fundamental and incidental interactions

Chapter 6

Testing, ramp-up and Product Launch

6.1 Testing and Refinement

- construction and evaluation of multiple production versions of the product

6.2 Production ramp-up

- Using the intended production system to make the product
- Purpose: To train the work force and to work out any remaining problems in the production processes
- Four Basic Types of Production Systems:
  - Process layout - functional
  - Product layout - line
  - Cellular layout - group
  - Fixed positions
- Goal:
  - Use space efficiently
  - Efficient personnel movement
  - Maximum equipment utilization
  - Convenient / safe work environment
  - Simplify repair / maintenance work
  - Smooth flow of work

6.3 Product Launch

- 3W1H: When, Where, to Whom, How
- Minimum Viable Product (MVP): Enterprises develop product versions that are usable and can express core concepts with minimal cost

6.4 Robust Design

- Robust product: Performs as intended even under nonideal conditions such as manufacturing process variations or a range of operating situations
- Robust design: the product development activity of creating a robust product
- Robust setpoint: A combination of design parameter values for which the product performance is as desired under a range of operating conditions and manufacturing variations
- Process:
  1. Identify control factors, noise factors, and performance metrics
  2. Formulate an objective function
     - Maximizing
     - Minimizing
     - Target value
     - Signal-to-noise ratio
  3. Develop the experimental plan
     - Experimental plan
       * Full factorial: 2^n
       * Fractional factorial
  4. Run the experiment
  5. Conduct the analysis
  6. Select and confirm factor setpoints
  7. Reflect and repeat

Chapter 7

Digital Transformation & Digital Product

7.1 Digital Transformation

- Digitization: Process of converting information from analog to digital
- Digitalization: Process of using digitalized information to make established ways of working simpler and more efficient
- Digital Transformation: Process of using digital technology to create new or modify existing business processes, culture, and customer experience to meet changing business and market requirements
- Types:
  - Process Transformation
  - Business Model Transformation
  - Domain Transformation
  - Cultural/Organizational Transformation
- Guildlines:
  - Understand your technology
  - Embrace Cultural Change
  - Consider a new digital business model
  - Digital upsklling
  - Ensure collaboration

  - Top management support

- Advantage of digital product:
  - Low investment, high return
  - More profitable than physical goods
  - No inventory, shipping or rent hassle
  - Automated delivery for passive income
  - Serve a niche at scale
  - Digital products offer unique ways to communicate directly with the customers

7.2 Digital Project Development

- 6 steps:
  1. Discovery
  2. Ideate
  3. Test
  4. Execute
  5. Launch
  6. Grow

Chapter 8

Managing R&D

8.1 The Importance and Nature of R&D

- Factors for the Evolution of R&D Pattern
  - Technology Explosion
  - Shortening Technology Cycles
  - Globalization of Technology

8.2 Strategic Role and Planning of R&D

- Supporting existing businesses to maintain competitiveness
- Driving new business opportunities
- Conducting exploratory research to understand emerging technologies
- Factors to be consider when planning:
  - Environmental forecasts (PEST)
  - Comparative technological cost-effectiveness
  - Risk assessment
  - An analysis of the organization's capabilities

8.3 Classifying and Funding R&D

- 2 main forms:

  - Maintenance:
    * Survival
    * Competitiveness
  - Growth:
    * Technology mastery
    * Break the mould

- Key considerations for funding:
  - Competitor spending
  - Long-term growth objectives
  - The need for stability
  - Potential distortions from large projects

- Common approaches
  - Inter-firm comparisons
  - A fixed relationship to turnover or profits
  - An internal customer-contractor relationship

8.4 Evaluating R&D Projects

- Challenge: The limitation of resources
- Use:
  - Decision support software
  - Expert judgment
- Evaluation criteria:
  - Technical feasibility
  - Market stability
  - Financial return
  - Strategic fit

Chapter 9

Patent & IP

9.1 IP

- Intellectual Property (IP or IPR): An intangible asset created by human intellectual or inspirational activity
- Main types:
  - Patents
  - Trademarks
  - Design
  - Copyright

9.2 Patent

- 2 Types:
  - Design patent
  - Utility patent
    - Useful
    - Novel
    - Nonovious
- Cost:
  - Annual fees
  - Patent agents

  - Court fees

- Things can have patent:
  - Process
  - Machine
  - Artical of manufacture
  - Composition of matter

- Benefits:
  - Only the owner can benefit
  - Owners can commercially exploit their ideas themselves or charge other organizations to use their patent

- Patent harmonization:
  - US: First to invent
  - UK: First to file

9.3 Patent preparation process

1. Formulate a strategy & plan
2. Study prior inventions
3. Outline claims
4. Write the description
5. Refine claims
6. Pursue application

9.4 Registered Design

- Protect the outward appearance of an artical

9.5 Trademark

- A distinctive name, mark or symbol that is identifiedwith a company's products
- Differentiating product
- Protect forever, bur need renew every 10 years
- Principle:
  - Include: Distinctive color, name, symbol and trademark symbol
  - Be distinctive
  - Not be deceptive
  - Not cause confusion
- Trademark can give IP protection long after patent has lapsed

9.6 Copyright

- 3 Categories:
  - Original literary, dramatic, musical and artistic works
  - Sound recordings, films, broadcasts and cable programmes
  - The typographical arrangement or layout of a published edition
- First creater or author or their employer owns it
- Cannot be copyright:
  - Titles
  - Facts
  - Ideas
  - Names
  - Data
  - Methods
  - Systems