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Skilling India in Electronics

Participant Handbook



Sector
Electronics

Sub-Sector
Semiconductor & Components

Occupation
System Software Development

Reference ID: **ELE/Q1501, Version-3.0**
NSQF Level: 5

Embedded Software Engineer

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Shri Narendra Modi
Prime Minister of India

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Certificate

COMPLIANCE TO QUALIFICATION PACK – NATIONAL OCCUPATIONAL STANDARDS

is hereby issued by the

Electronics Sector Skills Council of India

for

Embedded Software Engineer - PARTICIPANT HANDBOOK

Complying to National Occupational Standards of
Job Role/Qualification Pack: **Embedded Software Engineer** QP **NSQF ELE/Q1501 Level 5**

Date of Issuance: 16/12/2020

Valid up to : 16/12/2025

**Valid up to the next review date of the Qualification Pack or the 'Valid up to' date mentioned above (whichever is earlier)*

Authorised Signatory
(Skilling India In Electronics)

Acknowledgements

This participant's handbook meant for Embedded Software Engineer is a sincere attempt to ensure the availability of all the relevant information to the existing and prospective job holders in this job role. We have compiled the content with inputs from the relevant Subject Matter Experts (SMEs) and industry members to ensure it is the latest and authentic. We express our sincere gratitude to all the SMEs and industry members who have made invaluable contributions to the completion of this participant's handbook.

I would like to thank the team of Feedback Advisory for their support to develop the content, the SME and the team at the ESSCI along with the industry partners for the tireless effort in bringing the handbook in the current format.

This handbook will help deliver skill-based training in the field of drone service and maintenance. We hope that it will benefit all the stakeholders, such as participants, trainers, and evaluators. We have made all efforts to ensure the publication meets the current quality standards for the successful delivery of QP/NOS-based training programs. We welcome and appreciate any suggestions for future improvements to this handbook.

About this Book

This participant handbook has been designed to serve as a guide for participants who aim to obtain the required knowledge and skills to undertake various activities as a Embedded Software Engineer . Its content has been aligned with the latest Qualification Pack (QP) prepared for the job role. With a qualified trainer's guidance, the participants will be equipped with the following for working efficiently in the job role:

- Knowledge and Understanding: The relevant operational knowledge and understanding to perform the required tasks.
- Performance Criteria: The essential skills through hands-on training to perform the required operations to the applicable quality standards.
- Professional Skills: The Ability to make appropriate operational decisions about the field of work.

The handbook details the relevant activities to be carried out by a Embedded Software Engineer . After studying this handbook, job holders will be adequately skilled to carry out their duties efficiently according to the applicable quality standards, with minimum supervision.

The handbook has been divided into an appropriate number of units and sub-units based on the content of the relevant QP. We hope it will facilitate easy and structured learning for the participants. We sincerely hope that participants will obtain enhanced knowledge and skills after studying this handbook and make career progress in the relevant and senior job roles.

The Participant Handbook is designed based on the National Skill Qualification Framework (NSQF) aligned Qualification Pack (QP) and it comprises of the following National Occupation Stand rads (NOS)/ topics:

1.ELE/N1501: Develop embedded system software

2.ELE/N9905: Work Effectively at the Workplace

3.ELE/N1002: Apply Health and Safety Practices at the Workplace

Symbols Used



Key Learning Outcomes



Unit Objectives



Notes



Summary



Exercise

Table of Contents

Sl.No	Modules and Units	Page No
1.	**Introduction and orientation to the role of an Embedded Software Engineer**	**1**
	Unit 1.1 - Electronics Industry and its Sub-sectors- An Introduction	3
	Unit 1.2 - Employment Opportunities for an Embedded Software Engineer	7
2.	**Process of developing embedded system software (ELE/N1501 v2.0)**	**13**
	Unit 2.1 - Organisational Policies and Reporting Structure	15
	Unit 2.2 - System Design Modules and Computer Architecture	23
	Unit 2.3 - Basics of Software Development	32
	Unit 2.4 - Embedded System Software Development and Implementation	49
3.	**Work effectively at the workplace (ELE/N9905)**	**65**
	Unit 3.1 - Work and Communicate effectively at workplace	67
	Unit 3.2 - Work in a disciplined and ethical manner	85
	Unit 3.3 - Uphold social diversity at the workplace	91
4.	**Basic Health and Safety 5 (ELE/N1002)**	**101**
	Unit 4.1 - Dealing with Workplace Hazards & Risks	103
	Unit 4.2 - Fire Safety Practices	121
	Unit 4.3 - Emergency, Rescue and First-aid Practices	126
	Unit 4.4 - Effective Waste Management Practices	131
5.	**Employability Skills**	**145**
6.	**Annexure**	**146**
	Annexure I : QR Code	147

It is recommended that all trainings include the appropriate Employability skills Module. Content for the same is available here :https://www.skillindiadigital.gov.in/content/list



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1. Introduction and orientation to the role of an Embedded Software Engineer

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Unit 1.1 - Electronics Industry and its Sub-Sectors- An Introduction

Unit 1.2 - Employment Opportunities for an Embedded Software Engineer



Bridge Module

Key Learning Outcomes

At the end of this module, the trainee will be able to:

1. Discuss the job role of an Embedded Software Engineer

UNIT 1.1 - Electronics Industry and its Sub-Sectors-An Introduction

Unit Objectives

At the end of this Unit the trainee will be able to:

1. Describe the size and scope of the electronics industry and its various sub-sectors

1.1.1 Introduction to Electronic Industry

The electronics industry is the economic sector that manufactures electronic devices. It is one of the world's largest and fastest-growing industries. Today's society depends on many electronic devices manufactured in industrially run automated or semi-automated factories. Electronic products have a huge impact on our lifestyle. With the world more connected than ever, and the digital push induced by the COVID-19 pandemic, demand for electronic devices has risen steadily and remained a significant economic driver worldwide. The global electronics industry is rapidly expanding. In 2020, the global electronics industry is projected to be worth $2.9 trillion. In comparison, the global value of the electronics industry is nearly equal to India's current GDP of US$ 2.9 trillion. Asian countries such as China, Taiwan, Singapore, and South Korea dominate the electronic market. The industry is distinguished by rapid innovation and speed to market, a short product life cycle, highly automated manufacturing, and high-volume production, all of which result in consistent quality at a low cost and profit accrual through volume.

Exhibit 1: Global market size of key product segments in 2020-21 (US$ billion)[4]

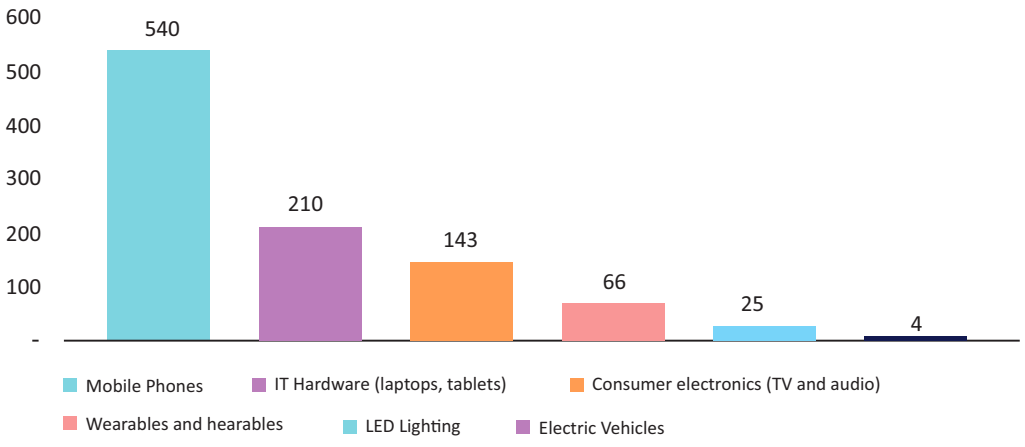


Fig. 1.1 Global Market Size 2020-21
(Source: IDC, Allied Market Research and ICEA estimates)

The electronics industry is not only self-sufficient in itself but also supports various other sectors like automotive, aviation, entertainment, healthcare, defence, telecommunications, etc. The industry is driven by innovation. Many resources are invested in research and development to design and improve electronic parts and products and improve various processes and procedures like manufacturing, quality, etc. Electronic companies always face tough competition to implement innovative ideas and first introduce the newest technology in the market. This creates a lot of pressure on the entire organization. For example, design and engineering teams need to develop innovative products and services faster and cheaper, and sales and marketing teams are pressured to drive sales and ensure that the profits always remain more than the production and operational costs.

The Government of India's National Policy for Electronics, 2019 ('NPE') recognizes the electronics industry's growth potential and strategic importance. NPE was founded to position India as a global hub for Electronics System Design and Manufacturing (ESDM), among other things, by creating an enabling environment for the industry to compete globally. Furthermore, the ESDM industry has been identified as one of the 25 priority sectors in the government's Make in India initiative and serves as a significant pillar in contributing to India's economic growth.

1.1.2 Sub-Sectors of the Electronics Industry

Consumer electronics is the most crucial segment of the Indian electronics hardware industry. The segment accounts for approximately 28 per cent of the country's electronic industry production. In 2009, the estimated turnover for this segment was 260 billion. Around half of the workforce is employed in the consumer electronics sector's production function. The current consumer electronics employment pattern is around 0.9 million approx. The electronic components accounted for the lion's share of exports in 2008, accounting for 45 per cent of total exports. According to the report "Human Resource and Skill Requirements in the Electronics & IT Hardware Sector (2022)," the electronics industry's output is expected to rise from $844 billion in 2008 to $7,520 billion by 2022. This is a good sign because it would increase overall employment from 0.9 million to over 4 million by 2022.

The Indian electronics industry is segmented into several sub-sectors:



Communications and Broadcasting Electronics

- Mobile Phones, Tablets, Wired, and Wireless Connections



Consumer Electronics

- Home Appliances, viz., Refrigerators, Washing Machines, Air Conditioners & Microwaves,Televisions, Music Systems, and Home Theatres, Direct-to-home and Set Top Boxes



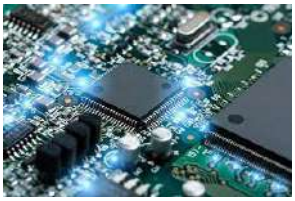
Industrial Electronics

- UPS, Supervisory Control and Data Acquisition (SCADA), Programmable Logic Controller (PLC), AC Drive Systems



Medical Devices

- Heart-rate monitors, Dialysis machine, ventilator, x-ray machines etc.



Electronic Components

- Semi-conductors, Capacitors, Resistors, Picture-tubes, X-ray tubes, and caters to the Consumer
- Electronics, Telecom, Defense, and IT segment of the electronic industry



Strategic Electronics

- Satellite-based Communication, Navigation, and Surveillance Systems, Sonar, Underwater
- Electronics Systems, Radar, Infrared-based Detection and Ranging Systems



Computer Hardware

- Desktop Computers, Laptops, Notebooks, Netbooks, and Servers



LED

- LED Lights in Automobiles, Communications, Signage, Signalling, Architecture, and
- Entertainment Sectors

Fig. 1.2 Sub-Sectors of Electronic Industry

1.1.3 Semiconductor Industry in India

The semiconductor industry in India is witnessing high growth as the industries that use semiconductors like telecommunication, information technology, automobiles, the internet of things (IoT), etc. are themselves witnessing high demand. India is also growing in the Electronics System Design Manufacturing (ESDM) Industry. The government is providing subsidies and other incentives for setting up such electronics manufacturing units in the country. The National Electronics Policy and National Telecom Policy have outlined a few initiatives like Preferential Electronic Manufacturing Clusters (EMC), Market Access (PMS), Modified Special Incentive Package Scheme (M-SIPS), etc. The major semiconductor clusters in India are Andhra Pradesh, Gujarat, Maharashtra, Tamil Nadu, Uttarakhand, West Bengal, etc.

1.1.4 Introduction to Embedded System

An embedded system is a combination of a computer processor, memory and input/out peripheral devices that has a specific function in a bigger electronic or mechanical system. Embedded systems are based on microcontrollers and microprocessors with integrated memory and peripheral interfaces. Microprocessors and microcontrollers have their origin in the MOS integrated circuit, an integrated circuit (IC) chip fabricated from MOSFET (metal oxide semiconductor field effect transistor). In an Integrated Circuit (IC), the interconnections between different components are formed on the same substrate like doped silicon, a semiconductor. In 1964, General Microelectronics introduced the first Metal-oxide Semiconductor (MOS) IC and in the 1970s, these ICs enabled complex telecommunication and semiconductor technologies to develop. Later in the 1980s, about tens of thousands of MOS transistors were fabricated on a single chip. The early ICs had a few devices like resistors, capacitors, transistors and diodes, which allowed one or more logic gates on a single chip. As the technology evolved, circuitry became more complex, and the number of components housed on the same substrate became larger. According to Business Wire, the global embedded system market is estimated to grow at a Compound Annual Growth Rate (CAGR) of 6.25% with USD 102.82 billion in 2022 and is projected to reach USD 139.23 billion by 2027. The applications of embedded systems can be seen in a large number of sectors, some of them are:

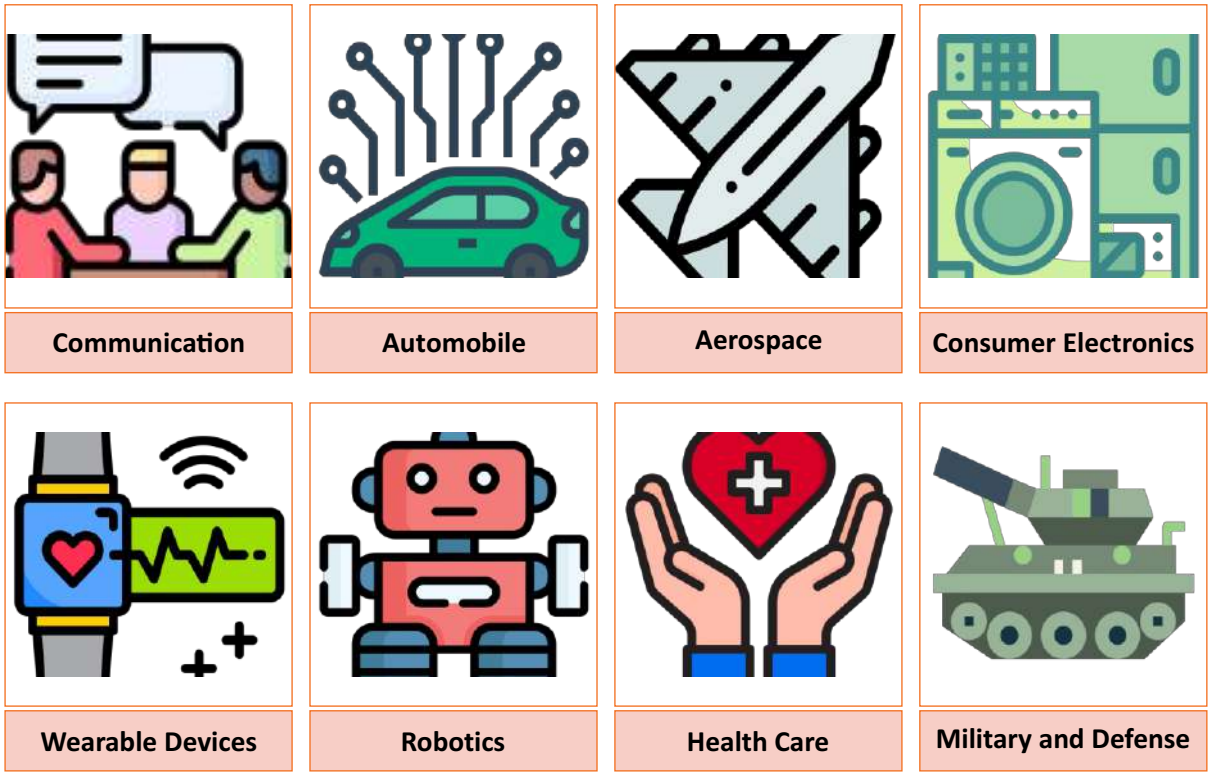


Fig. 1.3 Application of Embedded Systems in Various Sectors

The traditional software is typically written for computers, whereas embedded software is integrated into non-computer hardware like monitoring devices, wearables, machines, sensors, etc to control its functions. Embedded software is specifically created for a particular device and serves a single purpose unlike general computers which can be used for multiple purposes. An embedded system consists of a software module and a hardware module.

UNIT 1.2 - Employment Opportunities for An Embedded Software Engineer

Unit Objectives

At the end of this Unit the trainee will be able to:

1. Discuss the role and responsibilities of an Embedded Software Engineer
2. Describe various employment opportunities for an Embedded Software Engineer

1.2.1 Roles and Responsibilities of an Embedded Software Engineer

An Embedded Software Engineer is responsible for developing software modules for the embedded system. The person should assess the specification requirements, develop software, test, and validate the software by coordinating with the design engineers for system integration. The individual should assist in code reviews and rework the code to fix identified defects. The individual should coordinate with other software development teams involved in embedded systems. The individual should have logical thinking skills and attention to detail to carry out the responsibilities of an Embedded Software Engineer. An Embedded Software Engineer should have the following skills to accomplish all the roles and responsibilities:

Have knowledge on the principles and processes for electronics design programmable devices, software system design using embedded software and constraints.	**Have an understanding of circuit design functionality, logic involved in the system and software devolvement process.**	**Have knowledge of development and test tools to code, test and debug as per the requirements from the SRS.**
Have the ability to access reusable components, code generation tools and unit testing tools from company's database.	**Have the ability to develop unit test cases (UTC) as per requirement and conduct test to ensure that the software module meets the requirement.**	**Have practical skills to accomplish all the technical tasks and solve problems by applying basic methods, tools and information**
Have good communication and documentation skills for interacting with superior to breif them on work status, work-completion and pending targets.	**Have good planning ability to plan activity based on work-flow and deliverables in consultation with the lead engineer.**	**Have the ability to work independently without continuous monitoring.**

Fig. 1.5 Key Skills Required for an Embedded Software Engineer

1.2.2 Career Path for an Embedded Software Engineer

India has one of the world's fastest-growing GDPs, making it a haven for investors worldwide. The area of Embedded Systems is a highly technical field and technology is used in many sectors of the economy. The demand for Embedded Software Engineers is increasing due to the advancements in Artificial intelligence (AI), Smartphone technologies, Electric Vehicle (EV) technologies, etc. Embedded systems knowledge can be applied in the development of system-on-chip (SoC), application-specific integrated circuits (ASIC), field programmable gate arrays (FPGA), readymade computer boards, etc. Companies like Intel, IBM, Philips, Texas Instruments, Philips, L&T Technology Services, Honeywell, Robert Bosch India, etc. hire Embedded Software Engineers. Some of the job roles that an Embedded Software Engineer in the industry are Embedded Systems Architect, Firmware Engineer, Hardware Engineer, Hardware and Software Test Engineer, Embedded Operating System Engineer, Embedded Network Engineer, etc

An Embedded Software Engineer with some experience in working with different systems, firmware development, real-time operating systems, etc. and gaining more technical knowledge can get promoted to a middle-level position as a Lead Embedded Software Engineer and later as an Embedded System Designer. At this level, the individual will be able to lead a team. With more experience, the person can take on a managerial role as Head of the Design Group.

The career path for an Embedded Software Engineer

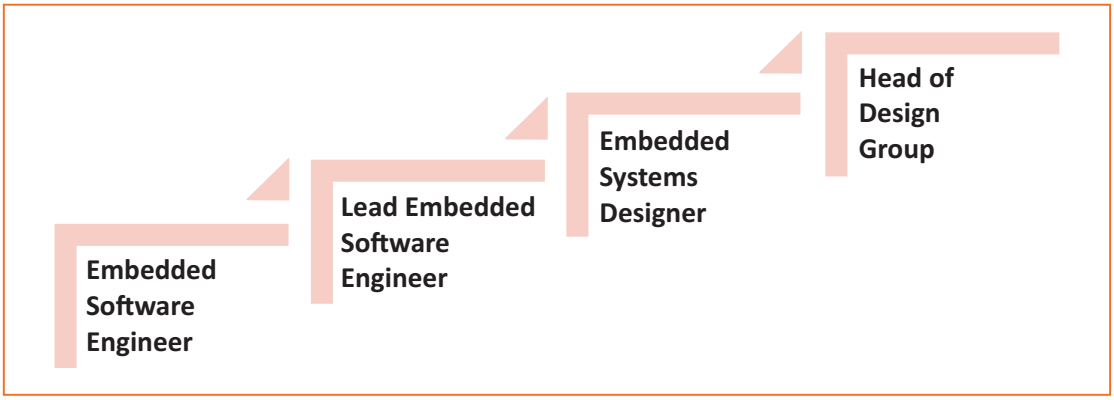


Fig. 1.6 Career Path for an Embedded Software Engineer

Notes

Summary

- The electronics industry is the economic sector that manufactures electronic devices. It is one of the world's largest and fastest-growing industries.
- With the world more connected than ever, and the digital push induced by the COVID-19 pandemic, demand for electronic devices has risen steadily and remained a significant economic driver worldwide.
- The electronics industry is not only self-sufficient in itself but also supports various other sectors like automotive, aviation, entertainment, healthcare, defence, telecommunications, etc. The industry is driven by innovation.
- The Government of India's National Policy for Electronics, 2019 ('NPE') recognizes the electronics industry's growth potential and strategic importance. NPE was founded to position India as a global hub for Electronics System Design and Manufacturing (ESDM), among other things, by creating an enabling environment for the industry to compete globally.
- Consumer electronics is the most crucial segment of the Indian electronics hardware industry. The segment accounts for approximately 28 per cent of the country's electronic industry production. In 2009, the estimated turnover for this segment was 260 billion.
- The semiconductor industry in India is witnessing high growth as the industries that use semiconductors like telecommunication, information technology, automobiles, the internet of things (IoT), etc. are themselves witnessing high demand.
- An embedded system is a combination of a computer processor, memory and input/out peripheral devices that has a specific function in a bigger electronic or mechanical system. Embedded systems are based on microcontrollers and microprocessors with integrated memory and peripheral interfaces.
- According to Business Wire, the global embedded system market is estimated to grow at a Compound Annual Growth Rate (CAGR) of 6.25% with USD 102.82 billion in 2022 and is projected to reach USD 139.23 billion by 2027.
- An Embedded Software Engineer is responsible for developing software modules for the embedded system. The person should assess the specification requirements, develop software, test, and validate the software by coordinating with the design engineers for system integration.
- The individual should have logical thinking skills and attention to detail to carry out the responsibilities of an Embedded Software Engineer.
- India has one of the world's fastest-growing GDPs, making it a haven for investors worldwide. The area of Embedded Systems is a highly technical field and technology is used in many sectors of the economy. The demand for Embedded Software Engineers is increasing due to the advancements in Artificial intelligence (AI), Smartphone technologies, Electric Vehicle (EV) technologies, etc.
- An Embedded Software Engineer with some experience in working with different systems, firmware development, real-time operating systems, etc. and gaining more technical knowledge can get promoted to a middle-level position and managerial position.

Exercise

Answer the following questions :

1. Write a brief note on the electronics industry and its various sub-sectors.

   _____

   _____

   _____

2. Write a brief note on embedded systems.

   _____

   _____

   _____

3. Discuss the employment opportunities for an Embedded Software Engineer.

   _____

   _____

   _____

Fill in the blanks:

1. _____ is a sub-sector of the electronics industry.
2. An_____ is a combination of a computer processor, memory and input/out peripheral devices that has a specific function in a bigger electronic or mechanical system.
3. An Embedded Software Engineer is responsible for _____ for the embedded system.

Notes

_____

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Notes

Scan the QR Code to watch the related video

https://youtu.be/PiR7PDEKy2A 1
Introduction to the Electronics Industry

https://www.youtube.com/watch?v=JChTishaqQM
Role and responsibilities of an Embedded Software Engineer



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2. Process of developing embedded system software

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Unit 2.1 - Organisational Policies and Reporting Structure

Unit 2.2 - System Design Modules and Computer Architecture

Unit 2.3 - Basics of Software Development

Unit 2.4 - Embedded System Software Development



ELE/N1501

Key Learning Outcomes

At the en d of this module, the trainee will be able to:

1. Describe the process of identifying the work requirement
2. Demonstrate the process of identifying the embedded system design specifications
3. Demonstrate the process of developing software for embedded system
4. Explain the importance of completing documentation

Unit 2.1 - Organisational Policies and Reporting Structure

Unit Objectives

At the end of this Unit the trainee will be able to:

1. Explain the company's policies on incentives, personnel management, documentation, IPR, code of conduct, quality and standards
2. Explain the company's license on IP core library, usage of software and design tools
3. Explain the company's reporting structure
4. Explain the company's different department and concerned authority need to communicate during the work
5. Explain the importance of individuals role in the work flow

2.1.1 Importance of Organisational Policies

Organisational policies are created to provide guidelines for the day-to-day operations and activities of the organisation. These policies help in internal processes, decision-making, and compliance with government and legal requirements. The policies must be reviewed and updated regularly or they can become redundant. They can be beneficial only if they are followed, hence employees must be made aware of the policies by providing training, creating manuals and making them accessible to employees.

1. **Incentive Policy**

   Incentive policy is used by companies to motivate their workforce. Incentives are given to employees besides salaries. The incentives are given to encourage people to typically carry out activities that benefit the company as well as the individual. These policies are made to boost productivity, encourage innovation, aid recruitment, retain talented employees, etc. The policies are made in such a way it only promotes positive growth and discourages bad or negative behaviour. A poorly framed policy can be detrimental in the sense that the employees may underperform knowingly to get the benefits of incentives. Incentives can be in the form of recognition-based incentives, financial incentives, or special reward-based incentives.

2. **Personnel Management Policy**

   The personnel management policy provides guidelines for people in the human resources (HR) department related to the recruitment and hiring process, wages and payroll information, work schedules and absence/leave policies, promotion and demotion, performance evaluation, training and development, transfers, job security, compliance with labour laws and policies of the Government.

3. **Code of Conduct**

   Every organization creates and outlines a set of principles that it commits to following or requires its employees to follow and it is documented as the company code of conduct. Codes of conduct may be applicable to vendors, suppliers, subcontractors, and third parties in some cases. It is crucial to establish a code of conduct in any organization. The following are the standard code of conduct that every organization should follow and practice:

- Be inclusive and considerate
- Address and report discriminatory, harassing, abusive, or offensive behaviour
- Encourage teamwork and employee participation
- Build trust and credibility
- Maintain accurate records
- Treat others with dignity and respect
- Seek advice from superiors and colleagues
- Collaborate with other teams
- Compliance with rules and regulations
- Be open minded to accept constructive feed back
- Avoid conflict of interest
- Encourage continuous learning and development
- Protect company assets including physical, digital and intellectual properties
- Ensure proper handling of confidential information

Fig. 2.1 Standard Code of Conduct

4. Documentation Policy

The documentation policy defines an organisation's approach to implementing document control and practices throughout the company. Documents serve as key records for management purposes and also as proof of compliance. To maintain clarity and uniformity across all processes and departments all the tasks that are required to be performed, the way in which it needs to be performed and the results obtained have to be documented. Most documentation policies also emphasise including the individual who has performed the task, which helps in improving accountability. Documents should have an appropriate title, unique identification number, version number, date, etc. some of the confidential documents should also have access control for security purposes.

5. Intellectual Property Rights (IPR) Policy

The IPR provides individuals and organisations property rights to the information and intellectual content/goods that they create. These rights are usually for a limited period of time and allow them to protect their ideas from being copied by others. This helps the creator or inventor of that property to get commercial benefits for their efforts. Some specialised varieties of exclusive rights like circuit design rights are also given. There are three different ways of obtaining IPR in software companies and each of these options covers different aspects of IP protection. They are:

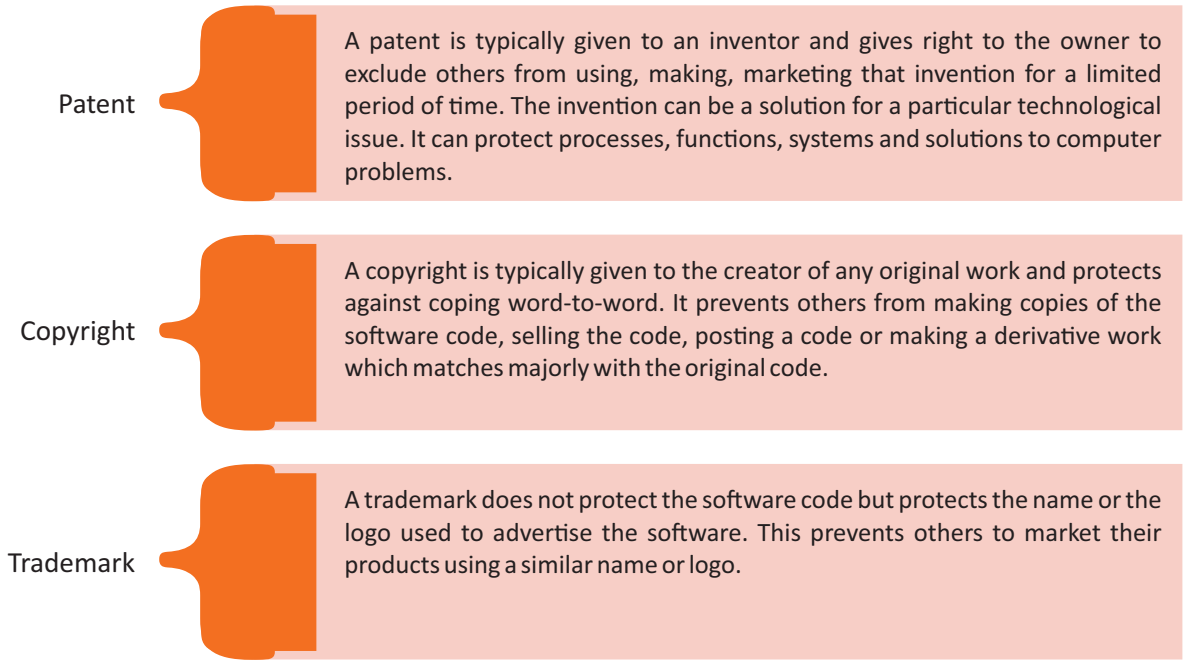


Fig. 2.2 Types of Intellectual Property Rights

IP theft can happen in organisations from their own employees or from external people. Therefore, many companies sign a non-disclosure agreement (NDA) with their employees or give restrict employee access. When a patent, copyright or trademark is obtained and someone steals the information, the person can be prosecuted on legal grounds.

6. **Quality and Standards policy**

Every organisation producing and delivering tangible or intangible products or services prioritises quality as it directly impacts the expectations and requirements of the customers. In computer software and information technology industries, quality policies are statements made to communicate the vision, objectives and goals in producing and delivering quality software products. Most of the quality policies are made based on certain quality standards like ISO 5055, and ISO/IEC 25000 series which provide the framework for quality objectives, and commitment to meet the requirements and improve on a continuous basis. Some of the software quality characteristics addressed are reliability, performance efficiency, security, maintainability, etc.

2.1.2 Company's License on IP Core Library, Usage of Software and Design Tools

Intellectual Property (IP) core is also known as semiconductor intellectual property (SIP) core or intellectual property (IP) block and it is the reusable unit of a cell, logic or an IC layout design that is the property of one company or party. It can be owned and used by a single party or licensed to other parties. The party that owns the design has the patent or copyright to the source code of the design. Each of the IP blocks is a reusable component of the design logic and has an interface and behaviour that can be verified by the creator and integrated into a design. There are different types of IP cores hard cores, soft cores and firm cores.

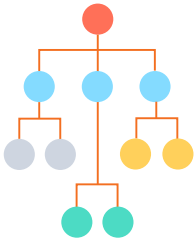
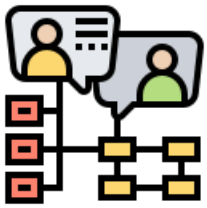
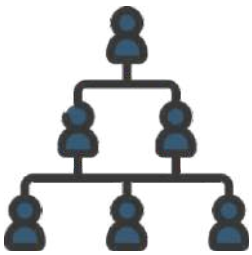
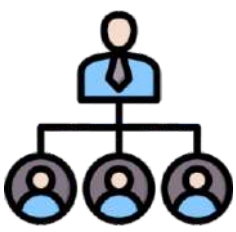
The software development tools consist of a set of programs and tools provided by hardware and software vendors. These are used by developers to build applications. The software tools include compilers, routines, subroutines, linkers, graphical user interface tools, support libraries, etc. The vendors provide permission as per the chosen license to use the tools. There are two types of software licenses provided, commercial license and open-source license. It includes software libraries, executable software elements, software tools, design support, etc.

Notes



2.1.3 Reporting Structure in Organisations

The interdependence of various authorities in an organisation is referred to as a reporting structure. It is a hierarchical chain of command that specifies the reporting format of all the employees in the company. In small businesses with a few employees, some reporting structures are self-evident. There are numerous types of organisational reporting structures, each with its own set of benefits and drawbacks. The reporting structure is chosen based on organisational requirements. The following are the top organisational reporting structures:

	**Vertical reporting structure** • It is a pyramid-like top-down management structure. • This type of organizational reporting structure has clealyr defined roles, with the highest level of leadership at the top, followed by middle management and then the regular employees.
	**Functional reporting structure** • It is a business structure that divides a company into departments based on areas of expertise or functions. • These departments function as functional units, with functional managers or department heads in charge.
	**Product-based reporting structure** • In a product-based structure (also known as a divisional structure), employees are assigned to self-contained divisions based on the specific line of products or services they produce.
	**Line-and-staff reporting structure** • In this structure, authorities (e.g., managers) establish goals and directives that are then carried out by employees and other workers. • A line-staff organizational structure aims to make a large and complex enterprise more flexible while retaining managerial authority.
	**Flat reporting structure** • A flat organizational structure means that there are few (if any) levels of management between the workforce and the highest-level managers. • Since there are no middle managers, workers have more authority in decision-making functions.

Continued...

	**Matrix reporting structure** • A matrix organization is a work structure in which team members report to multiple leaders. • Team members (whether remote or in-house) report to a project manager as well as their department head in a matrix organization.
	**Network organization structure** • It is a type of internal structure that prioritizes communication and relationship goals over hierarchy. • It enables companies to assist employees in collaborating and taking initiatives to aid in decision-making and also assist stakeholders in large organizations whom to approach.

Fig. 2.3 Types of Reporting Structure

2.1.4 Workflow in a Software Development Organisation

Typically, software development companies manage many projects at the same time and different teams are assigned to work on various projects. The two popular ways of structuring are either project-based or function-based.

1. **Project-based structure**

   In the project-based structure, the development teams are divided into groups according to the projects they are working on. The same team carries out all the tasks required to successfully complete the project. One of the drawbacks of this format is the distribution of work is not uniform among all the members of the team at all times. For example, during the initial phases, the designers are extremely busy and during the latter part of the project, the coding and testing team members become extremely busy and come under pressure to meet the deadlines. This type of structuring is more suitable for smaller organisations.

2. **Function-based structure**

   In the function-based structure, the employees are grouped according to the functions/tasks they carry out. For example, there are different people like designers, coders, testers, software maintenance executives, project managers, etc. proficient to carry out a particular task in the development project. These functional engineers and executives are borrowed for various projects during the particular phase of the project. For example, designers are borrowed at the initial stage of the project, when the specification and requirements are being analysed and the design is being developed, similarly coders are borrowed while the coding project reaches the coding phase. On completion of that particular phase of the project, they are returned to their original functional group. As the project is managed by a different set of people at the various stages of the project, it requires good coordination, collaboration and documentation. This type of structuring is more suitable for larger organisations.

2.1.5 Team Structures and Workflow

Team structuring becomes important while dealing with multiple projects in the organisation. Team structures may have to be altered often depending on the product, technical complexity, manpower availability, time and cost constraints, etc. There are basically three different approaches used in team structuring.

1. **Democratic team structure**

   A democratic team is also known as an ego-less team. In this format, all the team members agree on the objective of the project and inputs from each member are considered in the decision-making process. This helps in taking better decisions and also boosting the morale of all the team members. All the team members whether seniors or juniors can communicate with each other. This model is well suited for smaller groups and long-term research-type projects. In the figure below, **the hexagons represent the team members and the arrows represent the communication channel.**

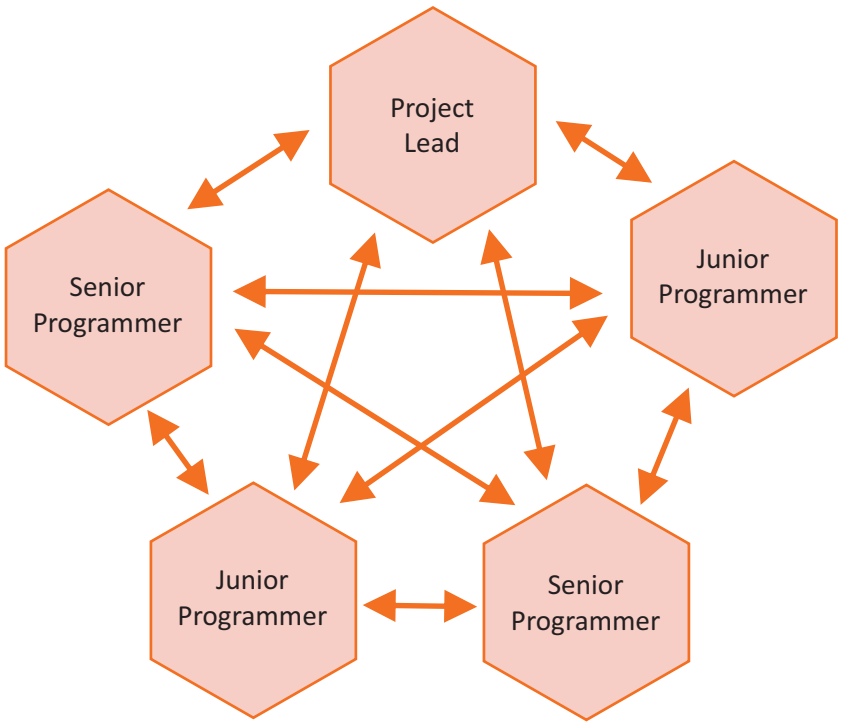


Fig. 2.4 Democratic Team Structure

Notes

2. Chief Programmer team structure

This type of format has a hierarchy and the team is headed by a chief programmer, who is responsible for taking all the major decisions and the other members provide support. The project is broken down into smaller tasks and assigned to different team members by the chief programmer. The chief programmer has a backup programmer who takes charge in the absence of the chief programmer. The communication is between the chief programmer and the individual team members. This can sometimes lead to a decrease in the morale of the team members.

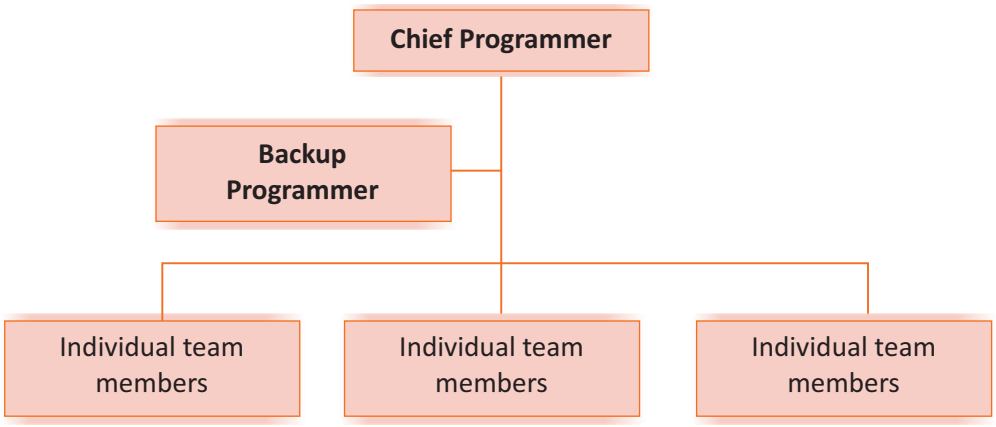


Fig. 2.5 Chief Programmer Team Structure

3. Mixed team structure

This structure incorporates both the above types of team structures. Typically, the team consists of a sub-set of individual teams, each consisting of a group of junior programmers reporting to a senior programmer, who in turn reports to the project manager. The individual teams behave like a democratic team and at the same time there is hierarchical reporting also. This type of structure is suitable for large organisations dealing with multiple projects. Each team will be responsible for a project. The communication flow is typically from the Project Manager to the Senior Programmer who in turn communicates to the Junior Programmers.

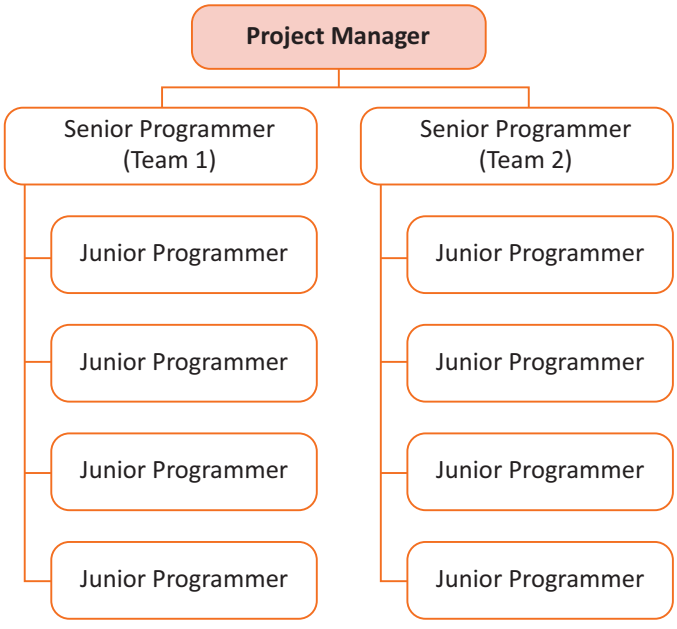


Fig. 2.6 Mixed Team Structure

Unit 2.2 - System Design Modules and Computer Architecture

Unit Objectives

At the end of this Unit the trainee will be able to:

1. Explain the system design modules and concepts of circuit design
2. Explain the schematics and data sheets
3. Explain the computer architecture

2.2.1 System Design Modules

System design is the process of defining, designing and developing the elements of a system like its components and their interfaces, modules, architecture, and the information/data that goes through the system as per the specific requirements for the business or organisation. Modular design is a principle of design where a system is subdivided into smaller parts known as modules and then used together to define the functionality of the device. These modules can be independently created, altered, replaced or exchanged with other modules or between various systems. The modules do not depend on each other for their functioning but depend on the base platform. For example, computer-on-module (COM) boards and other shield boards can be added to an already existing hardware platform using standard interfaces. An embedded system is a computer system or board consisting of all the devices like microprocessors, memory, interface and controllers on a single board or packages to perform tasks for a specific application.

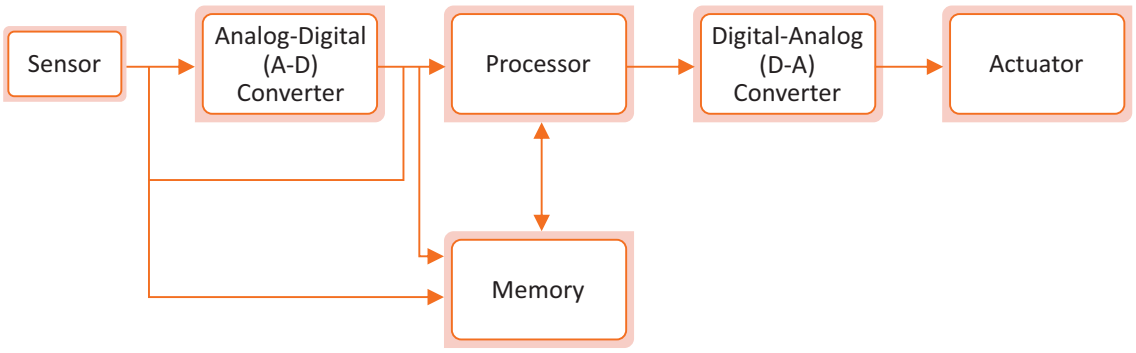


Fig. 2.7 Block Diagram of an Embedded System

Notes

The functions of the components shown in the above block diagram are:

- Sensor measures the physical quantities and converts then into an electrical signal that can be viewed on an analog device or through an electronic tool like an A-D converter.
- A-D converter converts analog signals sent by the sensor in to a digital signal.
- Processor takes the input and produces an output after processing the data.
- D-A converter converts digital signals to analog signals with the help of the processor.
- Actuator compares the D-A output to the actual anticipated output saved in it and acts as an output device.
- Memory helps processor to perform its functions and make the device work.

Fig. 2.8 Functions of Various Components in an Embedded System

The different system design modules used are:

Architectural design helps to describes the model, view, behaviour and structure of the system.

Logical design helps to represent the data/information flow and input and output of the system.

Physical design helps to define the way in which the information flows between the user and the system, the way data is modelled and stored, and the way data is validated, secured and transformed in the system.

Fig. 2.9 Different System Design Modules

The embedded systems architecture consists of the hardware, software and the real-time operating system (RTOS).

2.2.2 Concept of Circuit and Circuit Design

An electronic circuit consists of electronic components like resistors, capacitors, inductors, transistors, diodes, etc. connected by wires which allow the flow of electric current. The two main types of electronic circuits are analog and digital circuits.

In analog circuits, resistors, inductors, and capacitors are mainly used to process any analog input signal or data and produce an output in analog form. In these circuits, the signal is a continuous function of time and they can process the real-world signals that are analog directly without the need for signal converters. There are two types of analog circuits, active and passive circuits. Analog circuits are more susceptible to noise. The designing of analog circuits is complex as the components have to be placed manually and the implementation is also not flexible. They consume more power, have low processing speeds and are less accurate and precise compared to digital signals. Analog signals can be transmitted in these circuits in the form of waves either through wires or in wireless mode and they store data in the form of waves. Analog circuits cannot perform logical operations efficiently and are prone to observational error in the output.

In digital circuits, logic gates are the main components used to process discreet time signals (input) to digital signals (output). As real-world signals are analog, digital circuits require signal converters like Analog to Digital Converter (ADC) and Digital to Analog Converter (DAC). Digital circuits are immune to noise. The designing of complex digital circuits is relatively easy as software can be used and have more flexibility in implementation. They consume lesser power, have higher processing speeds and are more accurate and precise compared to analog signals. Digital signals can be transmitted in these circuits only through wires in the digital form and they store data in the binary form. Digital circuits perform logical operations efficiently and are free from observational error in the output.

Circuit Design

The process of circuit design ranges from the design of an individual transistor in an integrated circuit to complex electronic systems. Electronic circuits are used in computation, data transfer and signal amplifications. They consist of various electronic components interconnected in different ways. Traditionally, circuits are first designed on a breadboard or on PCBs as a prototype, which helps in the modification and enhancement of the circuit. Circuits produce the preferred output based on the input.

The process of circuit design involves several steps:

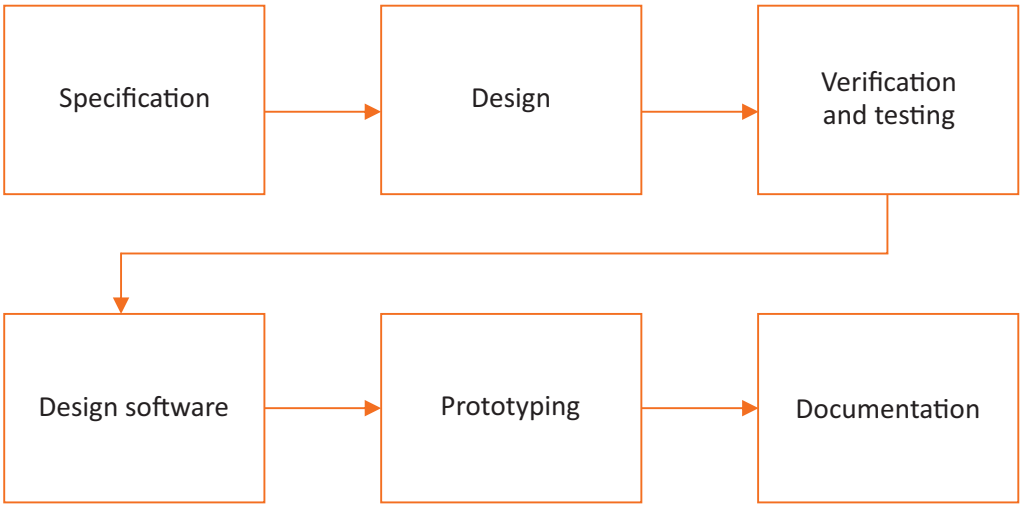


Fig. 2.10 Circuit- Design Process

1. **Specification**

   The circuit design process starts with getting the specifications from the customer, which details the functions of the final design without stating the methods to achieve them. It includes the requirements related to the type of input and output signals, the type of power supplies available, the permitted quantity of power consumption along with physical details like weight, size, thermal output, moisture resistance, temperature range, vibration tolerance, etc. The designers keep referring to the specifications throughout the design process to check if the conditions are being met and if any alterations are required. In order to meet the specifications, certain tests may have to be conducted to ensure that the conditions are met. In case of any changes or modifications that may be required, approval from the customer has to be taken.

2. **Design**

   After receiving the specifications, designing begins with making a block diagram keeping all the functions mentioned in the specifications in mind. At this stage, only the function is taken into account and not the components that go into each block. This helps to break down the main functions into smaller tasks. Next, each block is considered in detail related to the electrical functions, mathematical modelling, testing etc. in some cases, a certain block may not be able to meet all the specifications, then alterations may have to be done in the other blocks to meet the requirements. Once, all the individual components are chosen, the next step is to decide the electrical connections and physical layout which depends on the base like a PCB or IC. The cost of designing is very often more than the cost of production.

3. **Verification**

   The verification process helps to go through every stage of the design to check if it meets the specifications through computer simulations of the designs. The problems detected at this stage typically required design rework to fix the issues. Unlike verification where a simulation is used, testing involves the assessment of a prototype of the design for its functionality.

4. **Design Software**

   The design software helps to create cheaper, more efficient and longer-lasting circuits. There are different types of software available like HDL, VHDL, Verilog, etc.

5. **Prototyping**

   The prototyping process is important to know if there are any issues in the circuit which can cause damage to the product or the user. During the design and verification stages, designers keep detecting and fixing issues but prototyping is still required to see if all the physical parameters are met and also check if the product is safe for the customers.

6. **Documentation**

   The documentation process typically involves recording the specifications, design details, prototype details, verification and test procedures and results, compliance with regulatory guidelines, etc.

2.2.3 Schematics and Datasheets

Embedded software engineers should be able to understand the diagrams and symbols that are used to describe and create the designs. These diagrams contain information that the engineer will require to design software that is compatible with the hardware. There are different ways to represent the hardware drawings:

Block diagrams are used to show major components on a board like processors, input/output, memory, buses, etc. or single components like a processor at the system architecture level. Block diagrams are the simplest way to represent and describe components in a system as it uses squares and rectangles for the components and straight lines for the buses. These diagrams do not provide enough details for software designers to write the low-level software to control the hardware accurately. Refer to fig. no. 2.7 for the block diagram of an embedded system.

A schematic diagram or a circuit diagram is a symbolic representation of a circuit and shows the way all the components are connected within a circuit or within a single component. The schematic diagrams do not represent the show the physical layout like the block diagrams but provide information regarding the flow of data in the system. In these diagrams, schematic symbols are used to represent all the components. A schematic diagram gives information related to the actual working of the system, steps for debugging the hardware and software, etc. It also contains the list of changes or revisions made to the original design, known as engineering change orders (ECOs). It is important to track the changes as the design grows and changes over a period of time. The schematic diagram also consists of a title block located at the lower right corner of the sheet giving details of what the diagram represents, the date and who has created it.

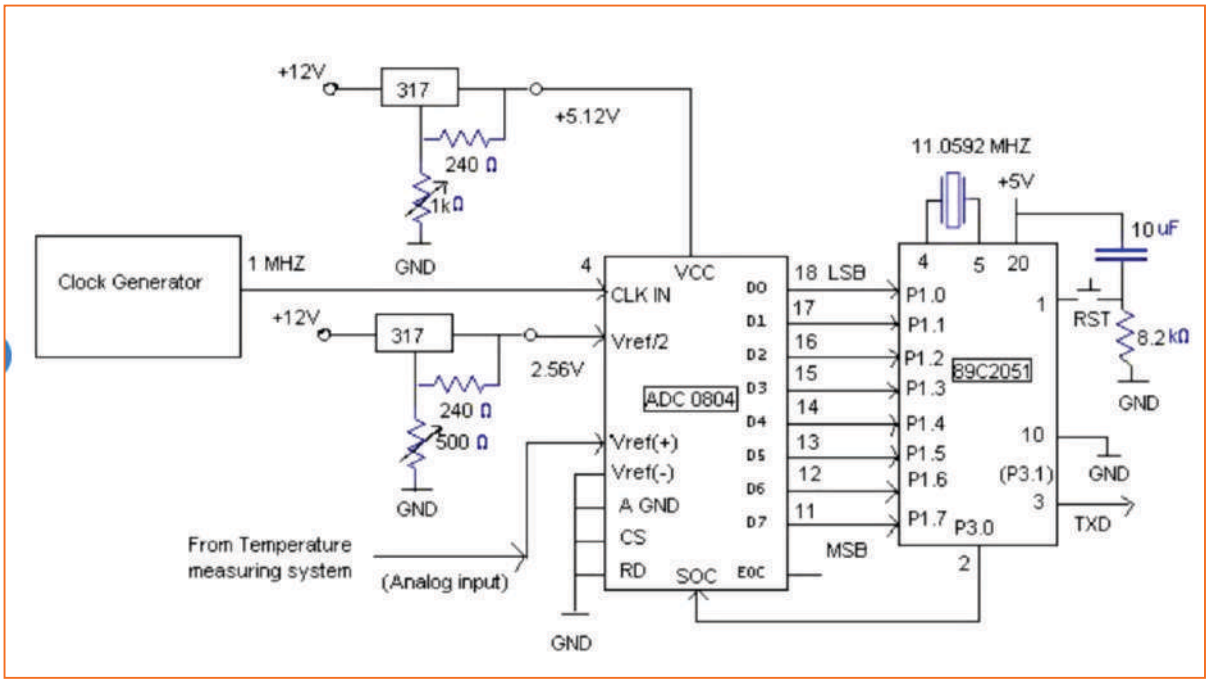


Fig. 2.11 Schematic Diagram of an Embedded System

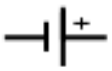
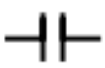
Source: https://www.researchgate.net/figure/Circuit-diagram-of-the-embedded-system_fig5_237570627

The following table shows the name of the component and its standarised identifier used in schematic diagrams:

Name of the Component	Identifier
Capacitors	C
Resistors	R
Inductors	L
Switches	S
Diodes	D
Transistors	Q
Integrated Circuits	U
Crystals and Oscillators	Y

Table 2.1 Component and its Standarised Identifier used in Schematic Diagrams

The following table shows the name of the components and its symbols used in schematic diagrams:

 Resistor	 DC voltage source (Battery)	 Capacitor	 Fuse
 Variable resistor	 AC voltage source	 Polarised capacitor	 Microphone
 Potentiometer	 Solar Cell	 Pre-set adjustment	 Loudspeaker
 Light-dependent resistor	 Current source	 Inductor	 Buzzer

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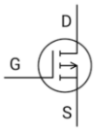
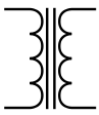
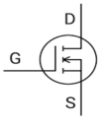
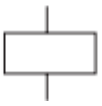
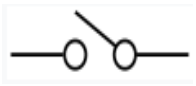
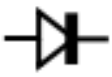
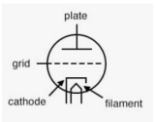
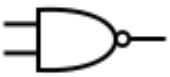
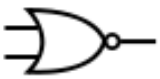
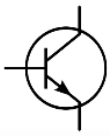
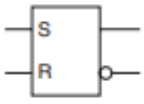
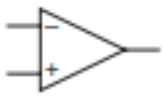
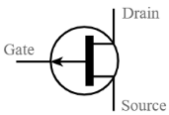
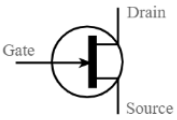
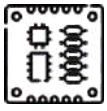
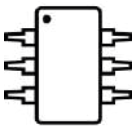
 Inductor with magnetic core	 Heating element	 P-channel MOSFET	 Thermistor
 Transformer	 Generator	 N-channel MOSFET	 Relay coil
 Aerial	 Motor	 Switch	 Break contact
 Diode	 Ammeter	 General ground	 Lamp or light
 Light-emitting diode	 Voltmeter	 AND gate	 OR gate
 Triode	 Oscilloscope	 NAND gate (Not-AND)	 NOR gate
 Breakdown diode	 Single junction	 XOR gate (Exclusive-OR gate)	 Inverter (Not gate)
 Transistor	 Double junction	 RS-bistable	 Operational amplifier
 P-channel FET	 N-channel FET	 Printed Circuit Board	 Integrated Circuit

Table 2.2 Symbols used in Schematic Diagrams

Datasheets

The schematics represented in the form of written technical information are datasheets. They contain information facts, figures and specifications and a step-by-step guide to identify and extract the information. Datasheets related to embedded software typically provide information related to its memory architecture, memory locations for various modes of operations, peripherals, special function registers, etc. The datasheet serves the same purpose as that of a user manual of a consumer electronic device. Datasheets are very technical in nature and may run into hundreds of pages in some cases.



Fig. 2.12 Datasheet of an RFID Reader

Source: https://www.yumpu.com/en/document/read/51014104/data-sheet-sunrom-technologies

2.2.4 Introduction to Computer Architecture

Computer architecture is a set of specifications describing the functionality, performance, organisation and implementation of computer systems. It provides details related to the interactions between a set of software and hardware technology standards interact to form a computer system. It involves the process of determining the requirements of the user, technology and the system and creating a logical design based on the requirements.

It can be divided into the following categories:

1. **System design –** It includes hardware components in the system like a graphic processing unit, direct memory access, memory controllers, data paths, and components for multiprocessing and virtualization.
2. **Instruction set architecture (ISA) –** defines the way in which the CPU is controlled by the software, it acts as an interface between the software and the hardware. It also specifies the processor capabilities. It includes processor register types, memory addressing modes, word size, data formats, etc. ISA translates the high-level language to binary language. It can be described as an instruction manual describing the way the instructions are encoded.
3. **Microarchitecture -** It is also known as the computer organisation and it describes the way in which a particular processor will implement the instructions from ISA. It defines the data paths, data processing and storage elements and determines the way in which they should be implemented in the ISA.

A computer consists of various components like a control unit, memory unit, I/O controllers, and arithmetic logic unit (ALU) which are realized with transistor circuits. Computers have a cache, which is a small extremely fast unit that can store information that is frequently and quickly required. The logic design helps to carry out the operations of the control unit, ALU, I/O controllers and other hardware. A very important area related to computer architecture is the design of microprocessors on a single IC chip. The microprocessors have the entire CPU- control unit, memory and ALU. Additional memory and I/O control circuitry are connected to the IC chip to form a complete computer. These tiny IC chips or the VLSI microprocessors consist of millions of transistors that implement the processing and memory units of present-day computers.

Notes



Unit 2.3 - Basics of Software Development

Unit Objectives

At the end of this Unit the trainee will be able to:

1. Explain the software fundamentals such as object-oriented design, data structures, algorithm design
2. Explain how to use and operate ERP system
3. Explain how to design, develop, test and debug software components
4. Explain how to use software module library and database
5. Recall basics of high level computer languages such as C, C++
6. Explin the operating system such as windows, linux

2.3.1 Software fundamentals

Software is designed in such a way to transform the user requirements into a form that helps the programmer in coding and implementation. Software programming involves designing and developing computer programs to meet specific outcomes. It involves various tasks like analysis, coding, algorithm generation, verification, etc. Some of the software fundamentals are:

1. Object-oriented design (OOD)

In the object-oriented design process, the whole system is seen as a collection of entities or objects. It is one of the approaches used in software design which involves the planning of a system of interacting objects to solve a software problem.

a) Input for OOD

The input for OOD is provided by the object-oriented analysis. The analysis and design can happen in parallel and in increments rather than completely developing at once. The typical input objects for OOD are:

Conceptual model captures concepts in the problem domain and allows parallel execution of concurrent units.

Use case is a description of the sequence of events when taken together can lead to a system doing something useful. Each use case provides scenarios that tells the way the system should interact with the users.

System sequence diagram (SSD) can be used to display a particular scenario of a use case, the events that users generate, their order of occurence and possible inter-system events.

User interface documents show and describe the aesthectics of the user interface of the end product, which helps the designer to visualise the end-product.

Fig. 2.13 Input Objects for Object-Oriented Design

b) Concepts used in OOD

The concepts of OOD are features that are built into the programming language.

Object	• Object contains data and procedures grouped together to represent an entity. • Each entity will have some attributes related to it and ways to act on the attributes.
Object interface	• It defines the method to interact with the object.
Object-oriented program	• The interaction of these objects is defined by an object-oriented program.
Object-oriented analysis	• It is the procedure to identify the requirements/objects and their interactions to solve a problem and document.
Object-oriented design	• It is the process of implementing the model produced during the object-oriented analysis.
Class	• It defines the attributes that an object can have and represents the functionality of the object. • An object can be part of a class having similar objects.
Abstraction	• It is the removal of irrelevant information and amplification of the required information.
Encapsulation	• It is the process of bundling the data into a single unit and hiding data and restricting access to the data to outsiders.
Inheritance	• It is the process where similar classes are stacked up in a hierarchial manner. A sub-class which is lower than a super-class in the hierarchy can be inherited from the super-class and can have its own set of functions and data.
Polymorphism	• It is the ability to replace an object with its sub-objects. • It provides means to assign the same name to methods performing similar taks

Fig. 2.14 Concepts Used in Object-Oriented Design

c) Designing Concepts used in OOD

The main features of the design concepts are:

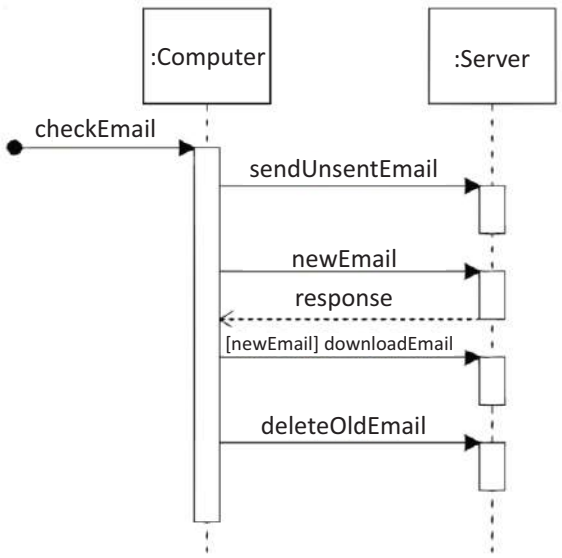
- Defining the objects and their attributes, creating the class diagram from the conseptual diagram.
- Creating and using design patterns that can be used as a template for various applications. They show the relationship and interactions between classes/objects, without specifying the final application of the objects involved.
- Defining an application framework which consists of a set of libraries or classes used to implement the standard structure for a specific operating system.
- Identifying persistent/ frequently occuring objects and designing an object relation mapping.
- Identifying and defining remote objects if any.

Fig. 2.15 Design Concepts used in Object-Oriented Design

d) Output of OOD

The two main types of output of OOD are:

A **system sequence diagram** is shown in the form of parallel vertical lines and horizontal arrows. The vertical lines show the objects that live simultaneously and the horizontal arrows show the messages exchanged between them in the order of occurrence.



Source:
https://upload.wikimedia.org/wikipedia/commons/9/9b/CheckEmail.svg

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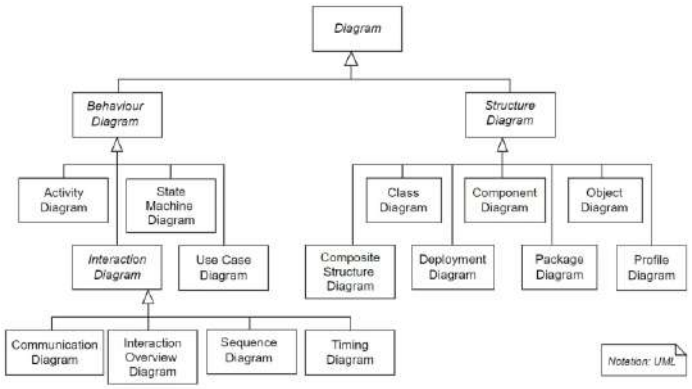
A **class diagram** describes the structure of a system by displaying the classes, its attributes and the relationship between the classes. It is a type of static structure of Unified Modeling Language (UML).	 **Source:** https://upload.wikimedia.org/wikipedia/commons/e/ed/UML_diagrams_overview.svg

Table 2.3 Output of Object-Oriented Design

2. Data Structures

A data structure is a method to manage, organize and store data in the memory for efficient access to data. It can be considered as a collection of data values, relationships between them and functions/operations that can be applied to them. They act as the basis for the abstract type of data (ADT) which defines the logical behaviour of a class of objects in the form of a set of values and a set of operations. There are different methods to organize data in the memory and the different data structures are suited for varying types of applications and specific tasks. Data structures are used in designing efficient algorithms that can be used in any programming language. They can be used in organizing and retrieving data stored in both main and secondary memory. The data structures can be either static where the maximum size is fixed and allocated at the time of compiling or dynamic where the maximum size is flexible and allocated during the run-time. Some of the common operations performed on them are searching, sorting, insertion, update and deletion. They can be mainly classified into two main categories:

Data structures

Primitive data structures having data types like int, char, double, pointer, float, etc. and they can hold a single value.

Non-primitive data structures

- Linear data structures where one element is connected to only one other element in a sequential or linear manner like arrays, stacks and queues.
- Non-linear data structures where one element is connected to a number of other elements and they are arranged in a random form like graphs and trees.

Fig. 2.16 Categories of Data Structures

3. Algorithm design

An algorithm is a set of rules or finite sequences of instructions followed to perform a computation or during problem-solving operations. They are used as specifications for data processing and also for performing calculations. Algorithms are the building blocks for programming and are vital for computers to process data. Algorithm design can be classified as:

Brute-force is also known as exhaustive search and involves attempting every possible solution to arrive at the best. The two types of brute-force algorithms are optimising and sacrificing. In optimising, all possible solutions are derived and then the best solution is taken out. In sacrificing, the search is stopped as soon as the best solution is found.

Divide and conquer as the name suggests reduces the occurrence of a problem to one or more smaller occurrences, until they are small enough to solve easily. This helps to design an algorithm in a step-by-step variation.

Branch and bound algorithm is applied for integer programming problems, where it divides all the sets of possible solutions into smaller subsets and they are evaluated to get the best solution.

Randomized algorithm is carried out by introducing a random variable in the input to get an output. Therefore, it is suitable for finding approximate answers where getting exact solutions can be impractical.

Reduction of complexity is also known as transform and conquer where the problem is transformed into a simpler, similar or easier version and then solve the easier versions and combine them to get the solution for the real/actual one.

Back tracking allows to build multiple solutions incrementally and abandon if it cannot get a valid complete solution.

Fig. 2.17 Classification of Algorithm Design

Notes



2.3.2 Enterprise Resource Planning

Enterprise resource planning (ERP) refers to a type of software used by businesses to manage day-to-day business operations such as accounting, procurement, project management, risk management and compliance, supply chain operations, etc. In today's scenario, organizations are progressively focused on streamlining their operations to drive profits, increase margins and deliver high quality to customers. A robust **ERP system** helps organizations integrate and streamline interdependent departments while remaining competitive.

ERP can help engineers like in all other industries to convert their unique system designs to specific products as per the customer requirement. It helps in various phases of design, development and manufacturing like managing resources, tracking the progress of work, communication, cost and time allocation, etc. It helps in better project management, especially for complex projects.



Fig. 2.18 Basic Modules of ERP

ERP is an application that is used to automate business processes. It provides insights and internal controls, draws on a central database that collects inputs from various departments including accounting, production, sales, marketing, and human resource, etc.

Once information is compiled in the central database, leaders gain cross-departmental visibility empowering them to analyze various scenarios, discover process improvements, and generate significant efficiency benefits. This further translates to cost savings and better productivity as people spend less time digging for needed data. Today, ERP solutions are helping companies and various industries to improve efficiency and assisting managers to deliver on time.

Integrates the system	Provides common database	Helps in real-time operation
Provides support for all applications	Can be hosted on-premise, cloud-based or hybrid	Provides common user interface across applications

Fig. 2.19 Benefits of ERP System

2.3.3 Software Development Process

The software development process begins with gathering the requirements of the system and user so as to develop the software to meet the expectations. The process involves dividing the software development tasks into smaller steps or sub-processes, which can be carried out parallelly or sequentially.

A component is part of the system architecture which is replaceable, portable and reusable. The software component interacts with other components through defined interfaces and conforms to the common behaviour that all components in the architecture need to follow. A software component can be deployed independently. A component can have different views:

Object -oriented view	Conventional view	Process-related view
• It is seen as a set of one or more classes and the interfaces for them to communicate are defined. • Each problem analysis and design are defined to identify all attributes and operations related to its implementation.	• It is seen as afunctional element of a program which integrates the data structures and the processing logic required for implementation. • It also defines the inteface that facilitates the component to be called and data to be passed to it.	• In this case, the system is built from existing components available in the library instead of creating the components from the beginning.

Fig. 2.20 Different Views of Components

Designing of software components

The component design has to be first represented in a form that can be translated into a source code. It is important to conform to the guidelines to prevent the introduction of errors while designing the interfaces, data structures, algorithms, etc. While designing the following points have to be considered:

- Identify all the design classes
- Create naming conventions for components
- Define all reusable and non-reusable components
- Identify the interfaces for each component
- Define the attributes, datatypes and data structures required for implementation
- Use activity diagrams and pseudo codes to describe the process flow within each operation
- Define persistent data dases and recognise the classes required to manage them
- Develop the behavioural representation for the component
- Provide details of implementation and deployment
- Indicate the location of components and designate specific and operating system environment

Fig. 2.21 Points to be Considered While Designing Software Components

Coding/Developing the software

Coding is the process of converting the design into a computer language format, in other words, it is translating the design specifications into the source code. The code has to be written and documented to verify the conformance of the code to the specifications. Coding is started after the technical specifications are verified and approved by the team leaders using the required software tool/programming language. The code should be easy to read and understand, efficient, easy to maintain, have a minimum dependency and behave as expected. High-level functional languages are used for coding and they should have the following characteristics:

- **Simplicity -** the language has to be simple to learn, understand, apply and maintain without compromising on the overall capability.
- **Efficiency -** the language should not consume too much memory and take too much time and be able to be translated and executed efficiently.
- **Portability -** the language should be easy to develop portable software and be maachine-indeopendent.
- **Generality -** the language should allow the coder to write for a large collection of programs.
- **Concise -** the language should be able to implement the algorithm with less amount of code.
- **Abstraction -** the language should be able to define and use complicated operations and structures by ignoring low level details.
- **Structuring -** the language should allow the coders to write the codes as per the structured programming concepts to avoid errors.

Fig. 2.22 Characteristics of High-Level Functional languages used in Coding

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Coding standards

Certain coding standards have to be followed by the coders/developers irrespective of the programming language being used. The coding standards are best practices to develop more readable, cleaner and more efficient code with minimum errors.

The following are some of the coding standards to be used:

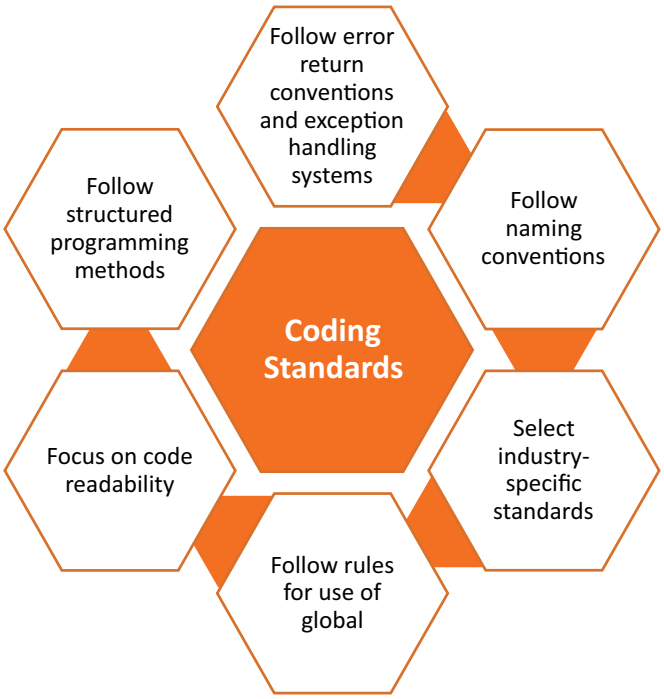


Fig. 2.23 Coding Standards

The advantages of using coding standards are:

- Makes the code more readable.
- Maintains uniformity to the code developed by different coders.
- Helps in creating reusable codes.
- Improves efficiency and produces quicker results.
- Helps in error detection and reduction of errors.
- Makes the codes simpler and easy to maintain.

Fig. 2.24 Advantages of Using Coding Standards

Software testing

Software testing is carried out to test the software against the system and user requirements. Testing is carried out at the module level in the program code. Code reviews are carried out to identify issues in codes and remove bugs in the early stages of software development. **Unit testing** is a method of testing individual isolated software components for their correctness. This enables us to test most of the code paths, argument bounds and failures cases. Proper unit testing helps to reduce the time taken to stabilise the embedded software, increase the productivity of the team and reduce control flow bugs, functional bugs, memory leaks and boot loops. Unit testing helps to identify and fix defects. It helps coders and developers to become aware of the causes of defects. The defects like errors, missing parts, or bugs in the programmer's implementation identified are fixed before integration. Unit testing can be carried out manually or with the help of testing tools. **Unit Test Case (UTC)** is a document providing details of the specific test set-up like the preconditions, expected results, and post-conditions to verify compliance with the requirements. The UTC document consists of the following details:

Test case ID	Prerequisites	Test case scenario and description	Test steps
Expected results	Information on testing environment	Test data and actual results	Comments

Fig. 2.25 Contents in a Unit Test Case Document

A good test case should be:

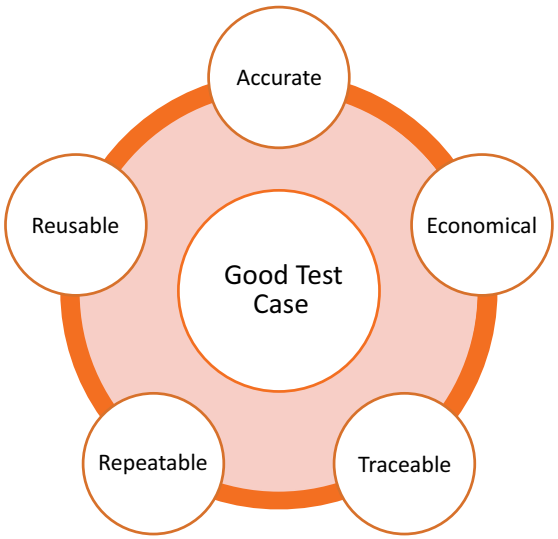


Fig. 2.26 Attributes of a Good Test Case

The test plan describes the objectives of the test, test procedures, features to be tested, the test environment, and the testers required for the testing

Debugging the software

Debugging is the process of detecting and removing bugs or errors in software codes. There are different types of errors or bugs that can occur like design errors, coding errors, poor user interface designs, complex interactions, system failures, etc. The main causes for errors to occur are writing the code without following the coding principles/standards and programming without thinking. Debugging tools can be used to identify errors at various stages of development. They help to reproduce the conditions in which the error has occurred in the code, test the program state at the time the error occurred and locate the cause. A few language packages provide debugging tools (debuggers) for checking the code for errors at run-time when the code is being written.

The steps to be taken for debugging are:

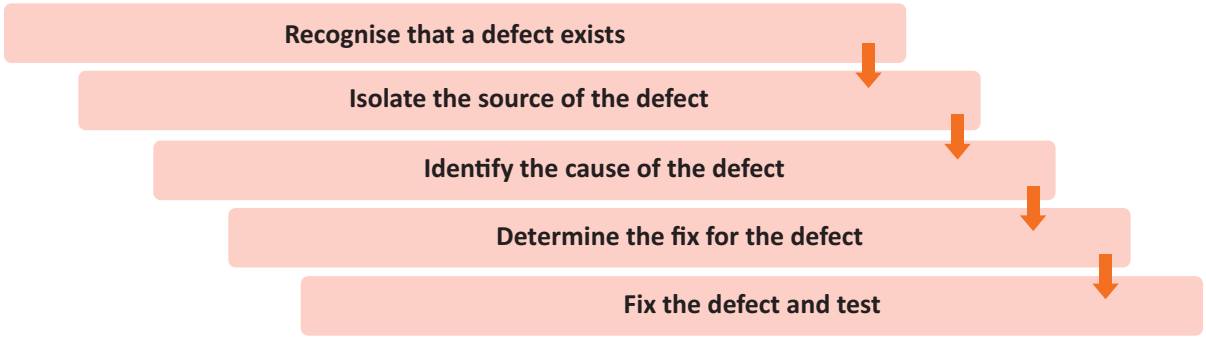


Fig. 2.27 Steps to Debug a Software

Debugging may be fixing a simple error or performing complex lengthy tasks like data collection, analysis, scheduling updates, etc. In programming languages like C, bugs can cause memory corruption, which may be difficult to observe when the initial issue occurred. In such cases, memory debuggers are used. Another type of tool called the static code analysis tool is used when there is a very specific set of known issues within the source code giving importance to data flow rather than the syntax.

In the case of embedded systems, debugging becomes difficult as the system is built for a single task or a small range of tasks and a specific platform is selected to optimise that application. Therefore, different debugging tools will be required for different platforms. Some of the debuggers available commercially for embedded systems are Green Hills Software, Lauterbach GnbH, MPLAB-ICD, Aveksha and Flocklab.

The various techniques of debugging are:

Print debugging also known as tracing involves watching either live or recorded the trace statements, which indicate the data progression and process flow of implementation. It can be carried out using specialized tools like GDB's trace or by insertion of trace statements in to the source code, known as *printf* debugging.

Interactive debugging allows the code execution of an application to be processed step-by-step at a time and stopped to inspect or alter the state of application. It allows watchpoints, where the execution to proceeds until a particular variable alters and catchpoints, where the debugger stops for certain types of program events like loading of a shared library or exceptions.

Remote debugging allows debugging of a program that is running on a system different from that of the debugger. For remote debugging the debugger connects to a remote system on a local area network (LAN) or any other communication link and control the execution of the program and retrieve the information.

Post-mortem debugging is carried out after the program has crashed. The dump of the crashed program can be obtained automatically by the system or by a programmer-inserted instruction or manually by an interactive user and techniques like analysis of memory dump, examining of log files, outputting a call stack can be carried out.

Record and replay debugging involve the technique of creating a recording of the program execution that can be replayed and interactively debugged. It can be used for remote debugging, intermittent debugging and hard-to-reproduce defects debugging.

Time travel debugging involves going back in time through the source code to understand the events occurring during execution of the program and allow users to interact with the program and change the history and observe the way the program responds.

Fig. 2.28 Various Techniques of Debug

Notes



2.3.4 Database and Software Module Library

A **database** is a set or collection of structured information or data that is stored electronically in a computer system. A database is controlled by Database Management System (DBMS). Large databases are hosted on computer clusters or cloud storage and small databases are stored in a file system. The various databases available are Oracle, MySQL, Sybase, SQL Server, Sybase, etc. the level and degree of support needed will vary from project to project. The DBMS helps to store and retrieve users' data by taking all the necessary security steps. It accepts data requests from an application and instructs the OS to give the specific data.

The choice of database for software programmers depends on the following factors:

- Data requirements for the software being developed
- Maximum number of users that will be using the application at the same time
- Space requirement
- Frequency of change in database schema
- Distribution of the user base
- Security features
- Scalability requirements of the software
- Budget availability for database software and licenses

Fig. 2.29 Factors to be Considered While Choosing Database

A **software library** is a collection of non-volatile resources like documentation configuration and helps data, message templates, pre-written codes, classes, sub-routines, values, etc. used for software development and computer programs. Programmers writing a higher-level program can use the library to make system calls instead of implementing these system calls repeatedly. It can also be reused by multiple independent programs.

- In a static library, the code of the library is accessed during the building of the invoking program. Or build the executable of the invoking program and distribute independent of the library implementation.
- In dynamic library, the library behaviour is connected after the executable has been invoked to be executed at the start or the middle of the process.
- In a shared library or shared object, the intended files is shared by executable files and further shared by object files. In shared libraries, when the executable files are created, the references to the library modules are resolved and the modules are allocated memory, i.e., during the compile-time. Many modern operating systems also have shared library files in the same format as the executable files.
- In memory sharing libraries, the library code can be shared in memory by multiple processes and on

Fig. 2.30 Types of Software Libraries

In a language like C, the behaviour in the library is called by using the normal-function call and the distinction between the call as a library function and as to another function in the same program is done by the way the code is organised in the system. A library code is organised in a way that it can be used by multiple programs which have no connection to each other, whereas a program code that is part of a program can be used only within that program. When a program becomes very large, then internal libraries can be reused by independent sub-portions of the large program.

There are standard libraries available for most of the compiled languages and also programmers create their own custom libraries. Modern software systems provide libraries with organised services required by modern applications.

2.3.5 High-level Computer Languages – C and C++

C language is also known as mother language as it is the base for other programming languages and they can directly interact with hardware devices. It was developed by Dennis Ritchie in 1972 at bell laboratories of American Telephone and Telegraph (AT&T) in the USA to construct utilities running on Unix. It is used in device drivers, operating systems, protocol stacks, etc. It is also used in computer architecture ranging from large supercomputers to small microcontrollers to embedded systems. It is a successor of the B language. It is one of the most widely used programming languages and C compilers are available for the latest computer architectures and operating systems. C language can be considered as:

- Mother language as most of the programming languages follow C syntax like C++ and Java, also most of the kernel, compilers are written in C language.
- System programming language as it is used to carry out low-level programming and create system software
- Procedural and structured programming language as it specifies the steps to be taken while programming and breaks it into parts, blocks, functions, etc.
- Mid-level programming language as it supports both low-level (specific to one machine) and high-level (machine independent) languages.

Fig. 2.31 Highlights of C Language

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Some of the features of the C language are:

Simple	• It helps to break the problem into parts and have a structured approach and provides numerous library functions, datatypes, etc., thus making the language simple.
Portability	• C programs can be executed on different machines with a few machines' specific modifications.
Quick development process	• The availability of inbuilt functions helps in quicker development process.
Better memory management	• The dynamic memory allocation helps to free the allocated memory by calling the free ( ) function at any time.
Pointer	• Pointers help to directly interact with the memory and also use for Functions, arrays, structures, etc.
Recursion	• Recursion helps to call the function within the function and use the backtracking approach. It also provides code reusability for every function.
Extensibility	• C language can adopt new features easily, which makes it extensible.

Fig. 2.32 Features of C Language

C++ languages

C++ is an extension of C programming and is an object-oriented, generic and procedural programming language. It is a mid-level language with features of both high-level and low-level language features. It supports inheritance, polymorphism, encapsulation and abstraction which are part of object-oriented programming. It is used in client-server applications, windows applications, device drivers, embedded firmware, etc. In addition to the features of the C language, C++ also have features like compilers, reusability, easy error detection, modelling real-world problems, clarity, flexibility, etc.

2.3.6 Operating System

An operating system is system software that runs on a computer and manages the computer hardware, computer memory and processes, software resources, provides services for computer programs, etc. It can be defined as software that acts as an interface between the users and the computer hardware. The OS performs various functions like:

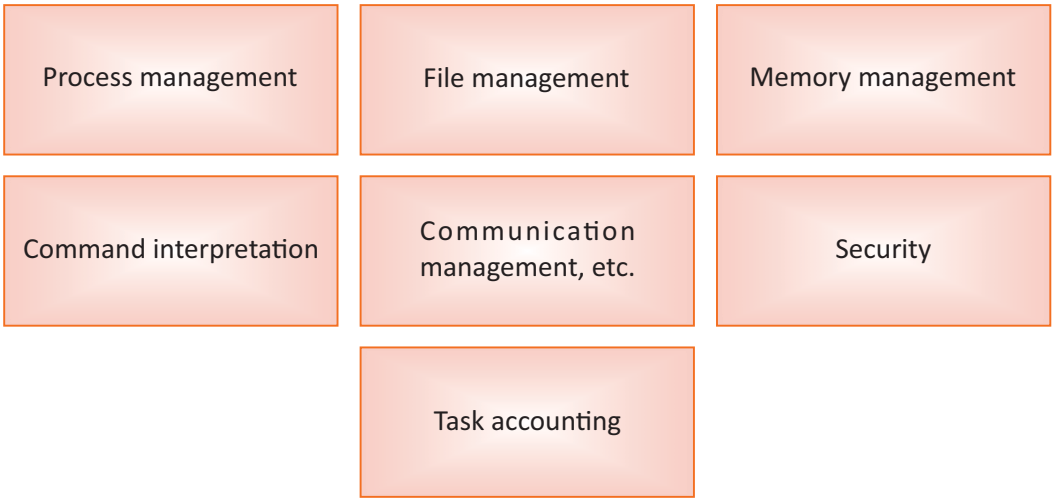


Fig. 2.33 Functions of Operating System (OS)

Windows Operating System (OS)

It is also known as Microsoft Windows or Windows and is developed by Microsoft Corporation. It was mainly developed to run personal computers, featuring the first graphical user interface (GUI). The first version of Windows was launched in 1985, which was a CUI offered as an extension of the Microsoft disk operating system (MS-DOS). It allows users to store and view files, play games, watch movies, run software, connect to the internet, etc. The advantages of MS Windows OS are speed, compatibility, good search tool, safety and security, lower hardware requirements, good interface, etc. The following figure shows the timeline of the version releases of Windows:

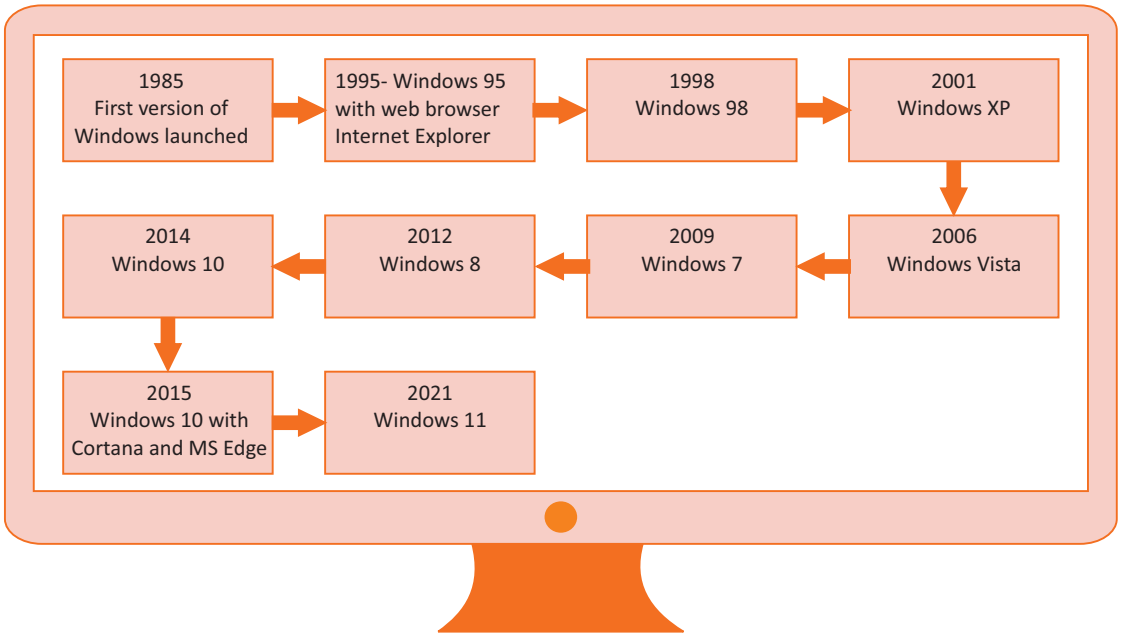


Fig. 2.34 Time-line of Release of Various Versions of Windows OS

LINUX OS

Linux operating system was created by Linus Torvalds. He felt that the UNIX OS needed improvements and launched an operating system which was receptive to changes suggested by its users. It was launched in 1991 as an open-source OS. Linux became attractive to programmers as they were able to use the Linux Kernel to design their own custom OS. Linux kernel is used in combination with GNU and all modern distributions of Linux are distributions of Linux/GNU. The advantages of Linux are, it's free, portable on any hardware platform, secure, versatile, scalable and has very short debug times.

Notes



Unit 2.4 - Embedded System Software Development and Implementation

Unit Objectives

At the end of this Unit the trainee will be able to:

1. Explain how to read and interpret project requirements from Business Requirement Specification (BRS) and Software Requirement Specification (SRS) document
2. Explain the embedded system, designing flow and implementation of embedded system software
3. Explain how to do system testing, product verification and validation
4. Explain the system level integration
5. Explain the end-product application, i.e. industry for which embedded system is designed

2.4.1 Business Requirement Specification (BRS) and Software Requirement Specification (SRS) document

In the process of software development, there are many stakeholders involved including users, investors, vendors, project managers, designers, coders, testers, senior management executives, etc. to name a few. All these different people have different requirements and expectations for the project and these have to be documented well for clear understanding, communication and execution of the project. For example, the investors and management would be interested in the financials of the project, the users would be interested in the functions and performance of the product, the coders would be interested to know the software requirements, etc. Therefore, the document is created in such a way that clear, concise and accurate information is available for all the stakeholders. Each of the concerned parties can refer to the portion that directly impacts their work while carrying out the tasks.

A business requirements specification (BRS) document describes the business objectives of the customers, performance expectations and key targets of the project. It is a high-level document and is created at the beginning of the project. It is based on the specifications mentioned by all the important stakeholders. The various people who use the BRS document are investors, middle and upper management and business analysts.

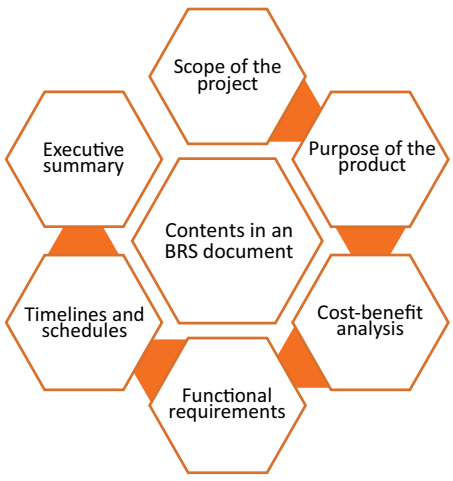


Fig. 2.35 Contents in a BRS Document

A **software requirement specification (SRS) document** is a document that specifies the purpose and function of the software. It also describes the way in which the software has to be developed and provides a roadmap for the project. The SRS document helps the requirement of the customer to be put in a language that the developers understand and is created as per the agreement made by the customers and the developers. It helps to estimate the scope and cost of the work/project. It also helps programmers to plan their work. the SRS document helps in communication between the various team members like the project managers, designers, coders, and testers. The SRS helps the various people involved in the project in the following manner:

- Gives designers the project insights to create a design that will fulfil the requirements
- Gives programmers an idea about the technical features that will be required.
- Gives testers the guidelines to prepare the unit test cases to meet the specifications.
- Gives end-users an insight about the software.
- Gives all other stakeholders an overview of the system & helps them in taking descisions.

Fig. 2.36 Benefits of SRS Document

The various elements in an SRS document are:

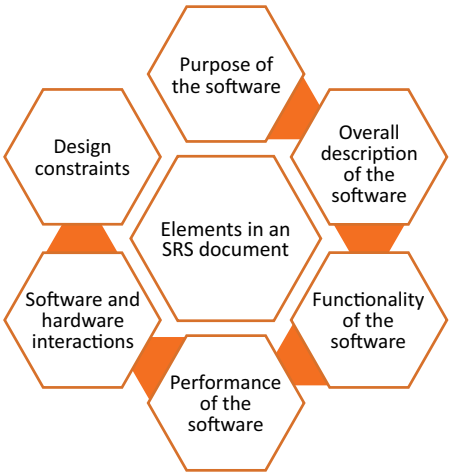


Fig. 2.37 Elements in an SRS Document

The following are some of the characteristics of an SRS:

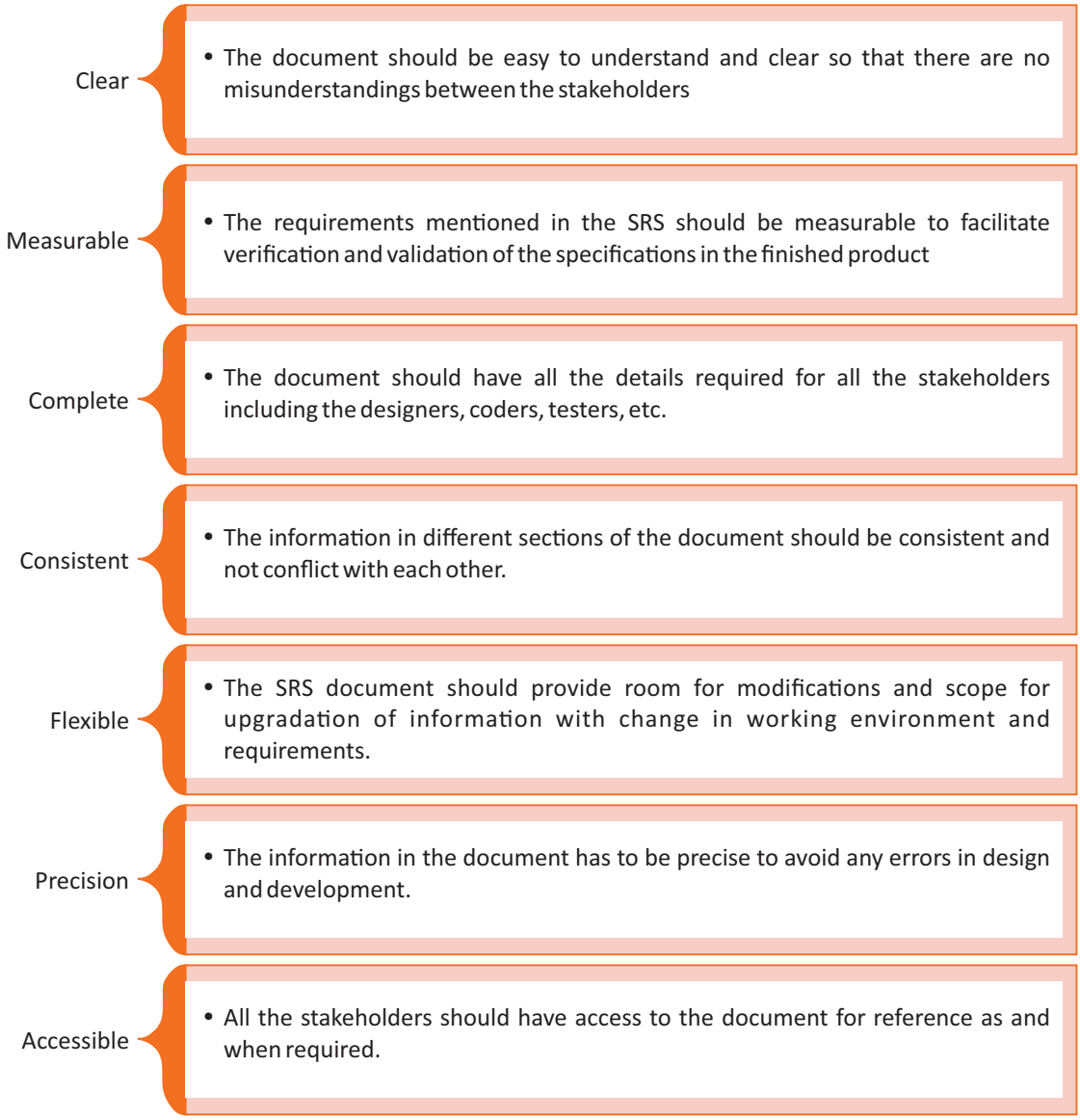


Fig. 2.38 Characteristics of SRS Document

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2.4.2 Embedded System Software Development Process

An embedded system consists of a computer hardware system with software embedded in it. It consists of three main components, hardware, application software and a real-time operating system. It can be an independent system or a part of a large system. It is built for carrying out a specific function that provides real-time output based on the features of the embedded system. The advantages of embedded systems are they provide high performance and efficiency at a low operational cost and power consumption, and a few hardware can be utilised for a variety of applications. The disadvantages are that it requires skilled engineers and requires more time to develop. An embedded system consists of both software and hardware components performing specific functions. The choice of components depends on the application and customer requirements. The language code used for communication in embedded systems is known as firmware. The following are the hardware and software components present in an embedded system:

Hardware components	Software components
• Processor • Power supply • Timers/Counters • Input/Output • Memory • Communication ports	• Emulator • Compiler • Debugger • Assembler

Fig. 2.39 Hardware and Software Components in an Embedded System

Process flow chart for embedded system design process and implementation of software:

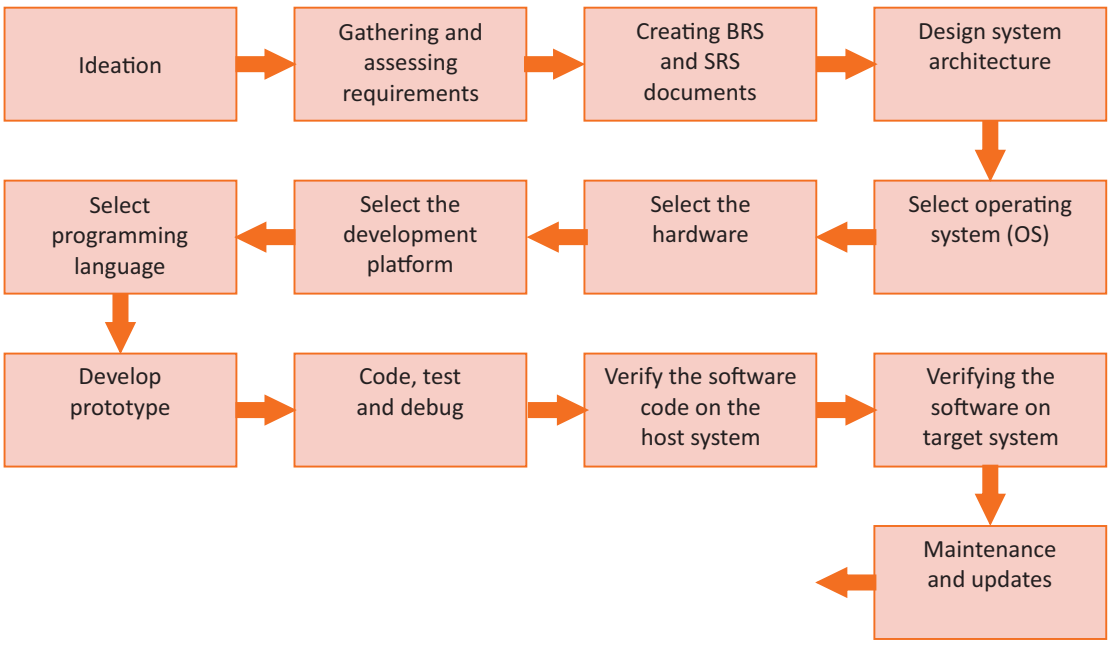


Fig. 2.40 Process Flowchart of Design Process and Implementation of Software in Embedded Systems

a. The first step in the design process of an embedded system is to ideate the product that is required. This may come from the customer of the manufacturer. At this stage, the initial requirements, working and benefits of the product are discussed along with the price points of the product.

b. The next step is to gather as much information as possible about the project, related to the technical specifications, functional and non-functional requirements, performance, physical aspects of the application, power consumption, manufacturing cost, timelines, manpower requirement, etc.

c. Based on the information gathered, the BRS and SRS documents are written and shared with all the stakeholders to seek their inputs, modifications required, etc. and final approval is taken to start the design and development process.

d. There are different types of architecture and its selection is done in this phase. The two types of architecture are Von Neumann and Harvard architectures. If the data and the code are in the same memory, then it is known as Von Neumann architecture and if the data and code are in different memory blocks, then it is known as Harvard architecture.

e. The selection of the software is based on time constraints, ease of development, efficiency, connectivity, graphics, hardware, licensing, pricing, etc.

f. The next step is to choose the required hardware like microprocessors, microcontrollers, peripherals, converters, etc.

g. The selection of development tools like editor, compiler, libraries, debugger, assembler, integrated development environment (IDE), etc. is carried out next.

h. The selection of the programming language is based on the ease of development, ease of maintenance, longevity, runtime efficiency, expressive power, low-level interface, availability of libraries/modules, graphic and connectivity support, developer community, etc. The most popular languages available are C, C++, Java, Python, etc.

i. The next stage is to develop a prototype based on the chosen architecture designs and verify the to see which of them suits best for the project.

j. The next step is the software coding, testing and debugging is carried out using the tools selected in the earlier phase.

k. Then the software is verified using an emulator within the system.

l. The next step is to verify if the software works in the target system where it is embedded.

m. The product is continuously monitored from this stage onwards upgrading to fix problems, making adjustments and maintaining the software.

Notes



2.4.3 Testing, Verification and Validation of Embedded Systems

Embedded system testing involves the process of checking the functional and non-functional features. This is carried out to ensure that both the hardware and software are free from defects and functioning as per the requirement and ready for the final release. Testing is carried out on five levels:

Software unit testing	• The testing is carried out on software components to check if the performance of the code is as per the requirement. It is carried out during the software development phase.
Integration testing	• This testing is carried out to test the interaction between the software components and the hardware and also between the software and the peripheral devices.
System unit testing	• This process is called as gray box testing, where the software codes, real-time OS (RTOS), communications, mechanisms, etc are tested. The point of protocol is used to send messages and see if it is done through the RTOS message queues.
System integration testing	• In this testing is the whole system consisting of the subsystem components in a node, network communiucation protocols, RTOS, network messages, etc. are observed.
System validation testing	• This is carried out to check if the complete embedded system and the subsystems are implemented correctly.

Fig. 2.41 Various Levels of Testing of Embedded Systems

Embedded testing is difficult as there are both hardware and software involved in it and it is highly dependent on the hardware that they are developed for. There are a few challenges faced during embedded system testing due to high defect levels, high dependency on hardware, difficulties in reproducing a defect/bug, frequent upgrades, etc. This can be addressed by using automated software testing tools.

Verification and validation

Verification and validation are used throughout the design and development stage of the product to ensure that the correct product is being built in the correct manner.

Verification is the process of checking the consistency, correctness and completeness of the product/software at each and every stage of the development life cycle. The different types of verification carried out on embedded software are static, dynamic and hybrid verification techniques.

Static techniques check the correctness of the software by analysing the specifications and implementation of the source code without actually running the code. The main techniques used are theorem proving, model checking and static analysis.

Dynamic techniques check the entire hardware-software system together with the help of simulators using techniques like testing, assertion-based verification and co-simulation.

Hybrid techniques uses the combination of both static and dynamic techniques to overcome the inefficiencies in both the techniques. Predicate abstraction technique is a hybrid technique where simulation and model-checking approaches are used.

Fig. 2.42 Various Verification Techniques

During verification, the software is first verified in the initial development stages, then the code is executed on a simulator to verify and finally, the software is deployed on the actual hardware for verification.

Validation is the process of checking the correctness of the final product with respect to the requirements of the user. There are different types of validation carried out like performance validation, functionality validation, communication validation, model validation, etc.

Performance validation focusses on the timing properties like real-time calculus, microarchitectural modelling, by considering external interference like preemption and interrupts.

Functionality validation involves the validation of low-level implementation of variuos components and is carried out using dynamic traces and directed testing.

Communication validation is carried out to validate the communication protocols between components.

Model validation is carried out on high-level abstractions like inter-component behavior of a system.

Fig. 2.43 Various Types of Validation

2.4.4 System-level integration

System integration is the process of combining or building a large system or a set of systems. The process of integration can be understood starting from the stage of chip-level embedded systems forming a board-level embedded system which can then be integrated into a device-level system.

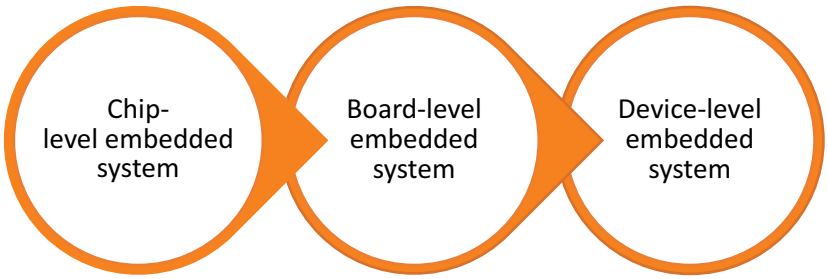


Fig. 2.44 System Level Integration of Embedded Systems

There are different methods of system integration. Vertical integration involves the process of integrating subsystems as per their functionality by creating functional entities. Star integration involves the process of interconnecting various subsystems to each other. Horizontal integration involves the creation of a specialized subsystem to communicate between the other subsystems.

2.4.5 Types and Application of Embedded System

There are different types of embedded systems are classified based on i. the performance and functional requirements and ii. the performance of the microcontroller.

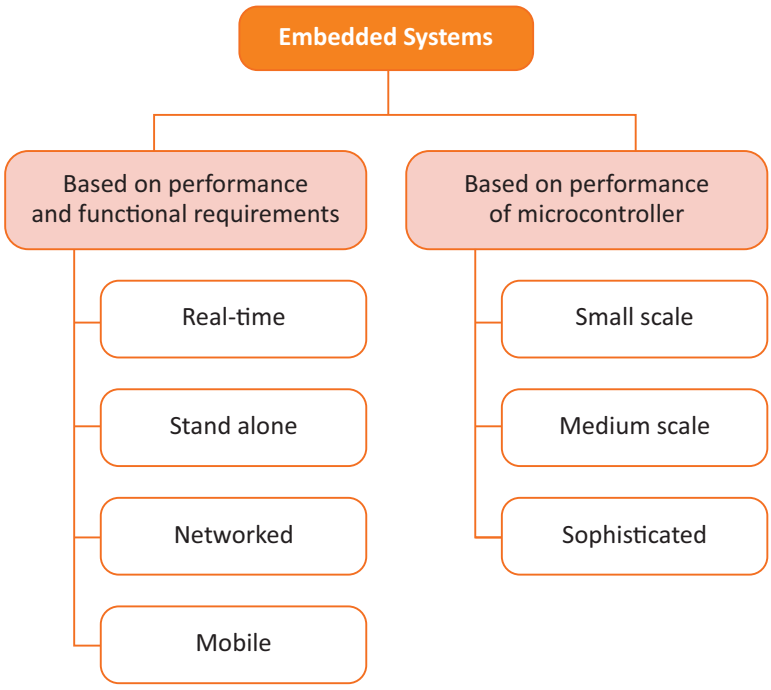


Fig. 2.45 Types of Embedded Systems

Types of embedded systems based on performance and functional requirements:

a. **Stand-alone** embedded systems work independently without a host system like a computer. It takes either the analog or digital data from the input ports, processes the data and displays, controls or drives the output on the connected devices. Examples: **digital cameras, microwave ovens, temperature measurement systems,** etc.

b. **Real-time** embedded systems give outputs at a particular time and follow time deadlines for performing and completing a task. Examples: **vehicle controls, pacemakers, anti-lock braking systems,** etc.

c. **Networked** embedded systems are connected to a network like a local area network (LAN), wide-area network (WAN) or the internet either by means of a wire or wireless techniques. In this type, all the embedded devices are connected to a web server and accessed and controlled by the web browser. Examples: **home and office security systems, automated teller machines (ATMs),** etc.

d. **Mobile** embedded systems are designed to be portable like **mobile phones, digital cameras, mp3 players, wearable devices,** etc.

Types of embedded systems based on the performance of the microcontroller:

a. **Small-scale** embedded systems are made with a single 8- or 16-bit microcontroller that can be activated with a battery. Programming tools like editor, cross assembler, assembler, integrated development environment, etc. are used. Examples: **Bluetooth headphones, motion sensors, smoke sensors, temperature sensors,** etc.

b. **Medium-scale** embedded systems are made with 16- or 32-bit microcontrollers and digital signal processors (DSPs). Programming tools like C, C++, Java, debugger, source code engineering tool, simulator, and IDE are used. Examples: **Automated Teller Machines (ATMs).**

c. **Sophisticated** embedded systems are made with 32- or 64-bit microcontrollers and multiple programmable logic arrays (PLAs) and configurable processors. Examples: **air-conditioners, hybrid vehicles, medical imaging systems,** etc.

Applications of embedded systems can be seen in aerospace, agriculture, consumer electronics, wearable devices, robotics, health care, military and defence, etc.

Notes



Summary

- Organisational policies are created to provide guidelines for the day-to-day operations and activities of the organisation. These policies help in internal processes, decision-making, and compliance with government and legal requirements.
- Incentive policy is used by companies to motivate their workforce. Incentives are given to employees besides salaries. The incentives are given to encourage people to typically carry out activities that benefit the company as well as the individual.
- The personnel management policy provides guidelines for people in the human resources (HR) department related to the recruitment and hiring process, wages and payroll information, work schedules and absence/leave policies, promotion and demotion, performance evaluation, training and development, transfers, job security, compliance with labour laws and policies of the Government.
- Every organization creates and outlines a set of principles that it commits to following or requires its employees to follow and it is documented as the company code of conduct. Codes of conduct may be applicable to vendors, suppliers, subcontractors, and third parties in some cases. It is crucial to establish a code of conduct in any organization.
- The documentation policy defines an organisation's approach to implementing document control and practices throughout the company. Documents serve as key records for management purposes and also as proof of compliance.
- The IPR provides individuals and organisations property rights to the information and intellectual content/goods that they create. These rights are usually for a limited period of time and allow them to protect their ideas from being copied by others.
- IP theft can happen in organisations from their own employees or from external people. Therefore, many companies sign a non-disclosure agreement (NDA) with their employees or give restrict employee access.
- Every organisation producing and delivering tangible or intangible products or services prioritises quality as it directly impacts the expectations and requirements of the customers.
- Intellectual Property (IP) core is also known as semiconductor intellectual property (SIP) core or intellectual property (IP) block and it is the reusable unit of a cell, logic or an IC layout design that is the property of one company or party.
- The software development tools consist of a set of programs and tools provided by hardware and software vendors. These are used by developers to build applications. The software tools include compilers, routines, subroutines, linkers, graphical user interface tools, support libraries, etc.
- The interdependence of various authorities in an organisation is referred to as a reporting structure. It is a hierarchical chain of command that specifies the reporting format of all the employees in the company. In small businesses with a few employees, some reporting structures are self-evident.
- Typically, software development companies manage many projects at the same time and different teams are assigned to work on various projects. The two popular ways of structuring are either **project-based** or **function-based**.
- Team structuring becomes important while dealing with multiple projects in the organisation. Team structures may have to be altered often depending on the product, technical complexity, manpower availability, time and cost constraints, etc.

- A democratic team is also known as an ego-less team. In this format, all the team members agree on the objective of the project and inputs from each member are considered in the decision-making process.
- This type of format has a hierarchy and the team is headed by a chief programmer, who is responsible for taking all the major decisions and the other members provide support.
- This structure incorporates both the above types of team structures. Typically, the team consists of a sub-set of individual teams, each consisting of a group of junior programmers reporting to a senior programmer, who in turn reports to the project manager.
- System design is the process of defining, designing and developing the elements of a system like its components and their interfaces, modules, architecture, and the information/data that goes through the system as per the specific requirements for the business or organisation.
- An electronic circuit consists of electronic components like resistors, capacitors, inductors, transistors, diodes, etc. connected by wires which allow the flow of electric current. The two main types of electronic circuits are analog and digital circuits.
- In **analog circuits**, resistors, inductors, and capacitors are mainly used to process any analog input signal or data and produce an output in analog form. In these circuits, the signal is a continuous function of time and they can process the real-world signals that are analog directly without the need for signal converters.
- In **digital circuits**, logic gates are the main components used to process discreet time signals (input) to digital signals (output). As real-world signals are analog, digital circuits require signal converters like Analog to Digital Converter (ADC) and Digital to Analog Converter (DAC).
- The process of circuit design ranges from the design of an individual transistor in an integrated circuit to complex electronic systems. Electronic circuits are used in computation, data transfer and signal amplifications.
- The circuit design process starts with getting the specifications from the customer, which details the functions of the final design without stating the methods to achieve them.
- After receiving the specifications, designing begins with making a block diagram keeping all the functions mentioned in the specifications in mind. At this stage, only the function is taken into account and not the components that go into each block.
- The verification process helps to go through every stage of the design to check if it meets the specifications through computer simulations of the designs.
- The design software helps to create cheaper, more efficient and longer-lasting circuits. There are different types of software available like HDL, VHDL, Verilog, etc.
- The prototyping process is important to know if there are any issues in the circuit which can cause damage to the product or the user
- The documentation process typically involves recording the specifications, design details, prototype details, verification and test procedures and results, compliance with regulatory guidelines, etc.
- Embedded software engineers should be able to understand the diagrams and symbols that are used to describe and create the designs. These diagrams contain information that the engineer will require to design software that is compatible with the hardware.

- **Block diagrams** are used to show major components on a board like processors, input/output, memory, buses, etc. or single components like a processor at the system architecture level. Block diagrams are the simplest way to represent and describe components in a system as it uses squares and rectangles for the components and straight lines for the buses.
- A **schematic diagram** or a circuit diagram is a symbolic representation of a circuit and shows the way all the components are connected within a circuit or within a single component.
- The schematics represented in the form of written technical information are the datasheets. They contain information facts, figures and specifications and a step-by-step guide to identify and extract the information.
- Computer architecture is a set of specifications describing the functionality, performance, organisation and implementation of computer systems.
- A computer consists of various components like a control unit, memory unit, I/O controllers, and arithmetic logic unit (ALU) which are realized with transistor circuits.
- A software is designed in such a way to transform the user requirements into a form that helps the programmer in coding and implementation.
- In the object-oriented design process, the whole system is seen as a collection of entities or objects. It is one of the approaches used in software design which involves the planning of a system of interacting objects to solve a software problem.
- The input for OOD is provided by the object-oriented analysis. The analysis and design can happen in parallel and in increments rather than completely developing at once.
- The concepts of OOD are features that are built into the programming language.
- The two main types of output of OOD are sequence diagram and class diagram.
- Data structure is a method to manage, organize and store data in the memory for efficient access to data.
- An algorithm is a set of rules or a finite sequence of instructions followed to perform a computation or during problem-solving operations. They are used as specifications for data processing and also for performing calculations.
- **Enterprise resource planning (ERP)** refers to a type of software used by businesses to manage day-to-day business operations such as accounting, procurement, project management, risk management and compliance, supply chain operations, etc.
- The software development process begins with gathering the requirements of the system and user so as to develop the software to meet the expectations. The process involves dividing the software development tasks into smaller steps or sub-processes, which can be carried out parallelly or sequentially
- The component design has to be first represented in a form that can be translated into a source code. It is important to conform to the guidelines to prevent the introduction of errors while designing the interfaces, data structures, algorithms, etc.
- Coding is the process of converting the design into a computer language format, in other words, it is translating the design specifications into the source code. The code has to be written and documented to verify the conformance of the code to the specifications.

- Certain coding standards have to be followed by the coders/developers irrespective of the programming language being used. The coding standards are best practices to develop more readable, cleaner and more efficient code with minimum errors.
- Software testing is carried out to test the software against the system and user requirements. Testing is carried out at the module level in the program code.
- Unit testing is a method of testing individual isolated software components for their correctness. This enables to test most of the code paths, argument bounds and failures cases.
- Unit Test Case (UTC) is a document providing details of the specific test set-up like the preconditions, expected results, and post-conditions to verify compliance with the requirements.
- The test plan describes the objectives of the test, test procedures, features to be tested, the test environment, and the testers required for the testing.
- Debugging is the process of detecting and removing bugs or errors in the software codes. There are different types of errors or bugs that can occur like design errors, coding errors, poor user interface designs, complex interactions, system failures, etc.
- Debugging may be fixing a simple error or performing complex lengthy tasks like data collection, analysis, scheduling updates, etc. In programming languages like C, bugs can cause memory corruption, which may be difficult to observe when the initial issue occurred.
- In the case of embedded systems, debugging becomes difficult as the system is built for a single task or a small range of tasks and a specific platform is selected to optimise that application.
- A database is a set or collection of structured information or data that is stored electronically in a computer system. A database is controlled by Database Management System (DBMS).
- A software library is a collection of non-volatile resources like documentation configuration and helps data, message templates, pre-written codes, classes, sub-routines, values, etc. used for software development and computer programs.
- In a language like C, the behaviour in the library is called by using the normal-function call and the distinction between the call as a library function and as to another function in the same program is done by the way the code is organised in the system.
- There are standard libraries available for most of the compiled languages and also programmers create their own custom libraries. Modern software systems provide libraries with organised services required by modern applications.
- **C languages** is also known as mother language as it is the base for other programming languages and they can directly interact with hardware devices. It was developed by Dennis Ritchie in 1972 at bell laboratories of American Telephone and Telegraph (AT&T) in the USA to construct utilities running on Unix. It is used in device drivers, operating systems, protocol stacks, etc. It is also used in computer architecture ranging from large supercomputers to small microcontrollers to embedded systems.
- C++ is an extension of C programming and is an object-oriented, generic and procedural programming language. It is a mid-level language with features of both high-level and low-level language features. It supports inheritance, polymorphism, encapsulation and abstraction which are part of object-oriented programming.
- An operating system is system software that runs on a computer and manages the computer hardware, computer memory and processes, software resources, provides services for computer programs, etc. It can be defined as software that acts as an interface between the users and the computer hardware.

- Windows Operating System (OS) also known as Microsoft Windows or Windows is developed by Microsoft Corporation. It was mainly developed to run personal computers, featuring the first graphical user interface (GUI).
- Linux operating system was created by Linus Torvalds. He felt that the UNIX OS needed improvements and launched an operating system which was receptive to changes suggested by its users.
- In the process of software development there are many stakeholders involved including users, investors, vendors, project managers, designers, coders, testers, senior management executives, etc. to name a few.
- A business requirements specification (BRS) document describes the business objectives of the customers, performance expectations and key targets of the project. It is a high-level document and is created at the beginning of the project.
- A software requirement specification (SRS) document is a document that specifies the purpose and function of the software. It also describes the way in which the software has to be developed and provides a roadmap for the project.
- An embedded system consists of a computer hardware system with software embedded in it. It consists of three main components, hardware, application software and a real-time operating system. It can be an independent system or a part of a large system.
- Embedded system testing involves the process of checking the functional and non-functional features. This is carried out to ensure that both the hardware and software are free from defects and functioning as per the requirement and ready for the final release.
- Embedded testing is difficult as there are both hardware and software involved in it and it is highly dependent on the hardware that they are developed for.
- Verification and validation are used throughout the design and development stage of the product to ensure that the correct product is being built in the correct manner.
- Verification is the process of checking the consistency, correctness and completeness of the product/software at each and every stage of the development life cycle.
- Validation is the process of checking the correctness of the final product with respect to the requirements of the user.
- A system integration is the process of combining or building a large system or a set of systems. The process of integration can be understood starting from the stage of chip-level embedded systems forming a board-level embedded system which can then be integrated into a device-level system.
- There are different types of embedded systems classified based on i. the performance and functional requirements and ii. The performance of the microcontroller.
- Applications of embedded systems can be seen in aerospace, agriculture, consumer electronics, wearable devices, robotics, health care, military and defence, etc.

Exercise

Answer the following questions :

1. Discuss the purpose of organizational policies.

_____

_____

_____

2. Write a brief note on BRS and SRS documents.

_____

_____

_____

3. What is meant by the object-oriented design process?

_____

_____

_____

Fill in the blanks

1. _____ is a set of specifications describing the functionality, performance, organisation and implementation of computer systems.
2. An_____ is a set of rules or finite sequence of instructions followed to perform a computation or during problem-solving operations.
3. _____ is the process of checking correctness of the final product with respect to the requirements of the user.

Notes

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Notes

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SRS document

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BRS documents

Skill India
कौशल भारत-कुशल भारत

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MINISTRY OF SKILL DEVELOPMENT
& ENTREPRENEURSHIP

N·S·D·C
National
Skill Development
Corporation
Transforming the skill landscape

ESSCI
Skilling India in Electronics

3. Work effectively at the workplace

Unit 3.1 - Work and Communicate effectively at workplace

Unit 3.2 - Work in a disciplined and ethical manner

Unit 3.3 - Uphold social diversity at the workplace



(ELE/N9905)

Key Learning Outcomes

At the en d of this module, the trainee will be able to:

1. Work effectively at the workplace
2. Implement the practices related to gender and PwD sensitization

Unit 3.1 - Work and Communicate Effectively at Workplace

Unit Objectives

At the end of this Unit the trainee will be able to:

1. State the importance of effective communication and interpersonal skills
2. Explain the importance of conveying information/instructions as per defined protocols to the authorized persons/team members
3. Discuss ways of dealing with heightened emotions of self and others
4. Explain the importance of working as per the workflow of the organisation to receive instructions and report problems
5. Explain the importance of individuals role in the work flow

3.1.1 Significance of Effective Communication & Interpersonal skills

Effective communication is required for all employees in the organization to perform basic management functions and carry out their jobs and responsibilities. The ability to communicate effectively at work is essential regardless of industry. Effective communication entails more than just exchanging information; it also encompasses the emotion and intentions behind the facts and conveying a message. Therefore, communicating more clearly and effectively requires learning some essential skills. Learning these skills can assist employees in developing stronger bonds, gaining more trust and respect, improving teamwork, problem-solving, and overall social and emotional health. As a result, we can state that "effective communication is a foundational component of successful organizations."



Fig. 3.1 Importance of Effective Communication and Interpersonal Skills

It is extremely difficult for **project managers** to manage their teams and coordinate efforts for successfully completion of a project without strong interpersonal communication skills. A project cannot be successful if there is no communication. Without effective communication skills, dealing with all of the intricate details, dependencies, decisions, and approvals that a project entails would be impossible. The project manager must possess following interpersonal communication skills.

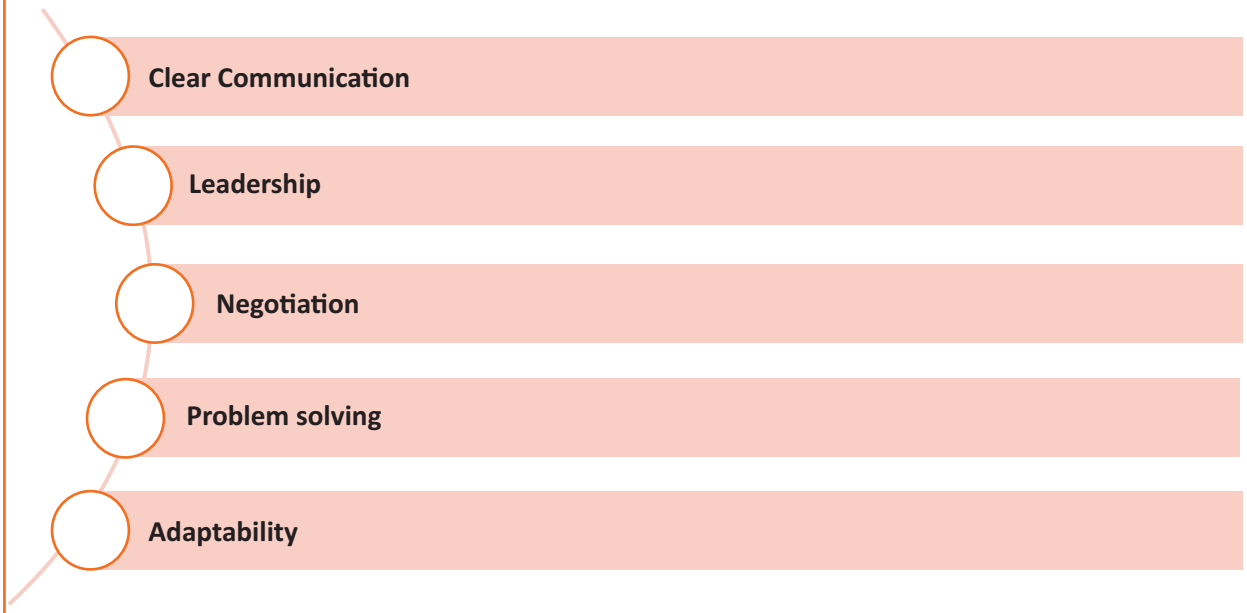


Fig. 3.2 Interpersonal Communication Skills of Project Manager

3.1.2 Communication Process

The process of communication is a dynamic structure that explains how a message is transmitted between a sender and a receiver via various communication channels. Its purpose is to ensure that the receiver accurately decodes the message and can provide feedback with precision and convenience.

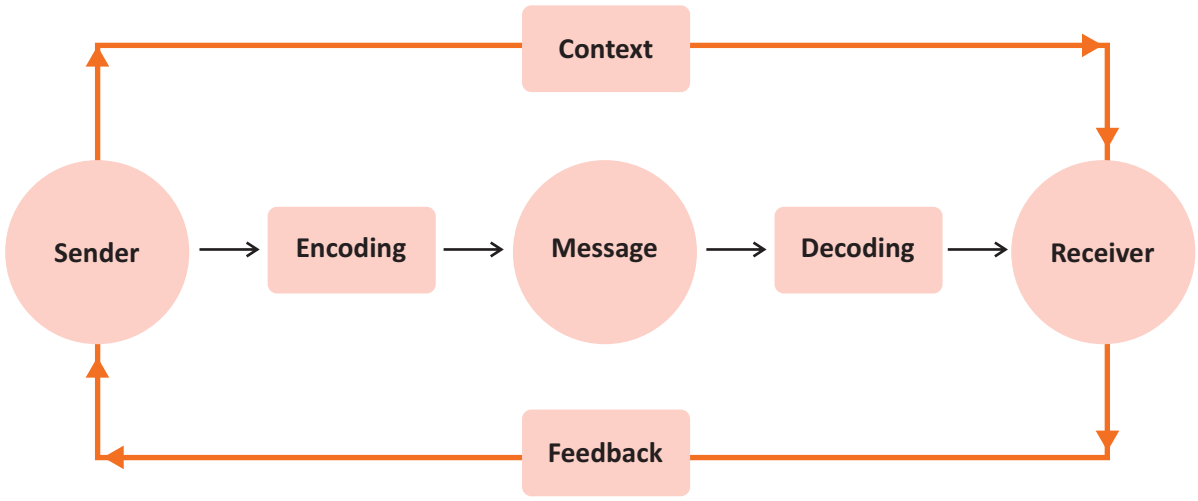


Fig. 3.3 Process of Communication

As demonstrated in the exhibit above, there are 8 elements of communication:



Sender
Who sends the message or is the source of the message.



Encoding
Transferring the message into a format that can be shared. It includes the language or tone chosen.



Message
The idea being communicated by the sender.



Channel
The mode chosen for communicating. Example- phone, oral, text, gestures, or writing.



Decoding
It means how the sender comprehends and understands the message that sender has communicated



Receiver
The idea being communicated by the sender



Feedback
The revert or the response communicated by the receiver to the source/sender after having decoded the message



Context
The environment, situation, or the circumstances in which the communication is happening

Fig. 3.4 Elements of Effective Communication

3.1.3 Communication Barriers

All of the elements depicted above can also act as a barrier to communication. Communication barriers are factors that prevent a message from being received in the way the sender sent it. People frequently face the problem of the message being received in an assumed manner when communicating. As a result, it leads to miscommunication and misunderstandings. Let us look at the table below to understand four significant barriers to communication.

Communication Barriers	
	**Physical or Environmental Barriers** • The barriers in the surroundings or in the environment are the physical barriers. • Example- Noise in the surroundings, the physical distance between the sender & receiver, defects in the communication system like network problems, poor signal, etc.

Continued...

Communication Barriers	
	**Language Barriers** • This barrier arises due to the different language or differences in the language of the sender and receiver. • This problem often occurs because of the different meanings perceived in the same word, or the receiver does not understand the jargon used in the message. The language barrier is not limited to spoken language. It also includes body language. • The same message is perceived differently by the receiver said with different body language.
	**Psychological Barriers** • Barriers or problems arising due to the differences in perception, ego clashes, prejudices, state of mind, poor past experiences, behaviors, attitudes, moods, and value systems are psychological barriers. • These barriers are generally exceedingly difficult to overcome.
	**Socio-Cultural Barriers** • Sometimes the differences in social or cultural norms cause communication problems. • These include how the people generally speak, wear, follow customs, behave, or eat is not completely understood by the receivers who are not accustomed to the differences. • For example, some communities are louder and more extravagant than others.

Table 3.1 Potential Barriers in Communication

3.1.4 Significance of Effective Communication with Team members

It is significant to convey information as per defined protocols to the authorized person's/team members, as it reduces communication gaps, strengthens alignment with all levels of leadership, and ensures that employees receive consistent messages. The Communication Protocol specifies the types of information to be communicated to the organization, as well as the person(s) in charge of communicating specific topics. The audience, frequency, and suggested communication vehicles are also discussed. The Protocol, which is prominently displayed in all common areas such as lobbies and conferences, and is distributed to all new hires, ensures that communications align with the company's key strategic priorities.

Effective communication with the supervisor is essential for professional development and advancement. Refer to the exhibit below for tips on communicating with the supervisor effectively.



Listen to your supervisor carefully and understand the goals and requirements



Report the facts and problems and ask for possible solutions if necessary



In case of an unsuccessful attempts, highlight it to the supervisor rather than covering it up



Stay open to feedback and keep a positive attitude



Inform immediately about any situation that needs attention



Follow the code of conduct that has been established by the organization



Igreet the supervisor with a smiling face



Don't argue with the supervisor in front of other employees



Concisely put your point of view, concerns, and requests in a polite and respectful manner



A loud voice tone suggesting impatience, sarcasm or taunt, is not acceptable by anyone



I Avoid words and topics which may offend someone



Communicate regularly with your supervisor to develop and maintain a successful professional relationship

Fig. 3.5 Effective Communication with Superior

Following proper communication, rules are critical to keeping a **healthy relationship with colleagues and co-workers.** The quality of the relationship with colleagues and co-workers will depend on the behavior you demonstrate while interacting with them. A relationship built on trust, excellent, clear communication, polite language, and appropriate behavior helps you succeed at work.

Greet everyone with a smile and positive body language.	**Listen actively and avoid jumping to conclusions**	**Offer help to a new colleague in your crew**
Show courtesy and respect to colleagues	**Speak in a polite and respectful tone**	**Make an eye contact while you speak**
Use positive words and body language	**Appreciate each other's work**	**Learn from your team members and collaborate with them**
Keep commitments made to your colleagues or team members	**Inform your colleagues in case of delay in the work**	**Do not be a grump. Leave your bad mood out of the worksite**
Do not engage in any kind of gossip	**Do not disturb others when they are working**	**Do not waste your time and others' time by holding conversations which are not related to work**
Do not interrupt when the other person is speaking. Wait for them to complete	**Avoid controversial conversations**	

Fig. 3.6 Effective Communication with Colleagues

3.1.5 Organizational Communication

Organizational communication can be divided into two categories: formal and informal communication.

1. **Formal communications** are those that are official and are part of a recognized communication system that is involved in the organization's operation. These communications can be either verbal or written.

   a. It can take place between a superior and a subordinate, or between a subordinate and a superior, administratively or externally.

   b. It can happen outside of the organization, i.e. with suppliers, clients, unions, government agencies, and community groups.

   c. It can sometimes be obligatory, indicative, or informative. Mandatory communication implies an order or command to be followed and is known by various euphemisms such as instructions, briefing, and so on.

   D. This type of communication is mostly vertical and usually one-way from top to bottom. Indicative or explanatory communication can occur at any level and may be vertical or horizontal.

2. **Informal communications** emerge from the social interactions of coworkers. These are bound by conventions, customs, and culture rather than any chart on the wall. In the form of grapevine, such communication provides useful information for upcoming events.

Any communication style is only effective if the listener actively listens, observes, and empathizes. In an organization, four major types of communication are used on a daily basis:

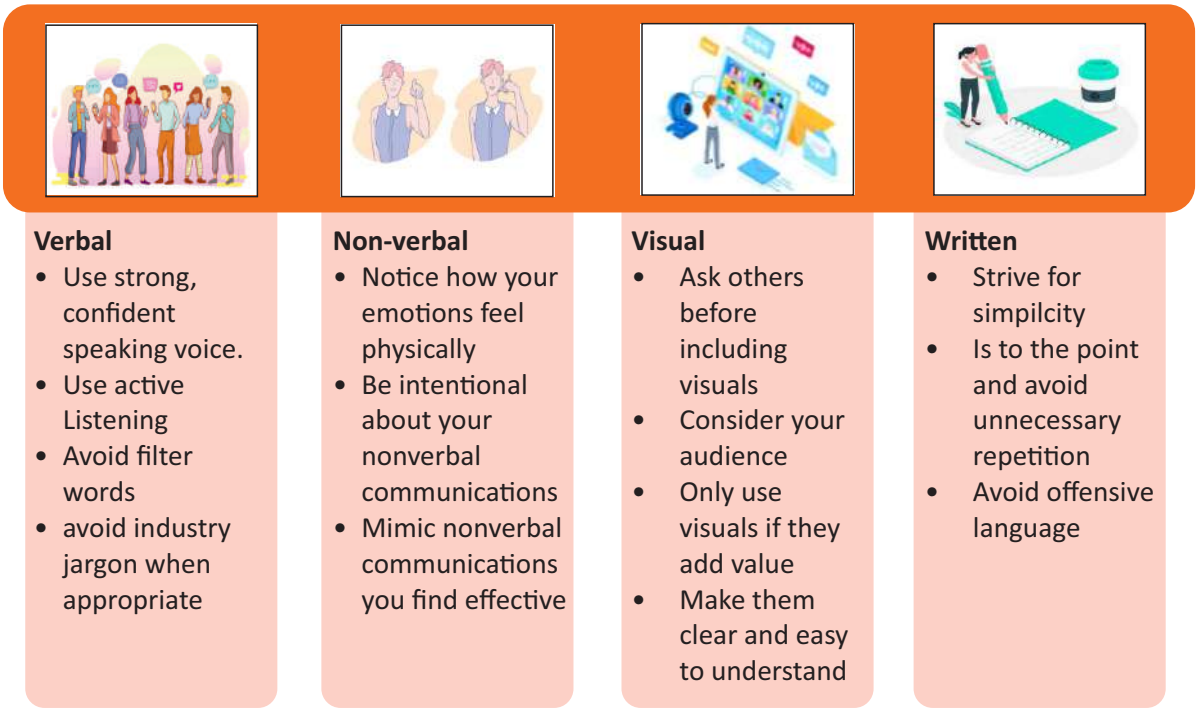


Fig. 3.7 Types of Communication and Ways to Use Them

3.1.5 Managing Emotions at Work

Humans are emotional beings. It is difficult for us not to be emotional. While it is generally beneficial to be in touch with our emotions and not suppress them, there are some situations in which we must manage our emotions especially well. This is especially true at work. Emotional outbursts at work could be caused by work-related issues or by stressors from our personal lives spilling over into our work lives. Handling our emotions (especially negative ones) at work is frequently regarded as a test of our professionalism. Although, it is never good to repress or suppress emotions, whether positive or negative. However, in order to function in a variety of situations, we must manage our emotions. The following are some coping strategies to deal with heightened emotions at work.



Fig. 3.8 Strategies for Coping with Heightened Emotions at Work

3.1.7 Organizational Structure

An organizational structure is a system that defines how specific activities are directed in order to achieve an organization's goals. These activities may include rules, roles, and responsibilities. The organizational structure also governs how information flows within the company. There are numerous types of organizational reporting structures, each with its own set of benefits and drawbacks. The reporting structure is chosen based on the organizational requirements. The following are the top organizational reporting structures.

Hierarchical organizational structure

- It is a pyramid-like top-down management structure.

Functional organizational structure

- It is a business structure that divides a company into departments based on areas of expertise.

Divisional or product organizational structure

- In a product-based structure (also known as a divisional structure), employees are assigned to self-contained divisions based on the -market, product line and geography.

Line-and-staff organizational structure

- In this structure, authorities (e.g., managers) establish goals and directives that are then carried out by employees and other workers.

Flat organizational structure

- A flat organizational structure means that there are few (if any) levels of management between the workforce and the highest-level managers.

Matrix organizational structure

- A matrix organization is a work structure in which team members report to multiple leaders.

Network organization structure

- It is a type of internal structure that prioritizes communication and relationship goals over hierarchy.

Fig. 3.9 Types of Organizational Structure

3.1.8 Importance of Working as per the Organization's Workflow

Workflow, in a broad sense, is the set of tasks—grouped chronologically into processes—and the set of people or resources required to complete those tasks to achieve a specific goal. The workflow of an organization consists of the processes that must be completed, the people or other resources that are available to perform those processes, and the interactions between them.



Fig. 3.10 Importance of Working as per the Organization's Workflow

Notes

3.1.9 Organizational Communication Policies and Procedures

Communication is a vital management component of any organization. Effective communication is a critical issue for effective management, whether the purpose is to update employees on new policies, prepare for a natural disaster, ensure safety throughout the organization, or listen to employees' attitudes. To attain success, organizations should have comprehensive policies for communicating with their, employees, stakeholders, and the community at large. With a formal, defined and comprehensive communication strategy, organizations can make sure that they:

1. Communicate consistent messages
2. Establish a distinguishable brand
3. Deliver messages that are congruent with the organization's mission, vision, and culture

Communication policies of an organization establish expectations and manage the flow of communications within and outside the organization. As a result, it facilitates meaningful and necessary communication for employee productivity and morale without restricting employees' feeling intimidated and powerless. In addition, good communication policy, reduces conflicts and misunderstandings.

An organization has many channels for communication, running internally and externally. It is imperative to regulate these channels for the sake of business interests. Therefore, communication policy and procedures need to be written out in clear, straightforward language for all the employees. When outlining these communication policies and procedures, it is essential to consider existing policies and regulations that must comply with the organization. It is important for a workplace where employees need to understand proper lines of communication and behavior with one another. Communication policy and procedures guide the employees for handling information, either outgoing or incoming, that pertains to the organization. It focuses on spreading important news and information to other co-workers, customers and stakeholders. Creating clear rules avoids liability issues and embarrassing or damaging situations in the organization.

1. **Procedures for verbal communication -** It is essential to communicate well verbally to understand what others are saying to you. Following are the key points when communicating verbally in an organization:

a. Employees should speak clearly and listen carefully when communicating with each other. If it is not clear, ask the person to repeat it or explain what they mean.

b. Speak clearly and slowly to deliver the correct message. Avoid speaking quickly or in a mumbling tone. Repeat the message to make sure it is right.

c. Pass on the urgent messages as soon as possible. If the person is busy, then then wait for your chance to speak. On the other hand, if the message is very urgent, inform them politely.

2. **Procedures for written communication -** Most workplaces have standard writing methods. They have special forms or layouts to use. These are sometimes called 'templates'. Using these is part of the organizational procedure. Each employee must use these standard layouts for written communication. For example, writing e-mails, letters, memos, faxes and messages and other office tasks. Below are the key points when using written communication in an organization:

a. Keep it simple. Make your sentences, paragraphs, and the overall document as short and concise as possible.

b. Strive for clarity

c. Keep it in a structured form

d. Use appropriate tone

e. Give the right amount of detail

f. Give copies to everyone concerned

3.1.10 Sharing Information with Team Members

In the workplace, information drives communication, and communication, in turn, allows all members of the organization, from entry-level employees to the CEO, to work together to achieve the company's goals and maximize productivity. Transparently sharing data and information ensures that everyone is in the loop and aware of any potential issues with the business, product, or service that can be addressed collaboratively. Employees might have lots of knowledge that is crucial for the organization and other employees. **Sharing information helps them connect, perform better, and become more vital as professionals.** The following chart explains the importance of sharing information with team members in an organization:

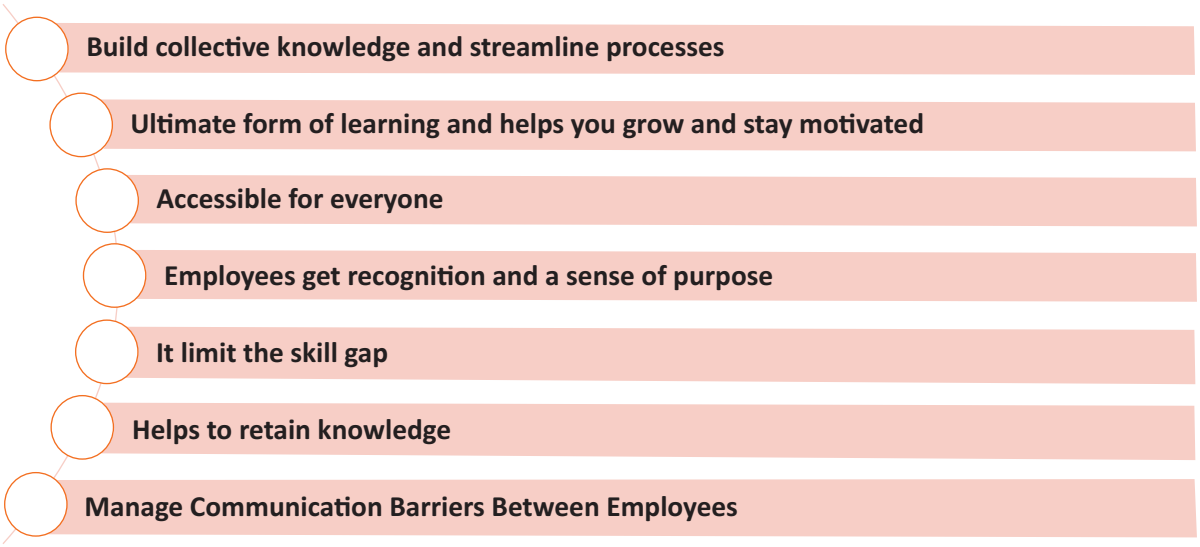


Fig. 3.11 Importance of Sharing information with team members

Notes

3.1.11 Individual and Team goals

Goal setting is undoubtedly one of the most effective motivational tools in the organization. Almost every organization requires employees to set goals regularly. Even when times change, continuously updating and setting goals is necessary to keep your business on track. Goals in each organization should be **S.M.A.R.T: specific, measurable, actionable, realistic, and timely.** It helps you and your team feel a stronger sense of purpose and direction. In addition, setting goals in place will help you and your team feel productive with each bit of accomplishment and ensure that more significant production stays on track.

Individual goals are significant because they give direction to the employees. While team goals are great for the overall guidance, personal goals will allow your team members to take distinct paths to digest the larger plan and turn it into action.

Team goals are necessary to guide the entire organization. It includes broad objectives that can be broken down into team projects and initiatives with individual key results. In addition to helping the organizations achieve their objectives, setting team goals also **boost employee engagement, productivity and retention by ensuring that every team member has a complete understanding of their role in the overall approach.** This also **saves time and improve efficiency.** In addition, setting team goals also offers organizations the following benefits:



Fig. 3.12 Benefits of Team Goals in an Organisation

3.1.12 Performance Measurement

Team performance evaluation is a key factor in inspiring teams, improving the quality of work, and keeping them motivated. It is the best channel to understand how the team is performing and an effective measure to get feedback about how production is going, whether the employees are working positively towards achieving goals, and what can be done to improve employees' engagement. It also provides a foundation to determine increments and succession plans for the team and the development of an organization.

A comprehensive team performance evaluation process often consists of different evaluation methods to help judge a team's performance. Using multiple techniques can help in getting a broader perspective of the areas where a team needs to improve and the steps you can take to support the team's growth.

The following chart explains the need for employee performance measurement methods:



Fig. 3.13 Importance of Performance Measurement

Performance evaluation methods include the following:

1. **Peer review:** This is one of the strategies that many organizations and employee evaluation software use to enhance the traditional evaluation process. The peer-review process consists of anonymous feedback from shift managers, colleagues, teammates, and peers on specific aspects of team members' performance.

    a. It provides a unique prospect to study the team member's skills and capabilities and help identify individuals' networking, leadership, occupational, and collaboration skills within an organization.

    b. This process provides a unique chance to determine each team member's strengths and weaknesses and use this valuable data to decide succession planning, building teams, and shift rotations.

2. **Self-evaluation:** Self-evaluation is a vital activity to help make the evaluation process more efficient. When done correctly, it can provide several critical inputs to the organization. In addition, this method offers a chance for the team to play an active role in their evaluation process. Thus, the employees are given a voice rather than simply receiving the management's feedback.

   This directly links their jobs and the evaluation process and thus, fosters better communication between the staff and the management. With active participation, employees tend to experience better engagement with the overall review process, while managers can better understand the individual's performance and their perception of their performance.

3. **Quantitative evaluation:** It is based on statistics and utilizes various standards to track the productivity. The process begins with the formulation of organizational standards against which employee data can be measured. Different industries have different ways to articulate their quantitative output. For example, the number of units produced in traditional manufacturing is generally a reliable quantitative metric. Similar metrics are still used in modern organizations.

4. **360-degree feedback:** This is another tool to evaluate employee's performance. To assess an employee's score, his managers, peers, subordinates, and customers are asked to provide feedback for specific areas. This feedback often gives an accurate and multi-perspective view of the employee's performance, skill level, and improvement points.

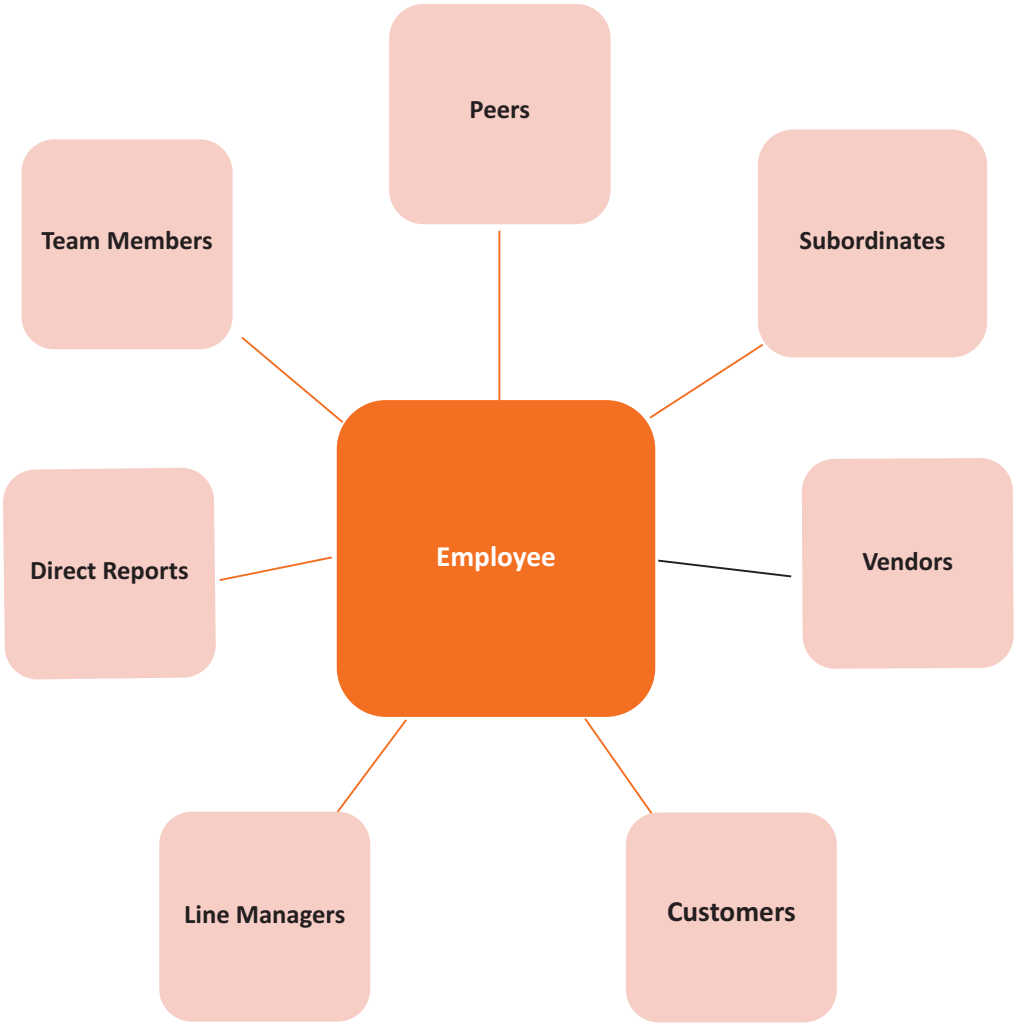


Fig. 3.14 360-degree Feedback Method

5. **Competency on a scale:** This is among the most frequently used employee performance evaluation techniques. In this method, the employee's performance in various job duties is rated on a defined scale. A wide range of criteria, including productivity, quality of work, concern for safety, customer service, teamwork etc., are evaluated. This method can be achieved with letters or numbers, and it usually consists of a range, unsatisfactory to outstanding. This method also allows employers to evaluate several employees simultaneously.
6. **Subjective appraisal by the manager:** In most organizations, performance is assessed several times a year during (bi-)annual performance reviews. Employees are evaluated on various criteria, the job-quality being the most common.
7. **Human Capital ROI:** It is a metric that assesses the human capital value (i.e., knowledge, habits, and social and personal attributes). Human Capital ROI can be determined by calculating the company's revenue (minus benefit-cost and operating expenses and compensation) and dividing this by the total compensation and benefit-cost that the company pays for its employees.
8. **Absenteeism Rate:** Absenteeism and performance are highly correlated constructs. Highly motivated and engaged employees generally take fewer sick days. Additionally, absent employees are less productive, and high absenteeism rates throughout an organization are a key indicator of lower performance.
9. **Overtime per Employee:**

Overtime per FTE = Total hours of overtime / FTE

The average overtime per FTE (full-time equivalent) is a final employee performance metric. Employees, eager to put in the extra effort are generally highly motivated and tends to produce more (in terms of work quantity).

Notes



Exercise

1. Fill in the Blanks:

a) _____is a building block of successful organizations.

b) A healthy relationship with colleagues is built on _____, _____ and_____.

c) _____ is a part of your organization's duties to its community and stakeholders.

d) Sharing information helps employees to limit the _____ gap.

e) _____ is a mechanism or strategy that enables different entities to work together.

f) _____ facilitates meaningful and necessary communication for employee _____and manage the communication flow within and outside the organization.

g) Fill in the Blanks-

h) _____ is a set of rules indicating the proper and polite way to behave at work.

i) _____include how the people generally speak, wear, follow customs, behave by the receivers who are not accustomed to the differences.

j) _____ is the response communicated by the receiver to the source/sender after having decoded the message.

k) The quality of the relationship with colleagues and co-workers will depend on the _____ demonstrate while interacting with them.

2. Goals in each organization should be:

   a) Specific, monthly, adjustable, realistic, and timely

   b) Smart, measurable, actionable, realistic, and timely

   c) Specific, measurable, actionable, realistic, and timely

3. The following are the types of communication at workplace, except:

   a) Employer – employee

   b) Colleagues

   c) Stakeholders

   d) Customer – friend

4. Which one is not the correct way of verbal and written communication?

   a) Short

   b) Irrelevant

   c) Simple

   d) Direct

5. Differentiate between team goals and individual goals.

6. What is effective communication?

7. How language barriers create gaps in workplace?

8. List any two tips for communicating effectively with superiors.

Notes

Unit 3.2 Work in a Disciplined and Ethical Manner

Unit Objectives

At the end of the unit, the trainee will be able to:

1. Explain the importance of work ethics and workplace etiquette
2. Explain ways to maintain discipline at the workplace
3. Discuss the importance of following organisational guidelines for dress code, time schedules, language usage and other behavioural aspects
4. Discuss the common reasons for interpersonal conflict and ways of managing them effectively
5. Explain the common workplace guidelines and legal requirements on non-disclosure and confidentiality of business-sensitive information

3.2.1 Importance of Work Ethics and Workplace Etiquette

A professional code of ethics establishes an organization's ethical guidelines and best practices for maintaining honesty, integrity, and professionalism. Violations of the code of ethics can result in sanctions, including termination, for members of an organization. The following figure explains the standard practices and professional code of ethics follow in every organization.



Fig. 3.15 Professional Code of Ethics

Work ethics are the morals or principles that govern a person's or group's behavior, whereas etiquette is a set of rules indicating the proper and polite way to behave at work. Both contributes positive energy and influence to the growth of an organization. Workplace etiquettes inspire healthy and interactive communication among employees and promote honesty, integrity, and respect for each other in the organization.



Fig. 3.16 Workplace Etiquettes

Notes

3.2.2 Managing Conflicts at Workplace

Dealing with conflict at the workplace is inevitable. The ability to recognize conflict with your colleagues, understand its nature, and try to bring a quick and fair resolution to the conflict is critical to anyone who works in a team. **Conflict management** is a crucial skill that enables an individual to handle confrontations tactfully and constructively. It aims to yield a positive result from disputes and disagreements that occur between people in the workplace and resolve the conflict in a way that respects everyone's wants and needs. At some point, we need skills for managing conflict in the workplace. The following tips can help us resolve the conflict or a disagreement in that situation.

Stay calm during a conflict	**Control your anger by staying conscious of the situation and swaying with the flow**	**Do not try to assume others' perspectives. Give them the opportunity to speak and one must listen**
Leave the site for a time-being, if the situation is heating up	**Sometimes it is not necessary to argue. Letting the moment pass shall avoid the conflict**	**Keep an open mind and compromise where necessary**
Mind your language if you enter an argument. Never say something which you may need to regret later	**Remember, everyone is different and can have a different point of view to yours**	**Try to look at the situation from others' point of view**
Determine the way in which both the parties could be mutually benefitted	**Do not try to overpower your intent**	**If the conflict intensifes, let a common lead help resolve the conflict**

Fig. 3.17 Tips for Managing Conflicts

3.2.3 Maintaining Discipline at Workplace

Employee discipline isn't about power or punishment. It is about making the workplace safe and enjoyable for both employees and management. Discipline is most effective when there is mutual trust between managers and employees. It all begins with clear communication and continues with consistency. Discipline assists employees in correcting any shortcomings to become valuable, contributing members of the workforce. Documentation created as a result of the disciplinary process can also help an employer protect itself if termination or other adverse employment decision is required. Here are the ways to maintain workplace discipline in the organization while maintaining employee respect:

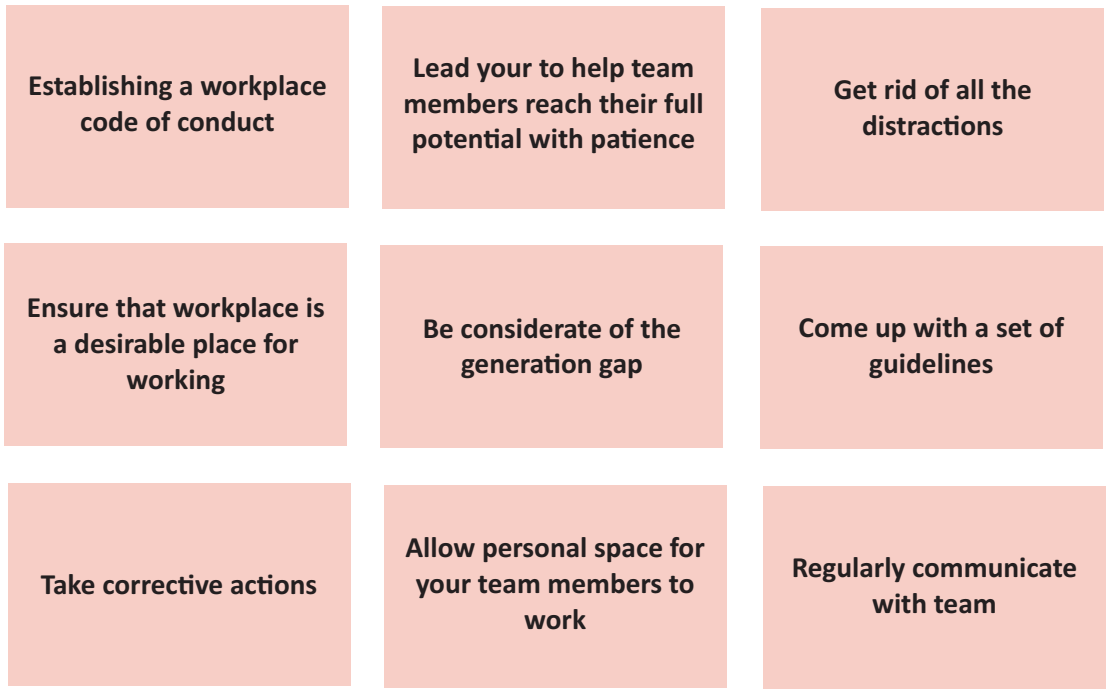


Fig. 3.18 Tips for Maintaining Discipline at Workplace

Notes

3.2.4 Confidentiality in the Workplace

Confidentiality, or not disclosing specific information, is essential in a variety of jobs. Confidentiality is important for legal and reputational reasons, but it is also important because future employment may be contingent on it. Some information, such as personally identifiable information and 'business secrets,' is legally protected in several countries. As a result, it is crucial to understand the nature of confidentiality and how to ensure that employees follow legal or ethical guidelines. Confidentiality refers to the state of keeping information secret or not disclosing it. Following are the type of information that comes under the non-disclosure and confidentiality of business-sensitive information.

Employee Information
- Includes the private information of employees such as name, address, maiden name and so on

Managerial Information
- Includes both information about individuals, such as disciplinary action, and also about broad management actions such as planned redundancies or employee relations issues

Organisational Information
- Also known as business information or 'trade secrets'

Customer or Contact Information
- Partially covered by 'trade secrets'

Professional Information
- Information about individuals or organisations through their professional position.

Fig. 3.18 Types of Confidential Information

Notes



Exercise

Answer the following questions:

1. Write a short note on work ethics and workplace etiquette.

2. List any 3 ways of maintaining discipline at the workplace.

3. What is conflict management?

4. Explain confidentiality in the workplace.

5. How language barriers create gaps in workplace?

Notes

Unit 3.3 Uphold social diversity at the workplace

Unit Objectives

At the end of the unit, the trainee will be able to:

1. Describe the process of reporting grievances and unethical conduct such as data breaches, sexual harassment at the workplace, etc.
2. Explain the concept and importance of gender sensitivity and equality.
3. Discuss ways to create sensitivity for different genders and Persons with Disabilities (PwD).

3.3.1 Grievance Management

Grievances results in collective disputes when they are not resolved timely. Also, this lowers the morale and efficiency of the employees. Frustration, employee dissatisfaction, low productivity, lack of interest in work, high absenteeism, etc. might be a result of unattended grievances. In short, grievance arises when the organization does not fulfill employees' expectations, resulting in a feeling of discontentment and dissatisfaction. This dissatisfaction must have cropped up from employment issues and not from the personal issues.

A grievance may result from the following factors-

a) **Working Conditions and Safety:** These consists of any complaint or grievance that directly addresses the employees' work environment. These can include everything from unsafe working conditions to difficult and indifferent managers.

b) **Unreasonable Management Policies:** If employees believe that a particular policy is unfair or unreasonable, they will want their concerns addressed. Such policies can include a gap in production standards or overtime regulation compliance.

c) **Violations of Rules and Policies:** These are related to any organizational rules which the employees feel are being violated by other workers and/or middle or senior management.

The project manager should immediately identify all grievances and take appropriate actions to eliminate the causes of such grievances to achieve employee's loyalty and commitment to their work. Thus, effective grievance management is an essential part of personnel management.

For Addressing Grievance, Project Manager should adopt the following approach to manage grievance effectively:

1. **Complaint:** As soon as the grievance arises, it should be identified and resolved. This lowers the detrimental effects of grievance on the employees and their performance.
2. **Acknowledging grievance:** Acknowledge the grievance put forward by the employee as a manifestation of true and genuine feelings of the employees. Acknowledgment implies that you are eager to look into the complaint impartially and without bias. This creates a conducive work environment with instances of grievance reduced.

3. **Gathering facts:** Gather relevant and adequate facts that explains the nature of the grievance. These facts must be recorded to be used at a later stage of grievance redressal.
4. **Examining the causes of grievance:** The actual cause of resentment should be identified. Consequently, remedial actions should be taken to prevent the repetition of the grievance.
5. **Decisioning:** After identifying the causes of grievance, an alternative course of action should be suggested to manage the grievance. The effect of each action on the existing and future management policies and procedures should be analyzed, and accordingly, the manager should take a decision.
6. **Execution and review:** The manager should implement the decision quickly, ignoring the fact that it may or may not hurt the concerned employees. After implementing the decision, a follow-up must ensure that the grievance has been resolved completely and adequately.

An effective grievance procedure ensures a pleasant work environment because it redresses the grievance to the mutual satisfaction of the employees and the supervisors.



Fig. 3.19 Grievance Addressing Process

3.3.2 Sensitivity for Person-With-Disability (PwD)

Disabled workers are a part of the diversity in today's workforce. However, being disabled does not imply that the individual is incompetent or unable to do his/her job. In fact, being disabled simply means the person has an impairment, which can be anything ranging from physical to psychological. Disabled co-workers and employees are not any different in that they are there to earn a living, advance their career, and better the organization through their contributions.
Listed below are some tips for interacting and communicating with people with disabilities.



Fig. 3.20 Communicating and Interacting with PWD

The RPWD Act, 2016 provides that "the appropriate Government shall ensure that the PwD enjoy the right to equality, life with dignity, and respect for his or her own integrity equally with others." The Government is to take steps to utilize the capacity of the PwD by providing appropriate environment.

Gender inequality in an organization's is a complex phenomenon that can be seen in organizational structures, processes, and practices. Following chart explains gender based issues in workplace:

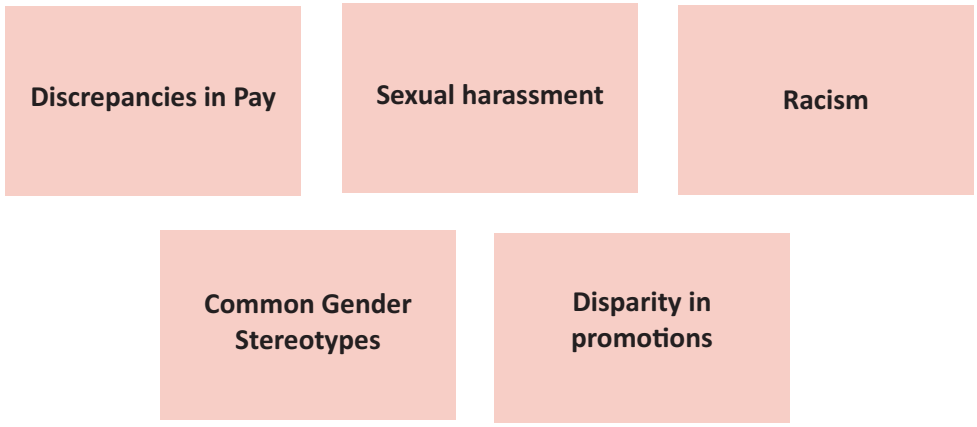


Fig. 6.21 Gender based Issues at Workplace

Females with disabilities are subjected to multiple layers of discrimination. Based on their gender and disability status, they often face double discrimination. They often face disproportionately high rates of gender-based **violence, sexual abuse, neglect, maltreatment and exploitation.** The exclusion experienced by women and girls with disabilities is a social issue that requires active participation of everyone.

It is important to follow organizational standards related to PwD at workplace because, it:

1. Protects them from any physical harm or any accidents
2. Provides them equal rights
3. Protects them from any kind of discrimination and racism
4. Provides security from any kind of violence and harassments
5. Protects their respect and dignity
6. Provides equal opportunities to deserving candidates

Notes



3.3.3 Gender Sensitivity

Gender sensitization is vital because representation is important. Representation of a person and community advocates equality and adds a sense of inclusion to the previously marginalized community. For a healthy performance-oriented culture, organizations need the correct mix of talent which is not bound by any gender. More than ever, accountability has become important now, organizations only have today to make the changes that count, as tomorrow they won't be able to hide under the pretext of ignorance. Each member of an organization seeks out to learn and grow at their workplace, and an insensitive place of work not only hinders that but also tends to become an unfriendly workplace. Gender sensitization is extremely significant as it helps the employees feel appreciated and cared for within the organization. Lastly, for the betterment of society, organizations have got an ethical responsibility in shaping the current structures by breaking the old norms. Organizations that do not emphasize on gender sensitization usually develop cultures where inequality and discrimination becomes normal. This kind of culture leads to a higher attrition rate, a higher rate of employee absenteeism, etc. Such policies also propagate the presence of a superior gender.

The concept of gender sensitivity shows the path to reduce barriers to personal and economic development created by gender differentiation. In addition, it helps to generate respect for individuals regardless of their gender.

Gender sensitivity is not about fighting women against men. On the contrary, gender-sensitive education, benefits members of all genders. It helps the individuals determine what assumptions are valid and which are stereotyped generalizations in matters of gender. Gender awareness not only requires intellectual efforts but also sensitivity and open-mindedness. It opens up the broadest possible range of life options for both women and men.

Some of the best practices followed to stay gender-sensitive would be to

- Use respectful language while communicating with each other. Do not reinforce gender stereotypes.
- Provide fair opportunity to everyone irrespective of their gender
- Do not promote creating gender-specific social groups.
- Neither victimize nor patronize based on gender

Notes



3.3.3 Rights and Duties at Workplace concerning PwD

The following chart explains the rights and duties at the workplace with respect to PwD:

Rights	Duties
• To an accessible workplace free of hazards and risks • To complete information about the job • To information, education, training and safely equipment that reduces risks and hazards • To equal access to benifits, conditions of employement and promotional opportunities • To special safety procedures and considerations that may relate to one's disability in case of emergency • To be treated with dignity and respect • To special tools and services that be needed to accomodate a disability on the job or in the community	• To provide complete and honest information as it relates to the job • To request reasonable accomodation or assistance if needed • To practice safely procedures and use equipment to reduce risks to self and others • To report illness or injury promptly • To cooporate and work with rehabitation professionals and employes in good faith regarding return to work. • To use the access and services provided to be fully productive • to advocate, educate and collaborate with legel, service and other systems to meet needs and resolve conflicts

Fig. 3.22 Rights and Duties at Workplace with Respect to PwD

Summary

- Effective communication is required for all employees in the organization to perform basic management functions and carry out their jobs and responsibilities.
- It is extremely difficult for Quality Managers to manage their teams and coordinate efforts for successfully completion of a project without strong interpersonal communication skills. A project cannot be successful if there is no communication.
- The process of communication is a dynamic structure that explains how a message is transmitted between a sender and a receiver via various communication channels. Its purpose is to ensure that the receiver accurately decodes the message and can provide feedback with precision and convenience.
- Communication barriers are factors that prevent a message from being received in the way the sender sent it. People frequently face the problem of the message being received in an assumed manner when communicating.

- Effective communication with your supervisor is crucial to your professional development and career advancement. Refer to the exhibit below for tips on communicating with the supervisor effectively.
- Following proper communication, rules are critical to keeping a healthy relationship with colleagues and co-workers. The quality of the relationship with colleagues and co-workers will depend on the behavior you demonstrate while interacting with them.
- Transparently sharing data and information ensures that everyone is in the loop and aware of any potential issues with the business, product, or service that can be addressed collaboratively. Employees might have lots of knowledge that is crucial for the organization and other employees. Sharing information helps them connect, perform better, and become more vital as professionals.
- Organizational communication can be divided into two categories: formal and informal communication.
- Emotional outbursts at work could be caused by work-related issues or by stressors from our personal lives spilling over into our work lives. Handling our emotions (especially negative ones) at work is frequently regarded as a test of our professionalism.
- An organizational structure is a system that defines how specific activities are directed in order to achieve an organization's goals.
- The workflow of an organization consists of the processes that must be completed, the people or other resources that are available to perform those processes, and the interactions between them.
- Communication policies of an organization establish expectations and manage the flow of communications within and outside the organization. As a result, it facilitates meaningful and necessary communication for employee productivity and morale without restricting employees' feeling intimidated and powerless.
- Goals in each organization should be S.M.A.R.T: specific, measurable, actionable, realistic, and timely. It helps you and your team feel a stronger sense of purpose and direction. In addition, setting goals in place will help you and your team feel productive with each bit of accomplishment and ensure that more significant production stays on track.
- Team performance evaluation is a key factor in inspiring teams, improving the quality of work, and keeping them motivated. It is the best channel to understand how the team is performing and an effective measure to get feedback about how production is going, whether the employees are working positively towards achieving goals, and what can be done to improve employees' engagement.
- A professional code of ethics establishes an organization's ethical guidelines and best practices for maintaining honesty, integrity, and professionalism. Violations of the code of ethics can result in sanctions, including termination, for members of an organization.
- Work ethics are the morals or principles that govern a person's or group's behavior, whereas etiquette is a set of rules indicating the proper and polite way to behave at work.
- Dealing with conflict at the workplace is inevitable. The ability to recognize conflict with your colleagues, understand its nature, and try to bring a quick and fair resolution to the conflict is critical to anyone who works in a team.
- Discipline is most effective when there is mutual trust between managers and employees. It all

- begins with clear communication and continues with consistency. Discipline assists employees in correcting any shortcomings to become valuable, contributing members of the workforce.
- Confidentiality is important for legal and reputational reasons, but it is also important because future employment may be contingent on it.
- Disabled co-workers and employees are not any different in that they are there to earn a living, advance their career, and better the organization through their contributions.
- The RPWD Act, 2016 provides that "the appropriate Government shall ensure that the PwD enjoy the right to equality, life with dignity, and respect for his or her own integrity equally with others." The Government is to take steps to utilize the capacity of the PwD by providing appropriate environment.
- Gender inequality in an organization's is a complex phenomenon that can be seen in organizational structures, processes, and practices.
- Females with disabilities are subjected to multiple layers of discrimination. Based on their gender and disability status, they often face double discrimination.
- For a healthy performance-oriented culture, organizations need the correct mix of talent which is not bound by any gender.
- Use respectful language while communicating with each other. Do not reinforce gender stereotypes.
- Gender sensitivity is not about fighting women against men. On the contrary, gender-sensitive education, benefits members of all genders. It helps the individuals determine what assumptions are valid and which are stereotyped generalizations in matters of gender.

Notes



Exercise

1. Write a short note on:
   a. Grievance Management

   b. Rights and duties of PwD at the workplace

   c. Gender based issues at workplace

   d. Best practices for gender sensitivity

   e. List down the steps for addressing grievance.

2. Match the following.

Column A	Column B
Gender inequality	Gender-specific social groups
Listen attentively	Equal access to benefits
Rights at Workplace concerning PwD	With hearing disability person to get his attention
Tap a person on shoulder	Disparity in promotions
Do not promote	While talking with people having difficulty speaking

Notes

Notes

QR Code

Scan the QR Code to watch the related video

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4. Basic Health and Safety Practice

Unit 4.1 - Dealing with Workplace Hazards & Risks

Unit 4.2 - Fire Safety Practices

Unit 4.3 - Emergency, Rescue and First-aid Practices

Unit 4.4 - Effective Waste Management Practices



(ELE/N1002)

Key Learning Outcomes

At the end of this module, the trainee will be able to:

1. Apply health and safety practices at the workplace

Unit 4.1 Dealing with Workplace Hazards & Risks

Unit Objectives

At the end of this unit, the trainee will be able to:

1. Discuss job-site hazards, risks and accidents
2. Explain the organizational safety procedures for maintaining electrical safety, handling tools and hazardous materials
3. Describe the importance of maintaining appropriate postures while lifting heavy objects
4. Explain various warning and safety signs
5. Describe how to interpret warning signs while accessing sensitive work areas
6. Elaborate on electronic waste disposal procedures
7. List the name and location of concerned people, documents and equipment for maintaining health and safety in the workplace
8. Explain the importance of good housekeeping

4.1.1 Workplace Safety

Workplace safety is one of the key aspects of any manufacturing business or facility. Getting it right can boost overall operation performance and lead to growth. On the other hand, putting safety at risk can lead to lost time, money, occupational injuries, and even reputational damage. Although every employer is required by law to adhere to workplace safety standards established by governments in order to ensure the safety of its employees and workers, it must be understood that safety is everyone's responsibility. Nobody wants to be hurt at work. As a result, employees/workers must be aware of and strictly follow the safety procedures in place.

Quality Managers are in a unique position because, as Quality leaders and coordinators, they indirectly influence health and safety. As safety is an integral part of the workplace, Quality Managers should not turn a blind eye and, if necessary, issue instructions. Quality Managers discuss health and safety during the following stages:

1. Planning because of its impact on accessibility and work methods

2. Initial workplace inspections due to the project's immediate environmental impact

3. Onsite meetings if the contractor or subcontractors are not addressing it

4. Site inspections and discussions as most important aspect of the worksite is health and safety

It is everyone's responsibility, whether the Quality Manager or team member, to keep the workplace clean, healthy, and safe. Everyone in the workplace must be extremely cautious and adhere to the established safety guidelines. The following are the standard practices to ensure health and safety in an organization.



Fig. 4.1 Health and Safety Guidelines

4.1.2 Safety Hazards, Risks and Accidents

A hazard or risk is something or someone that has the possibility of causing, serious harm, damage, or negative health effects. It has the potential to cause human injury or illness, property damage, environmental damage, or a combination of these effects. The figure below depicts the most common on-site hazards, risks, and accidents:

Notes



Fig. 4.2 Hazards and Risks at Workplace

The safety hazards and risks in the electronics industry vary depending on the various sub-sectors:

1. Various chemical hazards in the semiconductor and fabrication industries include exotic and dangerous chemicals such as arsine, phosphine, and silane
2. Noise, ionizing and non-ionizing radiation used for testing, quality control, and curing operations are all physical hazards in electronic work
3. Repetitive assembly line work or manual handling results in cumulative trauma disorders, backache, and musculoskeletal strains
4. Low humidity in clean room work, causing dermatological symptoms
5. Prolonged visual inspection work, especially when using a microscope, frequently causes eyestrain
6. Biological hazards are uncommon in electronics work, but communicable diseases can easily spread to other workers
7. Negative psychosocial factors such as the fast and constant pace of work, the monotonous nature of work, and rotating shifts

It is significant to ensure a high level of safety that no machine tool should be used unless the risk management process outlined below is understood and applied by the user:

1. Determine the potential hazard(s) that the machine tool may produce.
2. Using the Risk Assessment Matrix, determine the likelihood and severity of the hazard(s). The following individuals have risk acceptance decision authority for the risk levels
   a. very high
   b. very high
   c. moderate and low
3. Determine the risk-control measures that will eliminate or reduce the hazard(s). Then, implement risk control measures before and during machine tool operation to eliminate threats or mitigate their risks.
4. Monitor and evaluate the process. Enforce the established standards and risk management procedures. Evaluate the effectiveness of the control measures and make any necessary adjustments/updates.

4.1.3 Organizational Safety Procedures

An organizational safety procedure is a step-by-step instruction manual for carrying out a work procedure. It is used when a deviation from the procedure could result in injury or an accident.

When working with machinery, tools and equipment, employees are exposed to a variety of hazards and risks that can result in a variety of injuries. The following are the most common hazards in handling tools, hazardous materials and machining work:

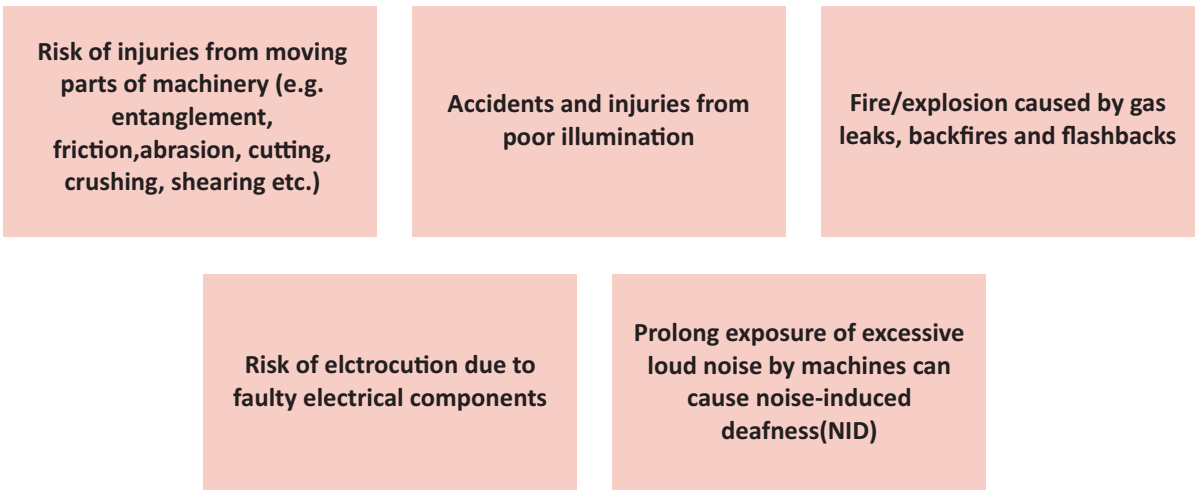


Fig. 4.3 Machine Hazards

Therefore, when working with tools and equipment in the workplace, specific safety procedures must be followed to prevent these hazards and accidents:

1. SOPs (Standard Operating Procedures) must be followed and maintained for all machinery in the manufacturing unit.
2. SOPs must be based on manufacturer recommendations and must include specific hazards associated with the machine as well as safe use recommendations.
3. SOPs (standard operating procedures) must be accessible at or near the machine.

Electricity is widely recognized as a serious workplace hazard that can cause electric shock, burns, fires, and explosions. Every year, many employees suffer pain, injuries, and even death as a result of electric shocks. To keep yourself and others safe, it is critical to adhere to electrical safety-related work practices.

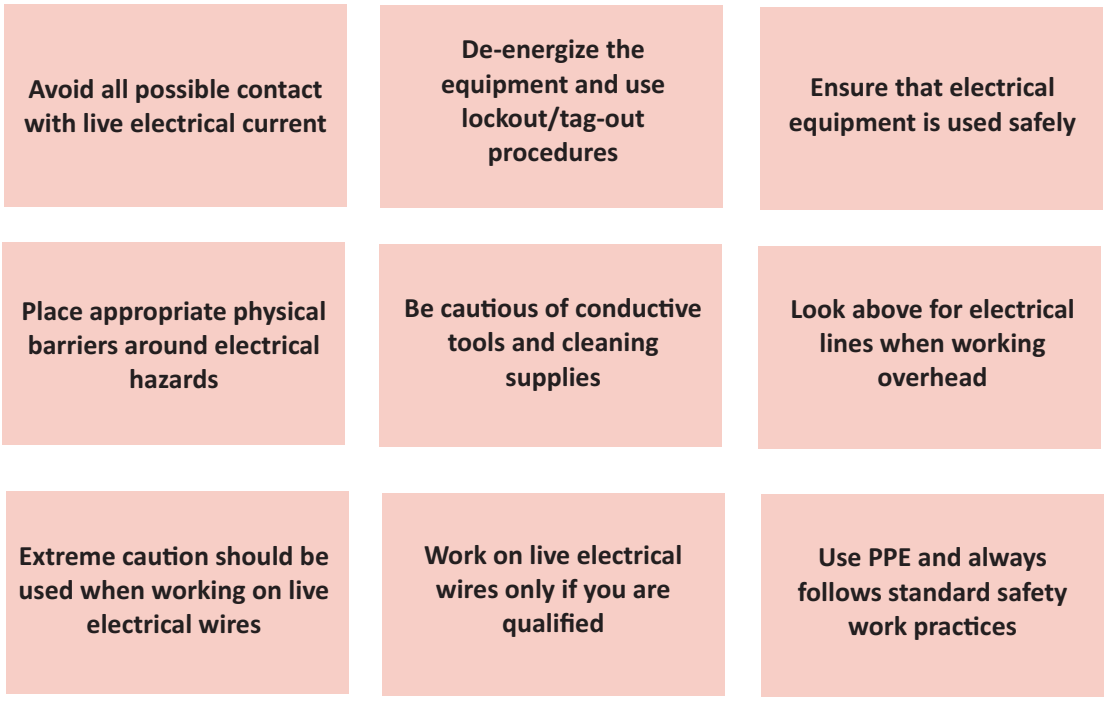


Fig. 4.4 Standard Procedures for Electrical Safety at Workplace

Notes

The following are some basic rules who work with or near hazardous materials should know and follow:

1. Pay close attention while working with or around hazardous materials.
2. Always wear the appropriate PPE.
3. Ensure that all containers are properly labeled and that hazardous materials are stored in an appropriate container.
4. Report damaged containers or illegible labels to your supervisor as soon as possible.
5. Read labels and the Safety Data Sheets (SDSs) before using any material to make sure you understand hazards and precautions Use hazardous materials solely for their intended purpose.
6. Never eat or drink while working with hazardous materials.
7. Store all hazardous materials properly, separate incompatibles, and keep them in well-ventilated, dry, and cool locations.
8. After handling any hazardous material, employees must keep themselves and the work area clean.
9. Gain knowledge about first-aid, emergency procedures, and evacuation procedures for dealing with fires or spills/leaks.
10. It also entails knowing what to do if a coworker is injured or poisoned by chemicals.

4.1.4 Significance of Maintaining Appropriate Postures While Lifting Heavy Objects

Lifting heavy objects is one of the leading causes of workplace injury. The main causes of these injuries were overexertion and cumulative trauma. Bending is the most frequently cited movement that resulted in back injuries, followed by twisting and turning.

Lifting loads incorrectly or carrying loads that are either too large or too heavy are common hazards associated with manually moving materials. Employees who use safe lifting techniques are less likely to sustain back sprains, muscle pulls, wrist injuries, elbow injuries, spinal injuries, and other injuries as a result of lifting heavy objects. The following figure explains on safe lifting and material handling at workplace.

Notes





Fig. 4.5 Tips for Maintaining Appropriate Postures While Lifting Heavy Objects

4.1.5 Warning and Safety Signages

Workplace safety signage evolved with the Industrial Revolution when workplace safety became a major concern. The purpose of a workplace safety sign is to identify and warn employees who may be exposed to various hazards. Safety signs help to communicate important instructions, reinforce safety messages, and provide emergency instructions. Workplaces that lack the necessary safety signs not only violate safety regulations but may also face hefty fines and regulatory action if they are audited by legal authorities. If an accident occurs and it is determined that proper safety signs were not present, the employer or other responsible parties could face legal consequences. It is essential to know the meaning of safety signs. Such signs warn us of danger and allow us to take precautions to keep safe. There are four main types of safety signs:

1. Prohibition signs
2. Mandatory signs
3. Warning signs
4. Information signs
5. Fire Safety signs
6. Danger Signs

The following table represents the various signages related to health and safety measures:

S. No.	Signage	Message
1.		Basic floor sign to stop moving ahead
2.		Stop Look Out for Forklifts
3.		Eye safety warnings
4.		Fire exit sign
5.		Authorized personnel only
6.		Fire hose notification
7.		Caution signage

S. No.	Signage	Message
8.		Caution signage
9.		Wet floor warning
10.		Watching out for step
11.		Water-saving signage

Table 7.1 Safety & Warning Signages

4.1.6 Electronic Waste Disposal Procedures

E-waste is an abbreviation for electronic waste. That is, waste produced by broken, obsolete, or surplus electronic devices. It is also referred to as e-scraps. These electronics frequently contain toxic chemicals and hazardous materials. And if it is not disposed of properly, it can result in the release of toxic substances into our environment. The reprocessing and re-use of these electronic wastes are referred to as e-waste recycling. It is straightforward. It is a method of recovering material from electronic waste. This allows you to incorporate them into new electronic products. These electronic wastes can take the form of household appliances such as air conditioners, televisions, electric cookers, air conditioners, heaters, DVDs, fans, microwaves, and radios. They can also take the form of information technology equipment such as computers, laptops, mobile phones, batteries, hard discs, circuit boards, and monitors. E-waste recycling is one of the most discussed issues in the world today due to its potential to

reduce environmental hazards and pollution. It can also protect our lives as humans and other life forms in our world. E-waste recycling is the reuse and reprocessing of any type of discarded or obsolete electrical and electronic equipment.

Recycling electronics can be a difficult task. This is due to the fact that e-scraps are typically sophisticated and made from a variety of materials such as metals, plastics, and glass. While this process frequently varies, the following figure explains the standard process of electronic waste disposal.

Step 1: Collection and Transportation

- This is the first stage of e-waste recycling. Recyclers set up take-back booths or collection bins in specific locations. When these bins are full, recyclers transport the e-waste to recycling centers and plants.

Step 2: Shredding and Sorting

- After collecting and transporting the e-waste, the next step is to shred and sort it. Shredding is the process of breaking down e-waste into smaller pieces for proper sorting. These tiny prices are sorted by hand and then manually dismantled. This is typically labor-intensive because waste items are separated at this stage to retrieve different parts.

Step 3: Dust Removal

- The tiny waste particles are evenly distributed on the conveyor belt by a shaking process. The uniformly distributed e-waste is then further broken down. The dust is extracted and disposed of in an environmentally responsible manner at this point. There is no environmental degradation in this manner.

Step 4: Magnetic Separation

- Following that, a powerful overhead magnet aids in the separation of steel and iron from other wastes. It has successfully recycled the steel from the waste stream in this manner.

Step 5: Water Separation

- Water separation technology is used to separate the glass from the plastic.

Step 6: Purification of Waste Stream

- The next step is to locate and extract leftover metals from plastics to further purify the waste stream.

Step 7: Preparing Recycled Materials For Sale

- The last step is to prepare recycled materials for sale. The materials are separated here for sale as raw materials to manufacture new electronics.

Fig. 4.6 Standard Process of Electronic Waste Disposal

4.1.7 List of Concerned Authorities, Documents and Equipment for Workplace Health and Safety

It is simply a huge task for a single person to be solely responsible for workplace health and safety. As a result, the **health and safety executive (HSE), legal bodies, business owners, managers and supervisors, contractors, and employees at all levels in a company all share equal responsibility**. However, this does not imply that responsibilities are distributed evenly. Staff in various roles will have varying health and safety responsibilities. **Employers**, for example, bear more responsibility than their employees because they are held accountable for their employee's safety and well-being. They are required by law to protect their employees and anyone else who may be harmed by their business, including customers, visitors to the workplace, temporary workers, and contractors. Employers must perform the following duties in order to meet their health and safety obligations:



Fig. 4.7 Roles and Responsibilities of Employers for Workplace Health & Safety

Procedure for Reporting Workplace Health & Safety Issues to Concern Person

To raise a workplace health & safety issue with the concerned authorities, constructive steps should be taken immediately to resolve the problem. These steps may include:

1. Reporting the issue to your supervisor or manager
2. Reporting the issue through the workplace's hazard reporting procedures
3. Raising the issue with the health and safety representative
4. Raising the issue with management through union representative

Issues can be related to:

1. Personal hygiene
2. Handling of food and beverages
3. Storage and Work area
4. Suitable dress and personal protective equipment and clothing
5. Cross-contamination
6. Machinery, tools, and equipment
7. Inappropriate handling and disposal of garbage
8. Cleaning and sanitizing

List of documents for maintaining workplace health and safety

Health and safety documents assist in controlling risks and communicating safe working procedures. Many health and safety documents, such as risk assessments and health and safety policies, are also required by law.

1. **Method Statements -** Method statements include information such as project start and end dates, a project description, and all potential hazards associated with the project. Emergency procedures and guidelines for monitoring are also included.
2. **Risk Assessment –** Risk assessment documents serve as a strategic tool for planning for and responding to specific workplace risks. These documents help to raise awareness of hazards, identify specific people who may be at risk and note ways to eliminate or control that risk.
3. **Near Miss Reports -** A near-miss report is a document that details a problem or issue that occurred at work that had the potential to injure or harm someone. This usually happens when a break in a chain of events prevents harm or damage from occurring. This type of safety document is similar to an accident/incident investigation report in which the accident did not occur but could have.
4. **Equipment and Machinery Inspection Reports -** These reports detail when specific equipment or machinery was inspected, who inspected it, and what they discovered. Regular inspection reports also help to ensure that employees are using up-to-date and safe equipment.
5. **Emergency Action Plan -** These plans provide clear, detailed instructions on how people in a building should behave in the event of a specific disaster. Emergency action plans provide a comprehensive overview of all potential disasters, including fires, tornadoes, earthquakes, floods, and explosions.
6. **Personal Protection Equipment Manual -** This manual assists both employers and employees in doing the following:
    a. Understand the various types of PPE.
    b. Understand the fundamentals of conducting a "hazard assessment."

Personal Protective Equipment

Every worker at workplace is responsible for their safety as well as the safety of their coworkers. A person must take different precautions for different situations to avoid accidents and hazards. To begin, everyone on the job site must wear Personal Protective Equipment (PPE) for their safety.



Fig. 4.8 PPE

PPE refers to the clothing or equipment designed to protect the workers/employees from shop floor hazards. It includes items such as hard hats, safety boots, coveralls, gloves, safety glasses and goggles, earplugs, high visibility vests, lifejackets, fall protection, and respirators.

Common types of PPE include the following:



Eye and Face Protection



Hand Protection



Head Protection



Hearing protection



Foot Protection



Body Protection



Fall Protection



Respiratory protection

Fig. 4.9 Types of Personal Protective Equipment

4.1.8 Significance of Good Housekeeping at Workplace

Effective housekeeping assists in the control or elimination of workplace hazards. Poor housekeeping practices frequently contribute to incidents. If the presence of paper, debris, clutter, and spills is accepted as normal, other, more serious hazards may be overlooked. Cleaning is only one aspect of housekeeping. It entails keeping work areas neat and orderly, keeping halls and floors free of slip and trip hazards, and removing waste materials (such as paper and cardboard) and other fire hazards from work areas. It also necessitates paying close attention to details such as the overall layout of the workplace, aisle marking, the adequacy of storage facilities, and maintenance. Good housekeeping is also a fundamental component of incident and fire prevention. Effective housekeeping is a continuous process, not a one-time event. Effective housekeeping is a continuous process; it is not a one-time or sporadic clean-up. Periodic "panic" clean-ups are both costly and ineffective in terms of incident reduction.

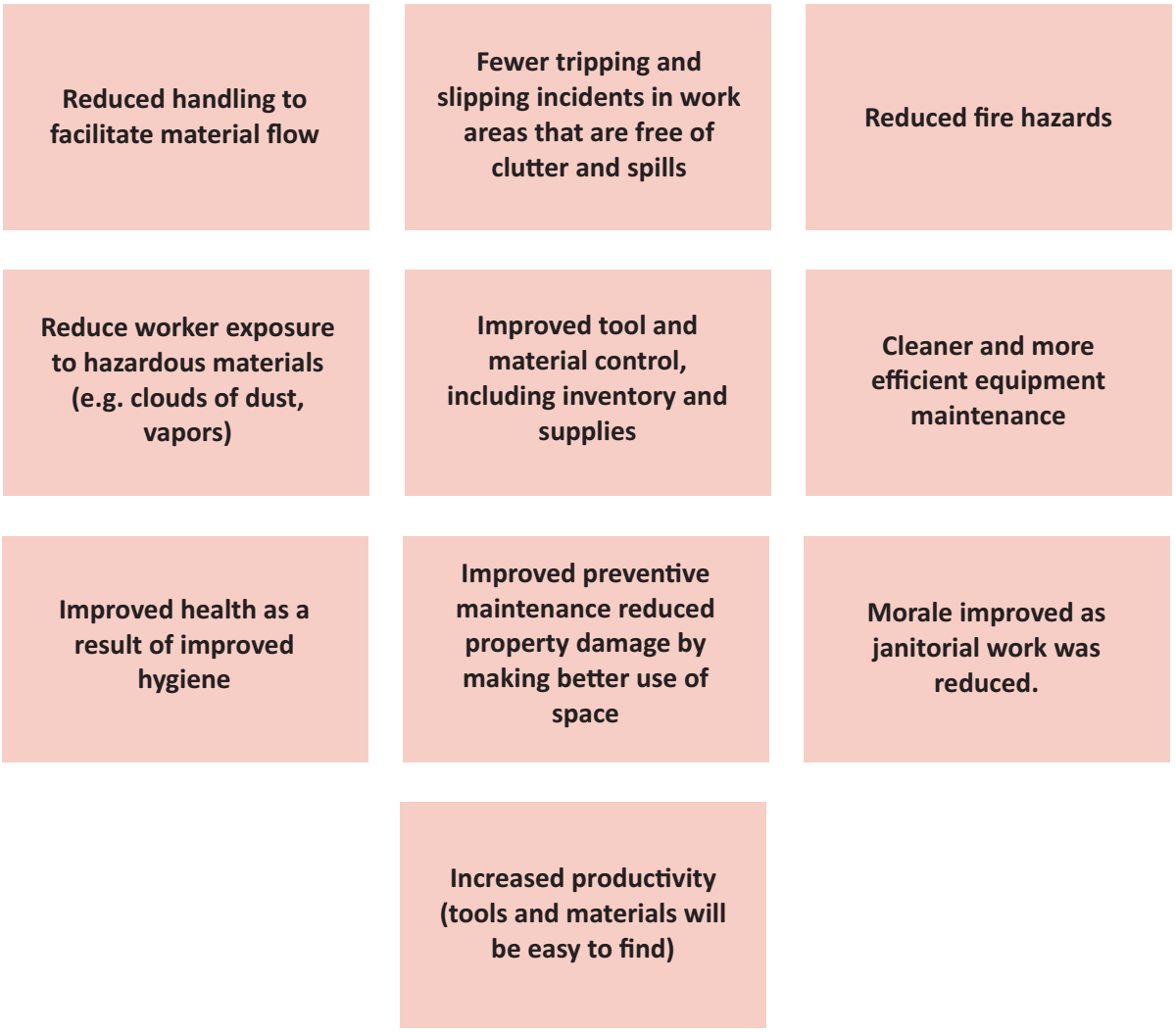


Fig. 4.10 Significance of Good Housekeeping at Workplace

4.1.9 5S

5S is intended to be a visually-oriented system of cleanliness, organization, and arrangement to attain greater productivity. It engages all employees and is a foundation for more self-discipline on the job for better work and better products. Along with engaging employees, it also builds a strong and positive culture of self-discipline at the workplace for better work and quality outcomes.

5S, sometimes referred to as 5s or Five S, refers to five Japanese terms used to describe the steps of the 5S system of quality management. Each term starts with an S. In Japanese, the five S's are **Seiri, Seiton, Seiso, Seiketsu, and Shitsuke**. The five S's are translated as Sort, Set in Order, Shine, Standardize, and Sustain in English**.**

S.No.	Japanese Words		English Translation	Definition
1	Seiri		Sort	Sorting means keeping only the essential items required in the workplace and removing all the nonessential items.
2	Seiton		Set in order	Ensures that all the items are organized and placed logically to make the task easier and convenient for the worker.
3	Seiso		Shine	Efforts to keep the orderly workplace area clean and maintain routine tasks are involved, like dusting, mopping, and maintenance of machinery, tools, and other equipment.
4	Seiketsu		Standardize	Create a set of standards for organization and processes where rules are made for how 3S will be maintained and when these tasks will be performed.
5	Shitsuke		Sustain	Sustain new practices and conduct audits to maintain discipline. Th2is means the previous four S's must be continued over time. This is achieved by developing a sense of self-discipline in employees who will participate in 5S.

Table 4.2 5S

The guiding principles underlying the 5S technique involve organization, cleanliness, and standardization. Overall workplace cleanliness, created by removing waste from the work area, promotes internal organization and enhances visual communication. By reducing wasted time and materials, productivity is increased along with safety, and costs are reduced. The system as a whole minimizes waste and improves efficiency by ensuring that employees are spending time doing productive tasks rather than looking for misplaced items, sorting unnecessary through stacks of waste material, or rearranging the work environment at the change of shifts.

Advantages of Implementing 5S Principle

1. **Sort**: It helps better allocate valuable resources, as additional space becomes available once the unnecessary items are removed from the area. Furthermore, the process forces inspection of the items, thereby recognizing the need to repair or eliminate any obsolete equipment and also preventing the equipment from being misplaced.
2. **Systemize**: A systematic work area also supports the efficiency of work. When kept at a fixed location, each object remains there until it is taken away while in use and is immediately kept back at the same place after use. Labeling and other identifying methods are also a part of this step. In addition, systematically storing and arranging things prevents a lot of time wasted searching for items. Overall, if each team member arranges things in an orderly fashion, it leads to the success of the whole organization.
3. **Shine**: It provides qualitative and quantitative results and improvises employee's pride and morale while working in a clutter-free pleasant work area. A clean area also results in a safe and healthy workplace.
4. **Standardize**: Following the standardized procedures helps achieve efficiency, improve workplace safety, and reduce workplace injuries.
5. **Sustain**: Maintenance of any system is essential as it increases its sustainability. Thus, maintaining the system is necessary; otherwise, the cost and effort spent on developing the system will go to waste.

Notes

Exercise

Answer the following questions:

1. Explain potential risks and hazards at the workplace.

2. Explain the benefits of 5S principles.

3. Explain any two types of Personal Protective Equipment.

4. List the ways for maintaining appropriate postures while lifting heavy objects.

5. Discuss the importance of good housekeeping at workplace.

6. List of documents for maintaining workplace health and safety.

7. What is PPE?

8. Write a short note on organizational safety procedures.

Fill in the blanks:

1. To raise a _____ with the concerned authorities, constructive steps should be taken immediately to resolve the problem.
2. _____ is one of the key aspects of any manufacturing business or facility. Getting it right can boost overall operation performance and lead to growth.
3. As safety is an integral part of the workplace, _____ should not turn a blind eye and, if necessary, issue instructions.
4. _____ has the potential to cause human injury or illness, property damage, environmental damage, or a combination of these effects.

1. An _____ is a step-by-step instruction manual for carrying out a work procedure.
2. Lifting heavy objects is one of the leading causes of _____.
3. The purpose of _____ is to identify and warn employees who may be exposed to various hazards.
4. _____ is one of the most discussed issues in the world today due to its potential to reduce environmental hazards and pollution.
5. _____ bear more responsibility than their employees because they are held accountable for their employee's safety and well-being.
6. _____ documents assist in controlling risks and communicating safe working procedures.

1. Choose the correct answers (MCQ)

a) The way of protecting individuals' well-being of health is classified as:

1. Safety
2. Health
3. Adverse Situation
4. Security

b) What are the most common risks in the workplace?

1. Risk of electrocution
2. Risk of injuries from faulty equipment
3. Being hit by falling objets
4. All of the above

Notes

Unit 4.2 Fire Safety Practices

Unit Objectives

At the end of this unit, the trainee will be able to:

1. List the types of fire and fire extinguishers

4.2.1 Fire Safety

Fire safety refers to a set of practices designed to reduce the devastation caused by fire. Fire safety measures include those used to prevent the ignition of an uncontrolled fire as well as those used to limit the development and effects of a fire once it has begun. Following are the standard practices for fire safety at workplace.

1. **Follow the emergency instruction in case of fire**
   a. Activate the ALARM.
   b. Evacuate the area.
   c. Call the fire department.
   d. Stay Calm
2. **Fight the fire only if:**
   a. You know-how.
   b. The fire is small.
   c. You are confined to the area where it started.
   d. You have a way out.
   e. You can work with your back to the exit.
   f. You have the right type of extinguisher.
   g. You feel confident that you can operate it effectively.
3. **Do not fight the fire if:**
   a. You have any doubts about fighting it.
   b. It is spreading beyond the area where it started.
   c. It could block your escape route.

4. Precautions to be taken during the fire:

Following precautions are to be taken in case of fire –

a. Switch off the main switch.

b. Snuff the fire by throwing dry sand on it.

c. Make sure that the fire extinguisher is operational and not expired.

d. Do not use water to extinguish an electrical fire.

e. Know the location of emergency exits and procedures.

Fire can be prevented by following these do's and don'ts at the workplace

Do's	Don'ts
Keep the work area clean.	Do not wear inflammable materials like nylon etc.
If empty containers contain inflammable materials, fill them with water.	Do not use inflammable materials near electrical lines.
Report any unsafe situation that may cause a fire.	Never weld near combustible materials.
Watch where the sparks and metals are falling from your work.	Never leave any cable without insulation.

Table. 4.3 Do's and Don'ts of Preventing Fire

Notes

4.2.2 Fire Extinguishers

Electrical fires are different from regular fires. They cannot be extinguished with water. Also, using water to put out an electrical fire is very dangerous and could lead to electrocution. To put out an electrical fire, the right type of fire extinguisher must be used. The following figure represents the different classes of fires:



Class of Fire - A

- Type of Fire - Ordinary Combustible : wood, paper, rubber, fabrics and many plastics.
- Type of Extinguisher- Water, dry powder, halon



Class of Fire - B

- Type of Fire - Flammable liquids and Gases: Gasoline, Oils, paint, lacquer and tar.
- Type of Extinguisher- Carbon Dioxide, dry powder, halon



Class of Fire - C

- Type of Fire - Fires involves live electrical equipment .
- Type of Extinguisher- Carbon Dioxide, dry powder, halon



Class of Fire - D

- Type of Fire -Combustible metals or combustible metal alloys
- Type of Extinguisher- Special Agents



Class of Fire - K

- Type of Fire - Fires in cooking appliances that involve combustible cooking media: vegetable or animal oils and fats.
- Type of Extinguisher - Wet Chemical

Fig. 4.11 Types of Fire

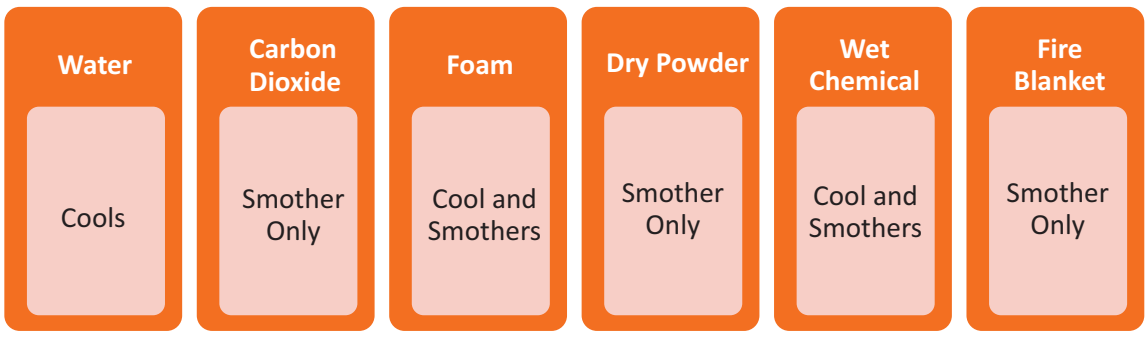


Fig. 4.12 Types of Fire Extinguishers



Fig. 4.13 Using a Fire Extinguishers

Notes

Exercise

Fill in the blanks:

a) _____cannot be extinguished with water.

b) Safety is _____ responsibility.

c) _____ in case of fire.

d) Do not fight the fire if_____.

Answer the following questions:

1. Explain various types of fire and fire extinguishers.

2. Write a short not fire safety.

3. Explain do's and don'ts of preventing fire.

4. List the precautions to be taken during the fire.

Notes

Unit 4.3 Emergency, Rescues and First-aid Practices

Unit Objectives

At the end of this unit, the trainee will be able to:

1. Describe different ways of preventing accidents at the workplace

4.3.1 Different Ways of Preventing Accidents/Hazards at the Workplace

ISO 45001 is an international standard for health and safety at work developed by national and international standards committees of government. An Occupational Health and Safety Management System (OHSMS) is a fundamental part of an organization's risk management strategy.

Implementing an OHSMS enables an organization to:

a. Protect its workforce and others under its control

b. Comply with legal requirements

c. Facilitate continual improvement

The following figure explains different ways/methods to control hazards and prevent accidents at the workplace:

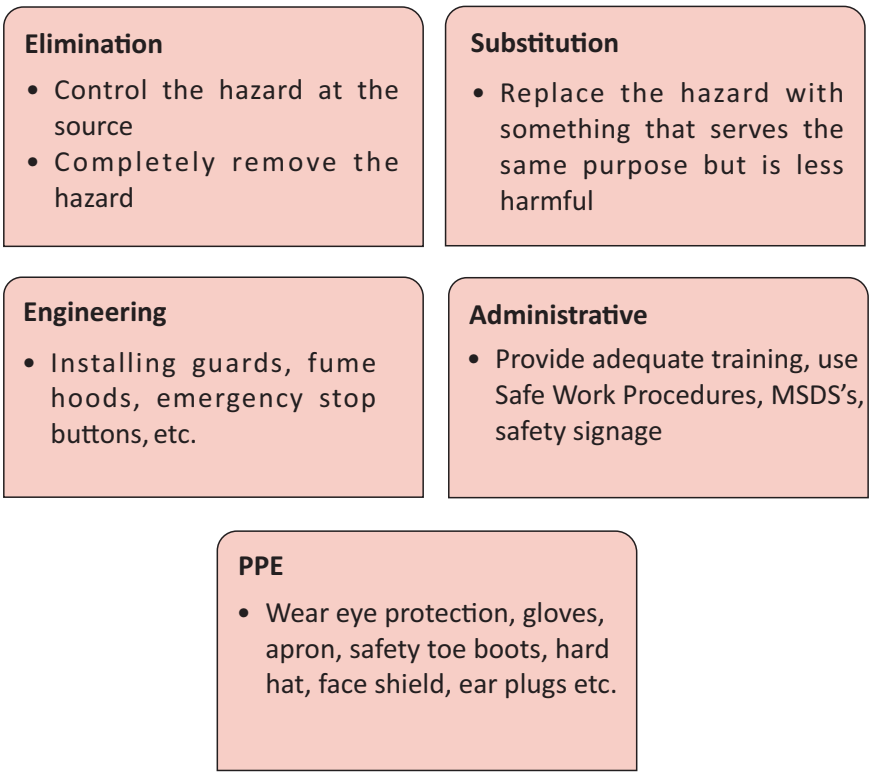


Fig. 4.14 Steps to Control Hazards and Prevent Accidents

4.3.2 Emergency Procedures to Deal with Electric Shock and Accidents

When a person somehow comes in contact with the live wire and gets shocked and faints, the following are the steps to be undertaken immediately as a first aid to save his/her life:

Responsibilities	Descriptions
Recognize the symptoms	• Common shock signs and symptoms include the following: o Pale, cold, clammy skin. It may appear grayish, the lips and fingernails may look blue. o The pulse and breathing are rapid. o The person is exhibiting disorientation or giddiness. o Nausea or vomiting may occur. o The person seems weak, with vacant eyes.
Call local emergency services number	• It's crucial to have paramedics on the way while you administer the treatment since the shock is a severe condition that will require hospitalization. • Stay on the line with the emergency services dispatcher in case of any need and provide the proper first aid. • In India, the Ambulance Emergency number is – 102
Make the person lie down	• Be extremely gentle since any sudden movements could injure the person. If the person is not in pain, place his or her legs on a pillow to elevate them about 12 inches above the head. • Do not move the person's head. • Keep the person flat and still after he or she is lying down.
Check for signs of breathing	• Observe the person's chest to see if it rises and falls, and place your cheek next to his or her mouth to check for breath. If the person is not breathing, perform CPR. Check the breathing every 5 minutes until the emergency services arrive.
Make the person comfortable	• Loosen the collars and unbutton or cutaway tight clothing. Unbuckle the person's belt, loosen the shoes and remove all tight jewelry on the person's wrists or neck. Cover the person with a blanket. • Do not give the person food or water. • Reassure and comfort the person; try to keep him or her calm until help arrives.

Continued...

Responsibilities	Descriptions
Check for vomiting and bleeding from the mouth	• If you observe vomit or blood coming from the mouth or nose, turn the person on his or her side to prevent him or her from choking. Help to prop the person up with pillows.
Administer treatment for injuries or blood loss	• If the person sustained a trauma, you might need to stop blood flow from a wound or provide first aid for a broken bone. • Seek further instructions from the emergency personnel over the phone.

Table. 4.4 Emergency Procedures to deal with Accidents

4.3.3 Safety Mock Drills

Safety is a priority to provide a safe working environment. Efforts should be taken to reduce the scale & probability of hazards. However careful we can be, hazards may still occur. Effective action has been possible in the emergency. In dealing with such emergencies, effective action is likely a pre-planned and practiced procedures for dealing with such emergencies.

What is a Mock Drill?

Mock Drill is a situation in which a fake emergency is announced, and workmen are asked to follow an emergency evacuation plan. This allows the workman to get familiarized with the emergency and act according to plan. Mock drills for chemical accidents and firefighting drills should be organized at regular intervals at the sites.

At the time of emergency evacuation, one must:

1. Raise the alert by crushing the glass cover of the closest break-glass alarm unit.
2. Be calm and composed.
3. Switch off all electrical apparatus except lights.
4. If possible, shut doors around the fire area to stop it from spreading.
5. Leave the building/site area immediately.
6. Follow the evacuation queue.
7. Give first preference to the physically disabled, expectant mothers, and the elderly
8. If it's dark and smoky, get down on your hands and knees and crawl to the nearest exit by counting the number of doors. If manageable, cover your nose with a wet towel or handkerchief.
9. Be acquainted with the hot exit door and pay attention to the thick smoke in the staircase. If the stairs are free from smoke, follow the directional signs and handrails.
10. Gather at the designated assembly point.
11. Do not re-enter the building until the signal is given
12. Max. time for evacuation should be 2.5 to 3.0 minutes.

4.3.4 Procedure for Reporting Accidents and Hazards

The essential responsibilities of an individual for reporting hazards and accidents are:

1. The people responsible for health and safety at the workplace;
2. The name, designation, and location of the person responsible to contact at the time of emergency

Additionally, an individual should also be adept in writing accident reports. An accident report needs to include all the essential information about the incident or near-miss. The report-writing process begins with facts and ends with recommendations for preventing future accidents.

An accident report involves four steps:

Gathering Facts: Collect and note all the facts, including –

- Date, time, and location of the accident
- Names, job titles, workers, and immediate supervisors involved
- Events leading up to the accident
- Job that the worker was handling at the time of the accident
- Names of employee who witnessed the accident
- Surrounding conditions (e.g., greasy floor, insufficient lighting, noise, etc.)
- Circumstances at the time of the accident (including tasks, equipment, tools, materials, etc.)
- PPE worn by the worker at the time of the accident
- Injuries that occurred (name of the injured body part and characteristics and extent of injuries)
- Type of treatment for injuries (first aid, if given)
- Damage to equipment, materials that the worker was working on or any other equipment or material around it.

Determining the Sequence: Describe the sequence of events after gathering the facts –

- **Events leading up to the accident:** Task the employee was performing at the time of the accident. For example: bending over, climbing, lifting operating machinery, using a tool, handling hazardous materials, etc.
- **Events involved in the accident:** Was the employee struck/caught in the machine or caught in the fire? Did the worker fall on the same level or from a height? Did he inhale hazardous fumes or get splashed with a hazardous chemical?
- **Events immediately following the accident:** What did the employee do: started bleeding? The body caught fire? Complain about back pain? Put a hand over a bleeding wound? Response from other workers/supervisors. Did they call for help, administer first aid, shut down equipment, move the victim to another place, etc.?
- The accident should be described in the report in sufficient detail that any reader can picture what happened.

Analysing: Analyse the causes of the accident. Causes include:

- Primary cause (e.g., a slip and fall from a ladder)
- Secondary causes (e.g., an employee not wearing appropriate goggles or helmet)
- Other contributing factors (e.g., poor ventilation).

Recommending: Recommendations for corrective action might include immediate as well as long-term corrective actions such as:-

- Training on safe work practices
- Preventive maintenance exercises that keep equipment in excellent working condition.
- Assessment of job techniques with a proposal for changes.
- Conducting a job hazard analysis to evaluate the task for any other hazards and then train employees on these hazards.
- Engineering changes that make the task safer or administrative changes that might include changing the way the job is performed.

Fig. 4.15 Accident Report Procedure

Exercise

Answer the following questions:

1. What are the different ways/methods to control hazards and prevent accidents at the workplace?

2. Explain emergency procedures to deal with electric shock and accidents.

3. Write a short note on safety mock drills.

4. Discuss the process of reporting accidents and hazards.

Notes

Unit 4.4 Effective Waste Management Practices

Unit Objectives

At the end of this unit, the trainee will be able to:

1. List the common sources of pollution and ways to minimize it
2. Describe the concept of waste management and methods of disposing hazardous waste
3. Explain the importance of efficient utilization of water, electricity and other resources
4. Describe the process of disposal of hazardous waste

4.4.1 Workplace Pollution

Workplace pollution is defined as the presence of hazardous materials or noises within a workplace that may affect employees while they are performing their duties. Such workplace pollutants can harm workers' health, especially if they are exposed for extended periods, even at low levels. The most common type of exposure is workplace air pollution. This includes workplace hazards from airborne pollution or the presence of hazardous substances in the workplace indoor air as gases (fumes) or as particulate matter (tiny particles - dust) dispersed in the air. Other modes of exposure include skin contact, ingestion, and/or injection.

Good Air Ventilation	**Identifying and avoiding direct contact with corrosive or toxic materials,**	**Not eating or drinking the presence of toxic or hazardous materials,**
Wearing protective gear as and when required).	**Effective Waste management practices at workplace**	**Effective cleaning and hygiene practices among the employees**
Re-use and Recycle	**No to plastic bags**	**Carpool or using public transport**

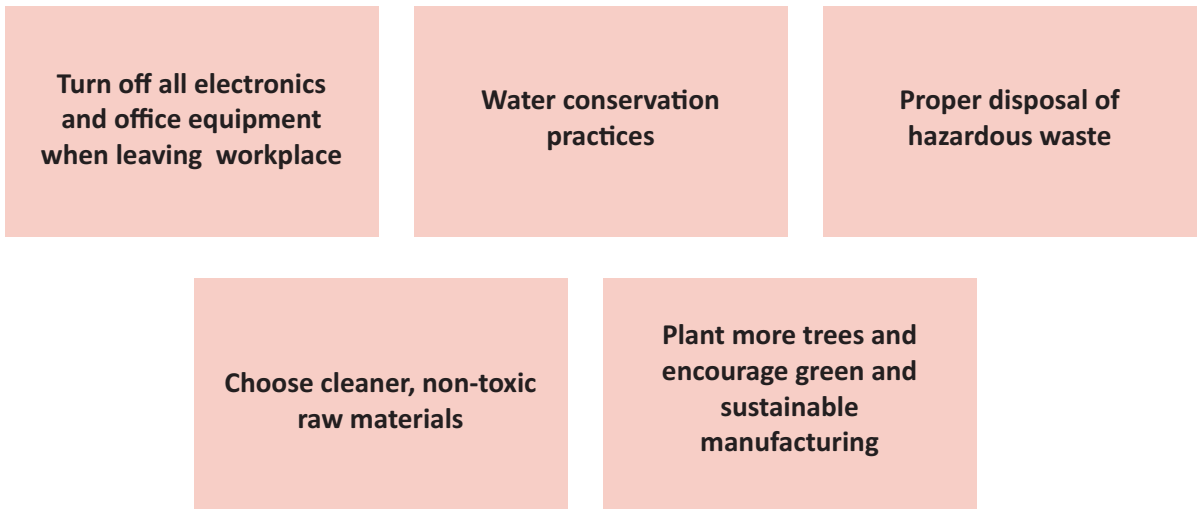


Fig. 4.16 Various Ways to Minimize Pollution

Notes

4.4.2 Effective Waste Management

Waste management refers to the activities and actions required to manage waste from its inception to its disposal. This includes the collection, transport, treatment, and disposal of waste and monitoring and regulation of the waste management process.

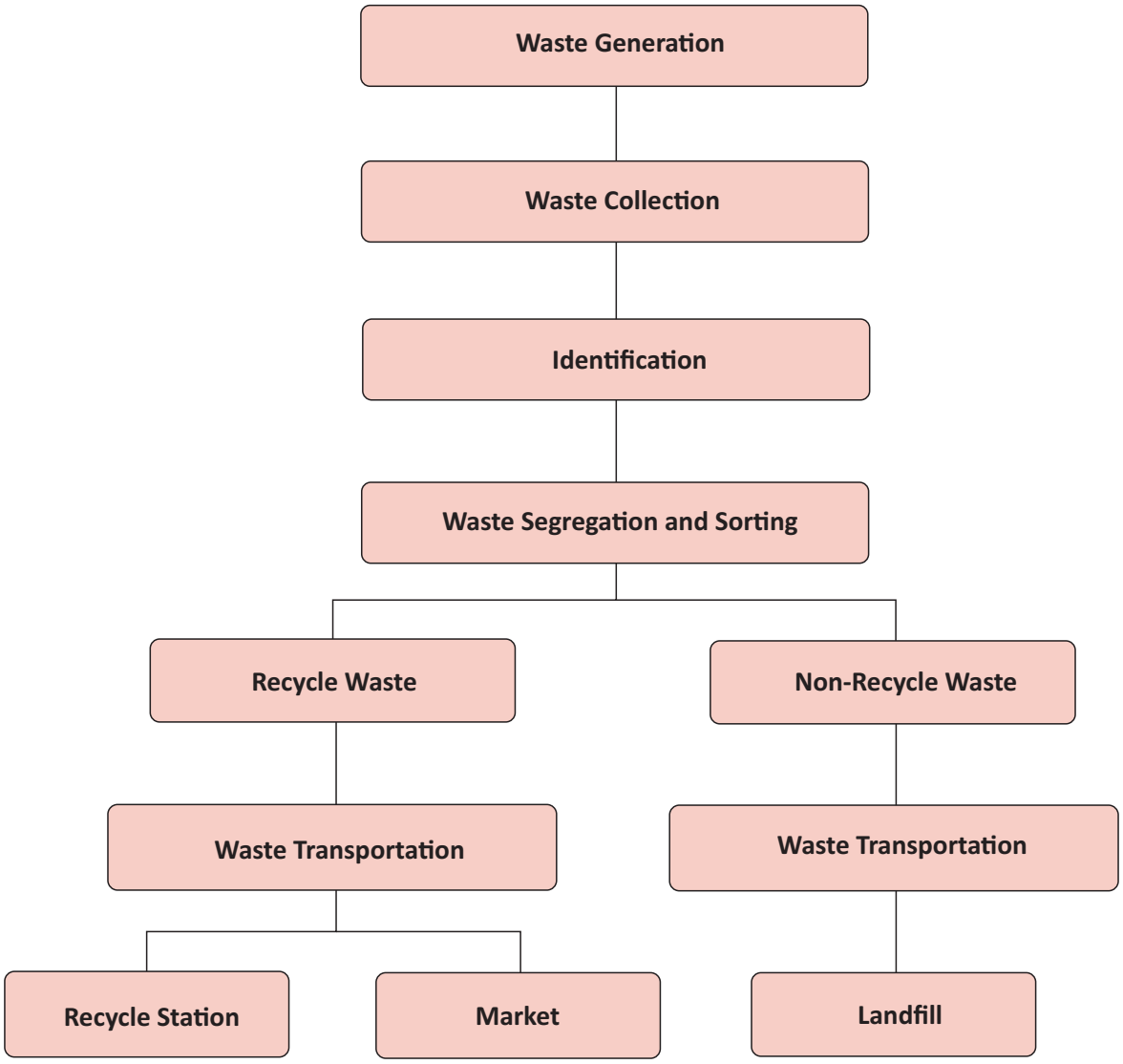


Fig. 4.17 Waste Management Process

Waste elimination is one of the utmost effective ways to escalate the profitability of any trade or business. To eliminate waste, it is essential to understand exactly what waste is and where it exists. While products significantly differ between places, the typical wastes found in electronic manufacturing environments are pretty similar.

There is a strategy to decrease or eliminate its effect on a company for each waste, thereby refining overall performance and quality. Everything that is done in an organization is divided into two groups: value-adding and waste. Usually speaking, value-adding is something the consumer pays for, and waste

is anything the consumer does not care about. All non-value-added activities belong to waste.

Specifically, waste metal is often difficult for businesses to manage in the electronic industries. Often exceptionally heavy and problematic to store, proper scrap metal disposal is a continuous challenge for businesses that produce large amounts of metal waste.

That is where the concept of waste mineralization becomes a must for every employee to understand. There are many ways to define waste mineralization. However, in its broadest sense, waste mineralization includes all practices including waste prevention, reuse, and recycling that reduce the amount of waste entering the environment.



Fig. 7.18 Waste Minimization

Waste Segregation

In general, waste is segregated as dry and wet waste. Dry waste includes wood, paper, plastic, glass, etc., related products that can be recycled, and wet waste refers to organic and biodegradable waste. The waste can be segregated using color-coded dustbins.



Fig. 7.19 Waste Segregation

1. **Green Bin**

   The green-colored bin is used to dump biodegradable waste, for example, wet/organic material, including cooked or leftover food, vegetable and fruit rinds, eggshell, rotten eggs, chicken/fish bones, tea or coffee grinds, coconut shells, and garden waste, including fallen leaves/twigs or the worship flowers/garlands.

2. **Blue bin**

   The blue-colored bin is used for segregating dry or recyclable left over. This category includes waste like plastic covers, bottles, boxes, cups, toffee wrappers, soap or chocolate wrappers, and paper waste, including magazines, newspapers, tetra packs, cardboard cartons, pizza boxes, or paper cups/plates, metallic items like tins/cans, foil paper, and containers.



Fig. 4.20 Dry &Wet Waste Bins

Recyclable Waste	Non-Recyclable Waste
Recyclable waste is renewable. The waste material can be reused or converted into new products or raw material, like paper, corrugated cardboard, glass, plastics container and bags, hard plastic, metal, wood products, e-waste, textile, etc.	Non-recyclable waste commonly includes materials that can be easily degraded in nature. For example, fruit shells, vegetable leaves, food leftovers, flowers and leaves, etc. it also includes cigarette end, muck, coal, cinder, construction waste, and paint waste which do not have big value after being discarded.

Table 4.5 Recyclable and Non-Recyclable Waste

The most commonly used methods of waste disposal are:



Landfill

It is a man-made method of disposing of solid and hazardous waste on land.



Incineration

It is a waste treatment method that involves the combustion of organic substances found in waste materials.



Waste Compaction

It is the process of compacting waste in order to reduce its size.



Biogas Generation

It is a renewable fuel that is created through the breakdown of organic matter. It can be used for vehicle fuel, heating, and electricity generation.



Composting

It is the natural process of decomposing and recycling organic material into a humus-rich soil amendment.



Vermicomposting

It is the process by which worms are used to convert organic materials (usually wastes) into a humus-like material known as vermin-compost.

Fig. 4.21 Methods of Waste Disposal

Notes

4.4.3 Hazardous Waste Management

Hazardous waste is defined as waste that poses significant or potential risks to public health or the environment. Characteristic hazardous wastes are materials that have been proven or tested to have one or more of the following hazardous properties:

1. Ignitability
2. Reactivity
3. Corrosively

Following are the impact of various hazardous material on the manufacturing process:

Increase risk and contamination	**Substandard quality and defective products**	**Certain hazardous substances also have the potential to explode or cause a fire**
Possible injuries and illness among the workers	**Possible damage of equipment and machinery**	**Low productivity**
Material and resources wastage	**Loss of time, money and goodwill**	**Economic consequences of recall and outbreak**

Fig. 4.22 Impact of Hazardous Material in Production Process

There are several options for hazardous-waste management. The most desirable option is to reduce waste at its source or to recycle the materials for another productive use. Nonetheless, while reduction and recycling are desirable options, they are not regarded as the final solution to the hazardous-waste disposal problem. There will always be a need for hazardous waste treatment, storage, or disposal.

1. **Chemical Treatment -** Chemical treatment processes include ion exchange, precipitation, oxidation and reduction, and neutralization.
2. **Thermal Treatment -** Thermal methods include high-temperature incineration, which can not only detoxify but also destroy certain organic wastes. Thermal equipment of specialized design is used to burn waste in solid, liquid, or sludge form. Fluidized-bed incinerators, multiple-hearth furnaces, rotary kilns, and liquid-injection incinerators are some examples of thermal treatment.

1. **Biological Treatment -** The waste is carefully mixed with surface soil on a suitable plot of land in this technique. Microbes that can metabolize waste, as well as nutrients, may be added.
2. **Surface storage and land disposal -** Hazardous wastes that cannot be destroyed by incineration or other chemical processes must be properly disposed of. Land disposal is the ultimate destination for the majority of such wastes, though it is not an appealing practice due to the inherent environmental risks involved. Landfilling of hazardous solid or containerized waste is subject to stricter regulations than municipal solid waste landfilling. Hazardous wastes must be disposed of in so-called secure landfills, which must have at least 3 meters (10 feet) of space between the landfill's bottom and the underlying bedrock or groundwater table. Two impermeable liners and leachate collection systems are required for a secure hazardous-waste landfill.

Manufacturers of hazardous substances must provide warning labels and safety guidelines with their products. Employers must ensure that the safety guidelines for each hazardous substance used in the workplace are available to employees and warning labels on hazardous substances should feature:

- Hazard Pictograms
- Signal Words (e.g. Danger and Warning)
- Hazard Statements (e.g. Fatal If Swallowed)
- Precautionary Statements (e.g. Wear Protective Gloves).

The Safety guidelines must include important information on handling the product safely, including:

- Potential Health Effects
- Precautions for Use
- Safe Storage Suggestions
- Emergency First Aid Instructions
- Contact Numbers for Further Information.

4.4.4 Material Utilization

Material efficiency means producing the same result with reduced amounts or lower grades of raw materials. Material efficiency measures seek to decrease the number of natural resources required to produce a certain output level and recycle post-consumption waste material back in the manufacturing process.

The reuse of wear parts and components is also part of material efficiency, extending the lifetime of machinery, components, and spare parts through reconditioning. Material efficiency includes new product innovations to replace previous products that consume greater amounts of raw materials.

4.4.5 Energy Conservation Practices

In general terms, energy conservation refers to the simple practices that we follow in our day-to-day life to preserve energy. Manufacturing facilities are among the largest consumers of energy. Therefore, efforts to improve energy efficiency are an increasing concern for many manufacturing facilities. This can be accomplished by evaluating energy end uses e.g., lighting, processing equipment, and heating, air conditioning, and ventilation, HVAC systems, and by implementing measures to reduce the total amount of energy consumed for one or more of the end uses. The following exhibit suggests a few steps which can be followed for achieving energy efficiency and consumption.



Switching off lights remains one of the easiest ways to save on energy but it's surprising how often lights are kept on, even when no one is in the lit area. This problem is compounded in when employees go in and out of various buildings and work areas as they go about their duties.



Ensure you shut off machinery and equipment when not in use. Walking through your plant after-hours and ensuring equipment is powered down when not in use can result in significant savings over time.



Regular cleaning and planned maintenance of the electrical and mechanical equipment will go a long way towards optimising its performance and lifespan, which can translate to energy efficiency savings.



Newer heating and cooling systems will be far more efficient than old ones, so it may be worth getting systems more than 10 years old replaced.



Insulation acts as a barrier against temperature shifts. By installing insulation in the roof, and walls of your workspace, you can reduce the amount of energy needed to maintain room temperature during heat loss and heat gain.



Use fixed or adjustable shading, plant trees and vegetation or install sun filters on the windows and walls of the workplace— especially industrial sheds— to protect from acute heat during summers.



Use LED lights which are more energy efficient.

Continued...



Use natural airflow where possible to avoid usage of cooling systems.



Optimise the energy consumption settings of the appliances being used in the unit, like refrigerator and AC can be made to run by a couple of degrees higher.



Create awareness on importance of energy consumption among the employees

Fig. 4.23 Energy Conservation Practices

4.4.3 Water Conservation Practices

Water conservation is the practice of using water efficiently to reduce unnecessary water usage. It is essential because fresh clean water is a limited resource and a costly one. We are already well aware of the financial costs of inefficient water use. Conservation of this natural resource is critical for the environment — and our wallets.

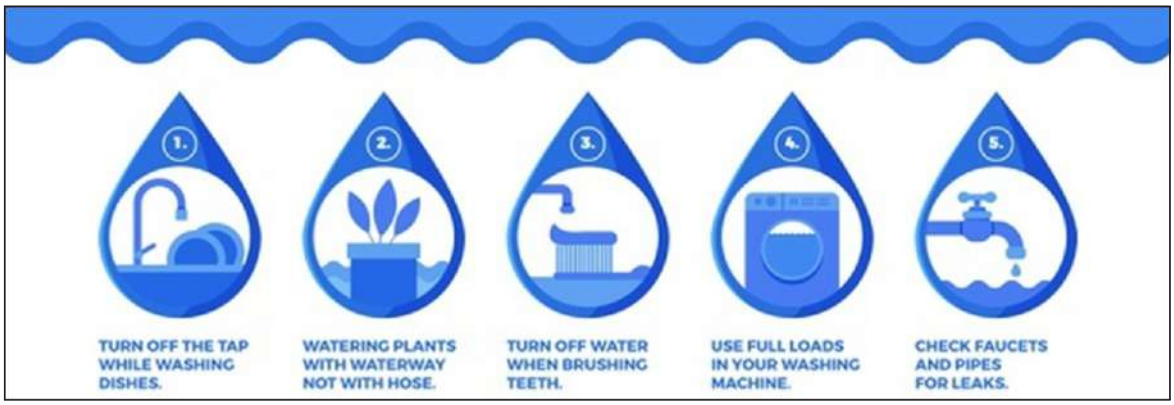


Fig. 4.24 Water Conservation Practices

Summary



- Workplace safety is one of the most significant concerns for any manufacturing company or facility. Getting it right can improve the overall performance of the operation and lead to growth.
- It is the responsibility of everyone, whether employer or employee, to keep the workplace clean, healthy, and safe.
- As safety is an integral part of the workplace, Quality Managers should not turn a blind eye and, if necessary, issue instructions.
- A hazard is something or someone that has the potential to cause damage, harm, or adverse health effects.
- An organizational safety procedure is a step-by-step instruction manual for carrying out a work procedure. It is used when a deviation from the procedure could result in injury or an accident.
- Electricity is widely recognized as a serious workplace hazard that can cause electric shock, burns, fires, and explosions. Every year, many employees suffer pain, injuries, and even death as a result of electric shocks. To keep yourself and others safe, it is critical to adhere to electrical safety-related work practices.
- Lifting heavy objects is one of the leading causes of workplace injury. The main causes of these injuries were overexertion and cumulative trauma. Bending is the most frequently cited movement that resulted in back injuries, followed by twisting and turning.
- Workplace safety signage evolved with the Industrial Revolution when workplace safety became a major concern. The purpose of a workplace safety sign is to identify and warn employees who may be exposed to various hazards.
- Electronic-waste recycling is one of the most discussed issues in the world today due to its potential to reduce environmental hazards and pollution. It can also protect our lives as humans and other life forms in our world. E-waste recycling is the reuse and reprocessing of any type of discarded or obsolete electrical and electronic equipment.
- Recycling electronics can be a difficult task. This is due to the fact that e-scraps are typically sophisticated and made from a variety of materials such as metals, plastics, and glass.
- Employers bear more responsibility than their employees because they are held accountable for their employee's safety and well-being.
- Health and safety documents assist in controlling risks and communicating safe working procedures. Many health and safety documents, such as risk assessments and health and safety policies, are also required by law.
- PPE refers to the clothing or equipment designed to protect the workers/employees from shop floor hazards. It includes items such as hard hats, safety boots, coveralls, gloves, safety glasses and goggles, earplugs, high visibility vests, lifejackets, fall protection, and respirators.
- Effective housekeeping assists in the control or elimination of workplace hazards. Poor housekeeping practices frequently contribute to incidents.
- 5S is intended to be a visually-oriented system of cleanliness, organization, and arrangement to attain greater productivity. It engages all employees and is a foundation for more self-discipline on the job for better work and better products.

- Fire safety refers to a set of practices designed to reduce the devastation caused by fire. Fire safety measures include those used to prevent the ignition of an uncontrolled fire as well as those used to limit the development and effects of a fire once it has begun.
- Electrical fires are different from regular fires. They cannot be extinguished with water. Also, using water to put out an electrical fire is very dangerous and could lead to electrocution. To put out an electrical fire, the right type of fire extinguisher must be used.
- If you observe vomit or blood coming from the mouth or nose, turn the person on his or her side to prevent him or her from choking. Help to prop the person up with pillows.
- A mock Drill is a scenario in which a fake emergency is declared and employees are instructed to follow an emergency evacuation plan. This allows the worker to become acquainted with the emergency and act accordingly.
- Workplace pollution is defined as the presence of hazardous materials or noises within a workplace that may affect employees while they are performing their duties. Such workplace pollutants can harm workers' health, especially if they are exposed for extended periods, even at low levels.
- Waste management refers to the activities and actions required to manage waste from its inception to its disposal. This includes the collection, transport, treatment, and disposal of waste and monitoring and regulation of the waste management process.
- Waste elimination is one of the utmost effective ways to escalate the profitability of any trade or business. To eliminate waste, it is essential to understand exactly what waste is and where it exists. While products significantly differ between places, the typical wastes found in electronic manufacturing environments are pretty similar.
- In general, waste is segregated as dry and wet waste. Dry waste includes wood, paper, plastic, glass, etc., related products that can be recycled, and wet waste refers to organic and biodegradable waste. The waste can be segregated using color-coded dustbins.
- Recyclable waste is renewable. Non-recyclable waste commonly includes materials that can be easily degraded in nature.
- Hazardous waste is defined as waste that poses significant or potential risks to public health or the environment.
- Material efficiency means producing the same result with reduced amounts or lower grades of raw materials. Material efficiency measures seek to decrease the number of natural resources required to produce a certain output level and recycle post-consumption waste material back in the manufacturing process.
- In general terms, energy conservation refers to the simple practices that we follow in our day-to-day life to preserve energy. Manufacturing facilities are among the largest consumers of energy. Therefore, efforts to improve energy efficiency are an increasing concern for many manufacturing facilities.
- Water conservation is the practice of using water efficiently to reduce unnecessary water usage. It is essential because fresh clean water is a limited resource and a costly one.

Exercise

Fill in the blanks:

a) Dry waste includes _____, _____ and _____ etc.

b) _____ can be reused or converted into new products or raw material.

c) The waste can be segregated using _____ dustbins.

Answer the following questions:

1. Differentiate between recycle and non-recycle waste.

_____

_____

_____

2. Explain waste elimination.

_____

_____

_____

3. Name any methods of waste disposal.

_____

_____

_____

4. List various ways to minimize pollution at workplace

_____

_____

_____

Match the following:

Column A	Column B
Energy Conservation Practices	Strains and sprains from lifting loads
Water Conservation Practices	Reuse of wear parts
Potential injuries occurs during moving of materials manually	Shut off machinery when not in use
Material efficiency	Turn off the tap when it is not necessary

Notes

QR Code

Scan the QR Code to watch the related video

youtube.com/watch?v=WW0U6o1XNec

Workplace Safety

youtube.com/watch?v=aH495epWeAE

Safety Hazards, Risks and Accidents

youtube.com/watch?v=ReL-DM9xhpI

Fire Safety Practices

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6. Annexure

Annexure I : QR Code



Annexure - QR Code

Serial No.	Module No.	Unit Number	Topic Name	Page No.	URL	QR Code
1.	Introduction and orientation to the role of an Embedded Software Engineer	Unit 1.1 Electronics Industry and its Sub-sectors- An Introduction	Introduction to the Electronics Industry	11	https://youtu.be/PiR7PDEKy2A 1	
			Role and responsibilities of an Embedded Software Engineer		https://www.youtube.com/watch?v=JChTishaqQM	
2.	Process of developing embedded system software	Unit 2.1 Organisational Policies and Reporting Structure	Intellectual Property Rights	64	https://www.youtube.com/watch?v=Bj1_z56VEJ0	
			Software fundamentals - data structures and algorithms		https://www.youtube.com/watch?v=1jAI-kjKelY	
			SRS document		https://www.youtube.com/watch?v=2SUNWVwQaXs	
			BRS documents		https://www.youtube.com/watch?v=FwKr2F2nPcU	

Annexure - QR Code

Serial No.	Module No.	Unit Number	Topic Name	Page No.	URL	QR Code
3.	Work effectively at the workplace	Unit 3.1 Work and Communicate effectively at workplace	Work in a Disciplined and Ethical Manner	100	youtube.com/watch?v=I-1Fa7aTYXA	
4.	Basic Health and Safety Practice	Unit 4.1 Dealing with Workplace Hazards & Risks	Workplace Safety	144	youtube.com/watch?v=WW0U6o1XNec	
			Safety Hazards, Risks and Accidents		youtube.com/watch?v=aH495epWeAE	
			Fire Safety Practices		youtube.com/watch?v=ReL-DM9xhpI	
5.	Employability Skills			145	https://www.skillindiadigital.gov.in/content/list	

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