Information and Communication Technology

Teachers' Guide
Grade 12

(Effective from 2017)

Department of Information Technology
National Institute of Education
Maharagama
Sri Lanka

www.nie.lk

Information and Communication Technology
Grade 12 – Teacher's Guide

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CONTENTS **Page No**

1.0	**Message from the Director General**	**ii**
2.0	**Message from the Deputy Director General**	**iii**
3.0	**Curriculum Committee**	**iv-v**
4.0	**Introduction**	**vi**
5.0	**Common National Goals**	**vii**
6.0	**Basic Competencies**	**viii-x**
7.0	**Objectives of the Subject**	**xi**
8.0	**Proposed number of periods for each units**	**xii**
9.0	**Syllabus**	**1 – 27**
10.0	**Learning Teaching process**	**28 -191**
11.0	**School Policies and Programs**	**192**
12.0	**Assessment and Evaluation**	**193**

Message from the Director General

With the primary objective of realizing the National Educational Goals recommended by the National Education Commission, the then prevalent content based curriculum was modernized, and the first phase of the new competency based curriculum was introduced to the eight year curriculum cycle of the primary and secondary education in Sri Lanka in the year 2007

The second phase of the curriculum cycle thus initiated was introduced to the education system in the year 2015 as a result of a curriculum rationalization process based on research findings and various proposals made by stake holders.

Within this rationalization process the concepts of vertical and horizontal integration have been employed in order to build up competencies of students, from foundation level to higher levels, and to avoid repetition of subject content in various subjects respectively and furthermore, to develop a curriculum that is implementable and student friendly.

The new Teachers' Guides have been introduced with the aim of providing the teachers with necessary guidance for planning lessons, engaging students effectively in the learning teaching process, and to make Teachers' Guides will help teachers to be more effective within the classroom. Further, the present Teachers' Guides have given the necessary freedom for the teachers to select quality inputs and activities in order to improve student competencies. Since the Teachers' Guides do not place greater emphasis on the subject content prescribed for the relevant grades, it is very much necessary to use these guides along with the text books compiled by the Educational Publications Department if, Guides are to be made more effective.

The primary objective of this rationalized new curriculum, the new Teachers' Guides, and the new prescribed texts is to transform the student population into a human resource replete with the skills and competencies required for the world of work, through embarking upon a pattern of education which is more student centered and activity based.

I wish to make use of this opportunity to thank and express my appreciation to the members of the Council and the Academic Affairs Board of the NIE the resource persons who contributed to the compiling of these Teachers' Guides and other parties for their dedication in this matter.

Dr. (Mrs.) Jayanthi Gunasekara

Director General

National Institute of Education

Message from the Deputy Director General

Education from the past has been constantly changing and forging forward. In recent years, these changes have become quite rapid. The Past two decades have witnessed a high surge in teaching methodologies as well as in the use of technological tools and in the field of knowledge creation.

Accordingly, the National Institute of Education is in the process of taking appropriate and timely steps with regard to the education reforms of 2015.

It is with immense pleasure that this Teachers' Guide where the new curriculum has been planned based on a thorough study of the changes that have taken place in the global context adopted in terms of local needs based on a student-centered learning-teaching approach, is presented to you teachers who serve as the pilots of the schools system.

An instructional manual of this nature is provided to you with the confidence that, you will be able to make a greater contribution using this.

There is no doubt whatsoever that this Teachers' Guide will provide substantial support in the classroom teaching-learning process at the same time. Furthermore the teacher will have a better control of the classroom with a constructive approach in selecting modern resource materials and following the guide lines given in this book.

I trust that through the careful study of this Teachers Guide provided to you, you will act with commitment in the generation of a greatly creative set of students capable of helping Sri Lanka move socially as well as economically forward.

This Teachers' Guide is the outcome of the expertise and unflagging commitment of a team of subject teachers and academics in the field Education.

While expressing my sincere appreciation for this task performed for the development of the education system, my heartfelt thanks go to all of you who contributed your knowledge and skills in making this document such a landmark in the field.

M.F.S.P. Jayawardhana

Deputy Director General

Faculty of Science and Technology

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5.0 Introduction

Information and Communication Technology has been identified worldwide as a tool that can be used to improve productivity, efficiency and effectiveness of organizational work and the daily activities of individuals. Therefore, providing an adequate level of ICT knowledge and skills, at different levels of education, is important for the students to progress and contribute towards national development.

The current Sri Lankan Secondary Education System has been substantially exposed to ICT through various programs including CAL, ICT for GCE (O/L), GIT at grade 12 and ICT as a component in A/L Technology stream. Consequently, students have shown a growing interest in ICT education and some have, in fact, performed excellently at international competitions in ICT, proving their high level of competence.

ICT as a main subject for GCE (A/L) was introduced in 2007. The syllabus was revisited in 2013. According to the syllabus revising policy the syllabus was revised in 2017. GCE (O/L) qualified students who are interested in developing their career path in ICT, have the opportunity of learning it at the GCE (A/L). ICT as a subject for A/L would set a national standard in ICT education at school level and provide the path to higher education at tertiary level. Furthermore, students who fail to earn a placement in a university would be in possession of a substantial foundation to build up their academic and professional careers.

The ICT syllabus at GCE (A/L) communicates core concepts of ICT covering both theoretical and practical usage of ICT. This will also strengthen student's awareness of the new trends and future directions of ICT. Also this subject will provide an added advantage to students by improving their soft skills, thereby enabling them to best fit into working environments.

6.0 National Goals

1. Based on the concept of respecting human values and understanding the differences between the Sri Lankan multi-cultural society, building up the nation and confirming the identity of Sri Lanka by promoting national integrity, national unity, national coherence and peace

2. While responding to the challenges of the dynamic world, identifying and conserving the National heritage.

3. Creating an environment which comprises of the conventions of social justice and the democratic life to promote the characteristics of respecting the human rights, being aware of the responsibilities, concerning each other with affectionate relationships.

4. Promoting a sustainable life style based on the people's mental and physical well-being and the concept of human values

5. Promoting the positive feelings needed for balanced personality with the qualities of creative skills, initiative, critical thinking and being responsible

6. Through education, developing the human resources, needed for the progress of the well-being of an individual, the nation as well as the economic growth of Sri Lanka.

7. Preparing the people for the changes that occur in a rapidly changing world by adapting to it and controlling them; developing abilities and potentialities of people to face the complex and unexpected occasions.

8. Sustaining the skills and attitudes based on justice, equality, mutual respect which is essential to achieve a respectable place in the international community.

National Education Commission Report (2003).

7.0 Basic Competencies

The competencies promoted through the education mentioned below might help to achieve the above mentioned National Goals.

1. Competencies in Communication

This first set of competencies is made up of four subsets - Literacy, Numeracy, Graphics and information communication skills:

Literacy: Carefully listening, speaking clearly, and Reading for comprehension, writing clearly and accurately.

Numeracy: Using numbers to count, calculate, code and to measure, matter, space and time

Graphics: Making sense of line and form, expressing and recording essential data, instructions and ideas with line, form, colour, two and three-dimensional configurations, graphic symbols and icons

ICT Competencies:

Knowledge on computers, and the ability to use the information communication skills learning or work as well as in the private life

2. Competencies relating to the Personality Development

- Generic skills such as creativity, divergent thinking, initiative, decision making, problem-solving, critical and analytical thinking, team work, inter-personal relationships, discovering and exploring
- Values such as integrity, tolerance and respect for human dignity
- Cognition

3. Competencies relating to the Environment

This is the second set of competencies related to the Social, Biological and Physical Environments.

Social Environment: Awareness, sensitivity and skills linked to being a member of society, social relationship, personal conduct, general and legal conventions, rights, responsibilities, duties and obligations.

Biological Environment: Awareness, sensitivity and skills linked to the living world, man and the ecosystem, the trees, forests, seas, water, air and plant -life, animal and human life.

Physical Environment: Awareness, sensitivity and skills relating to space, energy, fuels, matter, materials and their links with human living, food, clothing, shelter, health, comfort, respiration, sleep, relaxation, rest, wastes and excretion, media of communication and transport.

Included here are the skills in using tools to shape and for materials for living and learning

4. Competencies relating to preparation for the world of work

Employment related skills to maximize their potential and to enhance their capacity to contribute to economic development; to discover their vocational interests and aptitudes; to choose a job that suits their abilities and to engage in a rewarding and sustainable livelihood.

5. Competencies relating to religion and ethics

This fourth set of competencies laden with values and attitudes. It is essential for individuals to assimilate values, so that they may function in a manner consistent with the ethical, moral and religious modes of conduct, rituals, practices in everyday living, selecting the most appropriate.

6. Competencies in play and use of leisure

Competencies that link up with pleasure, joy, emotions and such human motivations. These find expression in play, sports, athletics and leisure pursuit of many types. These also link up with such values as cooperation, team work, healthy competition in life and work. Here are included such activities as are involved in aesthetics, arts, drama, literature, exploratory

research and other creative modes in human living.

7. Competencies relating to ‘Learning to learn’

These competencies flow directly from the nature of a rapidly changing, complex and interdependent and crowded world whatever one learns, that learning will need updating and review. This requires that one should be aware of, sensitive and skilful in sustained attention, and be willing to persevere and attend to details that matter in a given situation.

8.0 Objectives of the Subject

This syllabus enables students to:

- Establish the foundation for ICT education leading to higher education
- Establish the foundation to build up their professional career
- Produce entry level ICT human resources required for the industry
- Enable to use ICT effectively in achieving Sustainable Development Goals (SDG)
- Provide students with ICT knowledge to improve the quality of life in general
- Provide awareness of the importance of computer networking for communication
- Improve the skills required for the development of ICT based solutions for real world problems
- Provide awareness of the new trends and future directions of ICT
- Enable to use ICT for innovation and researches
- Develop an appreciation of the role of ICT in a knowledge-based society

9.0 Proposed number of periods for each units

Term	Competency Level	No. of Periods
First Term	1.1, 1.2,1.3,1.4,1.5,1.6,1.7 2.1, 2.2, 2.3,2.4 3.1, 3.2,3.3 4.1,4.2	28 22 18 14 (82 Periods)
Second Term	4.3, 4.4 5.1, 5.2, 5.3,5.4 6.1,6.2,6.3,6.4,6.5,6.6,6.7,6.8,6.9,6.10,6.11,6.12	12 22 50 (84 Periods)
Third Term	7.1, 7.2, 7.3, 7.4,7.5,7.6,7.7,7.8,7.9,7.10	68 (68 Periods)
		Total Periods 234

Competency	Competency Level	Contents	Learning outcomes	Periods
Competency 1: Explores the basic concepts of ICT together with its role and applicability in today's knowledge based society	1.1 Investigates the basic building blocks of information and their characteristics	• Life cycle of data ○ Data creation ○ Management ○ Removal of obsolete data • Data vs. Information • Definition of information • Characteristics of valuable information: timeliness, accuracy, presented within the context, enhanced understandability and less uncertainty • The need to handle large volumes and other complexities of data - Introduction	• Defines data and outlines its life cycle • Recognizes the need of a process to define data and information • Recognizes the strong inter relationship between data, process and information • Describes data, process and information • Lists various forms of data and their characteristics • Describes the characteristics of quality data • Distinguishes data from information • Illustrates the value of information • Describes the characteristics of valuable information • Recognizes big data, their needs and analysis	6
	1.2 Investigates the need of technology to create, disseminate and	• Applicability of information in day to day life ○ Decision making	• Identifies the drawbacks of manual data processing	6

Competency	Competency Level	Contents	Learning outcomes	Periods
	manage data and information	○ Policy making ○ Predictions ○ Planning, scheduling and monitoring • Drawbacks of manual methods in manipulating data and information ○ Inconsistency and duplication in data, room for errors, human errors and delay in processing ○ Lack of sharing information and reduced customer services • Infeasibility of applying manual methods where they can be harmful to humans • Emergence of ICT era ○ Use of IT to overcome the drawbacks of manual methods of data manipulation • Usage of information in various domains • Availability of technologies related to information retrieval and sharing • Development of computer networks, the Internet and WWW • Development of mobile communication, mobile computing and cloud computing	methods • Describes the importance of information in day to day life • Lists the available technologies related to information dissemination • Investigates the development of computer networks, the Internet and WWW • Describes the development of mobile communication, mobile computing and cloud computing • Appreciates the use of technology to create, disseminate and manage, data and information • Recognizes the usage of information in various domains • Investigates the safety issues of human operators in various applications	
	1.3 Formulates an abstract model of	• Abstract model of information creation ○ Input, process, output	• Identifies the components of an	2

Competency	Competency Level	Contents	Learning outcomes	Periods
	information creation and evaluates its compliance with ICT	○ Its appropriateness to Computer and ICT	abstract model of information creation • Defines a system • Analyses various systems using the system definition • Relates the abstract model to information systems • Matches the abstract model of information creation to the main functions of the computer • Recognizes the role of ICT in the abstract model of information creation	
	1.4 Selects and classifies the basic components of a computer system	• Hardware ○ Classification of hardware components • Software ○ Classification of software • Human Operators ○ Need of human operators in information systems	• Defines and classifies hardware and software components • Distinguishes proprietary software and open source software • Describes the advantages and disadvantages of proprietary and open source software • Identifies the role of human operators in the	2

Competency	Competency Level	Contents	Learning outcomes	Periods
			ICT enabled information systems	

	1.5 Analyses the activities of data processing	• Steps in data processing:
		  ○ Data gathering
		  ○ Data validation
		  ○ Data processing
		  ○ Data output
		  ○ Data storage
		• Data gathering methods
		  ○ Manual methods
		  ○ Semi-automated and automated methods
		• Tools - (OMR, OCR, MICR, card/tape readers, magnetic strip readers, bar code readers, sensors and loggers)
		• Data validation methods
		  ○ Data type check
		  ○ Presence check
		  ○ Range check
		• Modes of data input
		  ○ Direct and remote
		  ○ Online and offline
		• Data processing
		  ○ Batch and real time
		• Output methods
		  ○ Direct presentation to the user
		  ○ Storing for further processing
		• Storage methods
		• Local and remote storage (cloud)
		• Short and long term storage
			• Lists and briefly describes the data processing steps
			• Identifies data gathering methods
			• Identifies data validation methods
			• Lists data input methods
			• Describes data processing methods
			• Lists data output methods
			• Describes data storage methods
				4

	1.6 Investigates the	• Application of ICT in:	• Identifies appropriate	4

Competency	Competency Level	Contents	Learning outcomes	Periods
	application of ICT in different domains	○ Education ○ Healthcare ○ Agriculture ○ Business and finance ○ Engineering ○ Tourism ○ Media and journalism ○ Law enforcement	tools, skills and knowledge needed in different application domains • Discusses the benefits of ICT in different domains	
	1.7 Evaluates the impact of ICT in the society	• Benefits caused by ICT ○ Social benefits ○ Economic benefits • Issues caused by ICT ○ Social ○ Economical ○ Environmental ○ Ethical ○ Legal ○ Privacy ○ Digital divide • Confidentiality • Stealing / Phishing • Piracy • Copyright / intellectual property laws • Plagiarism • Licensed / unlicensed software	• Explains the benefits of ICT in terms of social and economic aspects • Explains briefly the issues caused by advancement of ICT in terms of social, economic, environmental, ethical and legal aspects • Investigates the legal situation connected with the usage of ICT • Explains the environmental issues associated with ICT • Explains safe disposal methods of e-waste • Explains briefly the ethical, Legal and social issues in the usage of ICT • Briefly explains the role of ICT in achieving	4

Competency	Competency Level	Contents	Learning outcomes	Periods
			Sustainable Development Goals (SDGs) • Investigates the approaches to eliminate digital divide	
Competency 2: Explores the evolution of computing devices, so as to be able to describe and compare the performance of modern computers	2.1 Elicits the significant changes occurred in the computers from generation to generation with more emphasis on the evolution of processors	• History of computing ○ Early calculating aids ❖ mechanical ❖ electromechanical ○ Electronic age of computing • Generation of computers ○ 1G, 2G, 3G, 4G and future • Different types of classifications ○ Technology ❖ analog, digital ○ Purpose ❖ special /general ○ Size ❖ super, mainframe, mini, micro (mobile devices –smart phones, tablet devices and phablets)	• Categorizes the early calculating aids with examples • Describes the generations of computers with their features in a table • Categorizes computers in terms of technology, purpose and size with examples	4
	2.2 Explores the functionality of a computer in relation to the hardware and their interfaces	• Major hardware components ○ Input devices: keyboard entry and direct entry (keyboard, pointing devices, touch pad, remote control, touch screen, magnetic strip reader, barcode reader, smart card reader, scanner, digital camera, microphone, sensors, graphic tablets, MICR, OMR and OCR readers, video	• Identifies hardware peripherals and their relevant interfaces • Identifies the advantages of direct entry input devices over keyboard entry input devices	6

Competency	Competency Level	Contents	Learning outcomes	Periods
		camera, digitizer, web cam) • Advantages of direct entry input devices over keyboard entry input devices • Output devices and their features (CRT monitor, TFT monitor, LED monitor, dot matrix printer, inkjet printer, laser printer, 3D printer, graph plotter, speakers) • CPU and its compatibility with motherboard • Storage devices(fixed internal hard disk, portable external hard disk, magnetic tape, Optical discs(CD Rom/DVD Rom, CD-R/DVD-R, CD-RW/ DVD-RW, DVD-RAM, Blu-Ray) flash memory card, mini disk) • Parallel and grid computing	• Describes the evolution of CPU and its compatibility with motherboard • Categorizes the Storage devices • Briefly explains the features of each storage device • Identifies the need for parallel and grid computing	
	2.3 Explores the Von-Neumann Architecture	• Von-Neumann Architecture ○ Stored program control concept ○ Components (input, output, memory, Processor control unit and processing ALU unit) • Fetch-execute cycle • Central processing unit (CPU) ○ Arithmetic and logic unit (ALU) ○ Control unit (CU) ○ Memory (Registers) ○ Data and control bus ○ Multi-core processors	• Describes the stored program concept • Names the major components of Von-Neumann architecture • Describes fetch-execute cycle • Briefly describes ALU, CU, Memory (Registers), data and control bus • Draws the Von-Neumann Architecture model and names its components	6

Competency	Competency Level	Contents	Learning outcomes	Periods
			• Describes the need of multi-core processors	
	2.4 Examines PC memory system to identify different types of memory and their main characteristics	• Memory hierarchy ○ Need of memory hierarchy ○ Comparison criteria ❖ Physical size / density of data ❖ Access method ❖ Access time (elapsed time/delay) ❖ Capacity ❖ Cost • Volatile memory and their characteristics ○ Registers ○ Types of cache memory ○ Main memory – RAM ○ Types of RAM ❖ SRAM, DRAM, SDRAM • Non-volatile memory and their characteristics ○ Types of ROMs ❖ PROM, EPROM and EEPROM ○ Secondary storage ❖ magnetic, optical and flash memory	• Briefly explains the memory hierarchy with a suitable diagram • Describes the need for different types of memory and their characteristics • Briefly explains the volatile and non-volatile memory • Lists volatile and non-volatile memories in computer • Describes the characteristics of memory in terms of performance, location, capacity, access method, cost, physical type and physical arrangement of data (bits into words) • Lists and briefly explains the types and characteristics of	6

Competency	Competency Level	Contents	Learning outcomes	Periods
			ROMs • Compares and contrasts each type of memory in terms of access time, cost / MB, capacity (typical amount used)	
Competency 3: Investigates how instructions and data are represented in computers and exploit them in arithmetic and logic operations	3.1 Analyses how numbers are represented in computers	• Need for instruction and data representation in digital devices • Methods of instruction and data representation in computers ○ Representation of data in two states (0,1) • Number systems used in computing ○ Binary, octal, hexadecimal ○ Conversion between number systems • Representation of decimal numbers (signed and unsigned) ○ Signed integer representations ❖ Signed magnitude ❖ One's complement ❖ Two's Complement	• Describes that instruction and data are represented using two states in computers • Explains the need of different number systems • Describes how different types of decimal numbers are stored in computers • Converts decimal integers into binary, octal and hexadecimal numbers and vice versa • Converts binary numbers to octal and hexadecimal, and vice versa • Converts octal numbers to binary and hexadecimal, and vice versa • Explains that the MSB	10

Competency	Competency Level	Contents	Learning outcomes	Periods
			is used to indicate the sign when converting the given binary value to one's complement • Converts the given binary value to two's complement • Explains the usage of one's complement and two's complement	
	3.2 Analyses how characters are represented in computers	• Methods of character representation ○ BCD ○ EBCDIC ○ ASCII ○ Unicode	• Lists the methods of character representation in computer • Converts given symbols into a representation scheme • Describes the advantage and disadvantage of different data representation schemes	4
	3.3 Uses basic arithmetic and logic operations on binary numbers	• Binary arithmetic operations - (integers only) ○ Addition, subtraction • Logical operations ○ Bitwise logical operations	• Works out additions (multiple numbers with or without carryovers) – in binary numbers • Works out subtraction (with or without borrowing) – in binary numbers	4

Competency	Competency Level	Contents	Learning outcomes	Periods
			• Works out NOT, AND, OR, XOR bitwise operations	
Competency 4: Uses logic gates to design basic digital circuits and devices	4.1 Analyzes basic digital logic gates in terms of their unique functionalities	• Digital logic gates and truth tables ○ Basic logic gates ❖ NOT, AND, OR, and XOR ○ Combinational gates ❖ NAND, NOR, and XNOR ○ Universal gates ❖ NAND, NOR	• Names basic logic gates and draws the appropriate symbols of them • Draws the truth tables for the basic logic gates • Identify symbols that represent negations of basic logic gates • Creates truth tables for given expressions (maximum three inputs) • Explains the need of universal gates • Explains the fabrication of any gate using universal gates	6
	4.2 Simplifies logic expressions using laws of Boolean algebra and Karnaugh map	• Two state logic and Boolean Algebra • Postulates (Axioms) • Laws/theorems ○ Commutative, associative • Distributive ○ Identity, redundancy ○ De Morgan's • Standard logical expressions ○ Sum of products and product of sums	• Describes the need for simplifying Boolean expressions • Represents logical expressions in standard forms (SOP and POS) according to the given truth table • Transforms SOP into POS and vice versa	8

Competency	Competency Level	Contents	Learning outcomes	Periods
		○ Transform SOP into POS and vice versa • Simplify logic expressions using ○ Boolean theorems ○ Karnaugh map	• Simplifies logic expressions using Boolean theorems, axioms, De Morgan's Laws and Karnaugh map	
	4.3 Designs simple digital circuits using logic gates	• Truth tables and logic expressions for their designs (up to three inputs) • Digital circuit design	• Identifies situations to apply logic circuits in day to day life • Designs logic expressions and truth table for identified applications • Designs digital circuits	6
	4.4 Explores how combinational Logic circuits are used in CPU and sequential circuits in physical memory	• Building blocks of CPU ○ Half adder ○ Full adder • Storing bits in digital circuits ○ Feedback loop ○ Flip-flops	• Identifies the major building blocks of CPU • Creates truth table and logical expressions for half adder circuit • Creates truth table and logical expressions for full adder circuit • Briefly describes the usage of Flip-Flops	6
Competency 5 : Uses operating systems to manage the functionality of	5.1 Defines the term computer operating system (OS) and investigates its need in computer systems	• Introduction to computer operating system • Evolution of OS • Main functions of an operating system ○ Providing interfaces	• Defines the computer operating system • Briefly describes the evolution of OS • Identifies the main	4

Competency	Competency Level	Contents	Learning outcomes	Periods
computers		○ Process management ○ Resource management ○ Security and protection • Classification of operating systems ○ Single user – single task ○ Single user – multi task ○ Multi user – multi task ○ Multi-threading ○ Real time ○ Time sharing systems	functions and the abstractions (directories, files and data) provided by the operating system to the user • Describes how the operating system manages the resources of a computer • Classifies the operating systems based on their users and tasks	
	5.2 Explores how an operating system manages directories/folders and files in computers	• File types ○ Need for file types (.exe, .jpg .txt, etc) • Directory and file organization ○ File hierarchy ○ File systems – FAT etc • File security ○ Passwords and access privileges • File storage management ○ Storage allocation ❖ Contiguous allocation ❖ Linked allocation ❖ Indexed allocation • Defragmentation • Maintenance of secondary storage ○ Need and outcome of disk formatting	• Describes files and directories • Briefly describes the need of disk formatting • Identifies the need for file types • Lists attributes of file and directories • Describes the structure of the file systems • Illustrates the organization of files and directories • Briefly describes the methods used in file security • Briefly describes how	6

Competency	Competency Level	Contents	Learning outcomes	Periods

			an operating system manages file security
			• Briefly explains
			  ○ Contiguous allocation
			  ○ Linked allocation
			  ○ Indexed allocation
			• Describes defragmentation and explains how it occurs	

	5.3 Explores how an operating system manages processes in computers	• Definition of process • Interrupts and interrupts handling • Process management • Process states • Process Transitions • Process control block • Context switching • Process schedulers	• Explains processes • Lists the operating system tasks when a process is created • Lists the types of processes • Lists the process states • Explains process termination • Distinguishes a process and a program • Explains process states using the seven state process transition diagrams • Describes process schedulers and scheduling policies • Compares long, short and medium term schedulers	6

Competency	Competency Level	Contents	Learning outcomes	Periods
			• Describes multi programming and its needs • Describes time sharing systems • Compares multi programming vs. time sharing systems • Defines context switch • Briefly explains turnaround time, response time, throughput time and waiting time • Briefly explains the process control block and lists its contents	

	5.4 Explores how an operating system manages the resources	• Memory management
		  ○ Memory Management Unit (MMU)
		  ○ Physical Memory
		  ○ Virtual memory
		• Input and output device management
		  ○ Device drivers
		  ○ Spooling
			• Briefly explains the need of memory management and Memory Management Unit (MMU)
			• Briefly explains the virtual memory
			• Briefly explains paging and mapping
			• Briefly describes how an OS manages Input and output devices
			• Briefly describes device drivers
				6

Competency	Competency Level	Contents	Learning outcomes	Periods
			• Briefly describes the need of device drivers • Briefly describes spooling • Installs appropriate device drivers when connecting a peripheral	

Competency 6: Explores the data communication and computer networking technologies to share information effectively	6.1 Explores signals and their properties	• Signal Types
		  ○ Digital
		  ○ Analog
		• Properties
		  ○ Amplitude
		  ○ Frequency
		  ○ Wave length
		  ○ Phase
		• Propagation speed in a media
			• Graphically represents digital and analog signals and their properties
			• Solves problems related to the relationship between signal properties
				4

	6.2 Explores signal transmission media	• Wires – Guided media (Twisted pair, coaxial cable, Fiber optics etc.)
		• Free space – Unguided media
		• Properties
		  ○ Latency
		  ○ Bandwidth
		  ○ Noise
		  ○ Attenuation
		  ○ Distortion
		• Simple topology: point-to-point connection
			• Classifies media as guided and unguided media
			• Describes how latency, bandwidth, noise, attenuation, and distortion affects signal transmission
				4

	6.3 Investigates how digital data is encoded using signal elements	• Agreeing on signal elements to represent data (a protocol) ○ Two simple elements – two voltage levels (amplitudes)	• Graphically represents encoding of digital data using two voltage levels as well as	4

Competency	Competency Level	Contents	Learning outcomes	Periods
		○ Other possibilities (briefly) ❖ Frequency ❖ Phase ○ Changing speed of signal elements ○ Need for synchronization ❖ Timing/Clocks ❖ Manchester encoding ○ Handling errors ❖ Example: Parity	Manchester encoding • Describes the possibility of using the changes in frequency and phase as signal elements • Explains the need for synchronization and describes the problems that arise when the transmitter and the receiver are not synchronized • Compares and contrasts the relationship between how fast the signal elements are changed and the bit rate in simple two voltage encoding and Manchester encoding • Describes how the parity bit enables detecting a bit error	
	6.4 Explores the use of Public Switched Telephone Network (PSTN) to connect two remote devices	• Public Switched Telephone Network ○ Providing a circuit between two points that can carry analog voice • Modulation, Demodulation and Modems ○ Encoding data using analog signal elements • Connecting two devices using Modems	• Describes a PSTN as an analog voice carrying line • Describes how modems modulate analog signals so that they can be sent along	4

Competency	Competency Level	Contents	Learning outcomes	Periods
			a PSTN line • Draws a schematic diagram depicting two computers connected using modems via a PSTN line	
	6.5 Investigates how the problem of connecting multiple devices into a network is addressed	• All-to-all connections are impractical • A solution: Bus Topology ○ Simple ○ Problem: Controlling access to the bus (media) • Other topologies ○ Star ○ Ring ○ Mesh • Simplifying wiring ○ Hubs ○ Switches	• Demonstrates the impracticality of connecting large number of devices in all-to-all topology • Demonstrates the simplicity of a Bus • Draws diagrams of different topologies • Describes the use of Hubs and Switches to simplify the wiring of a network and compares/contrasts their functionalities	4
	6.6 Explores the role of Media Access Control (MAC) protocol	• Local Area Network (LAN) • Identifying devices ○ Addresses – MAC addresses • Frames • Orderly access to the media ○ Very simple protocol as an example – ALOHA ○ Improvements from ALOHA to Ethernet • Broadcasting and Uni -casting messages	• Describes the need to uniquely name devices (addresses) so that the sender and the receiver can be identified • Explains the role of frames as the unit of transmission • Describes the need of a protocol to ensure	4

Competency	Competency Level	Contents	Learning outcomes	Periods
			orderly access to media with respect to a bus • Briefly describes the evolution of MAC protocols from ALOHA to Ethernet	
	6.7 Explores how the multiple networks are interconnected to form the Internet	• A device to connect two or more networks – gateway • Need for globally unique uniform addressing independent of MAC addresses and LAN technology ○ IPv4 addresses ○ Assigning IPs to networks ❖ Sub-netting ❖ Subnet masks ❖ CIDR notation ❖ Private IP addresses ❖ DHCP ○ Scarcity of IPv4 addresses and IPv6 as a solution(an overview) • Finding the path to the destination ○ Routing and routers ○ Packet switching • Best effort delivery	• Explains the role of a gateway device in inter connecting two LANs • Explain the need for a uniform, MAC protocol independent addressing scheme and how IP addresses play that role • Describes the role of subnet masks • Calculates subnet masks and IP address ranges for a given block of IP addresses and network sizes • Describes how DHCP is used to dynamically assign IP addresses • Describes the role of routers in finding a suitable path from the sender to the receiver • Explains packet switching and best	6

Competency	Competency Level	Contents	Learning outcomes	Periods
			effort delivery in IP networks	
	6.8 Explores the role of transport protocols in the Internet	• Delivering data from an application process to another application process ○ Multiple applications at a host identified by an IP ❖ Multiplexing – multiple end points at the same IP ○ Ports and port numbers ○ UDP ❖ Properties ❖ Applications ○ TCP ❖ Properties ❖ Applications	• Explains that it is not sufficient to deliver a message from one IP address to another by demonstrating that the communication is from process to a process • Explains the need for multiplexing messages and how port numbers identify the end points • Briefly describes the functionality of UDP and lists applications that use it • Briefly describes the functionality of TCP and lists applications that use it	4
	6.9 Explores some applications on the Internet	• Domain Name System (DNS) ○ IP addresses are hard to remember ○ Human friendly names ○ Hierarchical name space ○ Each domain is responsible for managing the names under it ○ Top level domains	• Describes the need for human friendly names instead of IP addresses • Explains the role of DNS in translating names to IP addresses • Graphically represent	4

Competency	Competency Level	Contents	Learning outcomes	Periods
		• HTTP • Client Server model	the hierarchical and distributed structure of the DNS • Describes a simple GET request and its response in HTTP • Describes the client server model using DNS and HTTP	
	6.10 Investigates the role of reference models to describe the network architecture	• TCP/IP model ○ Application ○ Transport ○ Internet ○ Host to network • OSI model ○ Application ○ Presentation ○ Session ○ Transport ○ Network ○ Data link ○ Physical	• Describes the functions of layers of TCP/IP and OSI models • Describes the data units in different layers (packet, frame and bit) • Describes the data flow in a network using TCP/IP and OSI models	4
	6.11 Investigates the security aspects of the communication and protection of devices connected to the Internet	• Encryption and digital signature – basic idea ○ Public Key ○ Private Key ○ Signing • Threats ○ Viruses ○ Trojans	• Identifies the need for confidentiality and authentication of messages and notes that the Internet does not provide • Briefly explains the use of the public and	4

Competency	Competency Level	Contents	Learning outcomes	Periods
		○ Malware ○ Phishing • Protection ○ Firewalls ○ Antivirus software ○ Education/ better awareness/ good practices	private keys to encrypt and sign messages • Describes different threats faced by networked systems and protection against them	
	6.12 Explores the role of ISPs and technologies used for connecting Home Networks to the Internet	• ISPs • Connecting to ISP ○ Modems ○ DSL/ADSL • A home LAN that uses private IPs ○ Network Address Translation /Proxies	• Describes the role of an ISP • Explains the use of modems and dialup lines to connect a home machine to an ISPs network • Explains the advantages of DSL/ADSL lines • Explains the roles of NATs and Proxies in a LAN that uses private IPs	4
Competency 7: Explores the systems concept and uses systems analysis and design methodology in developing information systems	7.1 Explores Characteristics of Systems	• System concept • Classification of systems ○ Open and closed systems ○ Natural and manmade systems ○ Living and physical systems	• Recalls the definition of systems • Lists and describes the characteristics of systems • Classifies and describes systems with examples	4

Competency	Competency Level	Contents	Learning outcomes	Periods
	7.2 Compares and contrasts different types of manmade systems in terms of their objectives and functionality	• Information systems ○ Office Automation Systems (OAS) ○ Transaction Processing Systems (TPS) ○ Management Information Systems (MIS) ○ Decisions Support Systems (DSS) ○ Executive Support Systems (ESS) ○ Geographical information systems (GIS) ○ Knowledge Management Systems (KMS) ○ Content Management Systems (CMS) ○ Enterprise Resource Planning Systems (ERPS) ○ Smart systems	• Compares the objectives and functionality of different types of manmade systems • Distinguishes the different types of manmade systems in terms of objectives and functionality	4
	7.3 Explores different information system development models and methods	• System development Lifecycle models ○ Waterfall ○ Spiral ○ Agile ○ Prototyping ❖ Rapid Application Development (RAD) • System development methodologies ○ Structured ○ Object Oriented	• Lists and briefly describes system development models • Investigates the applicability of each model • Lists and describes the stages of System Development Life Cycle (SDLC) in Waterfall model • Lists and describes phases of the SDLC in Spiral model • Lists and briefly	08

Competency	Competency Level	Contents	Learning outcomes	Periods
			describes system development methodologies	
	7.4 Examines the Structured System Analysis and Design Methodology (SSADM)	• Introduction to SSADM • Stages of the system development life cycle	• Defines SSADM • Lists and briefly describes the stages of SDLC covered by SSADM	2
	7.5 Investigates the need for a new information system and its feasibility	• Preliminary investigation ○ Identification of the problems in the current system ○ Suggest alternative solutions ○ Prioritizing information systems needs • Feasibility study ○ Technical feasibility ○ Economic feasibility ○ Operational feasibility ○ Organizational feasibility	• Describes the tasks in preliminary investigation stage • Identifies information problems in an organization • Identifies priorities of the problems to be solved • Describes the need of feasibility study • Lists and briefly describe the types of feasibility	4
	7.6 Uses different methods to analyze the current system	• Requirement analysis ○ Functional requirements ○ Non – functional requirements • Analytical Tools ○ Business Activity Modeling ❖ Business activity model ○ Data Flow Modeling (DFM) ❖ Data Flow Diagrams (DFD) ❖ Elementary processes and	• Describes the need for requirement analysis • Describes type of requirements with examples for a given system • Defines requirements in IEEE standard • Lists the analytical	18

Competency	Competency Level	Contents	Learning outcomes	Periods
		Elementary Process Descriptions (EPD) ❖ Document flow diagram ○ Logical Data Modeling (LDM) ❖ Logical Data Structure (LDS) • Business System Options (BSO)	tools and describes the purpose of them • Draws business activity model, context diagram, document flow diagram, data flow diagrams and logical data structure for a given system • Writes elementary process descriptions • Describes the need for business system options • Proposes business system options • Selects the most appropriate business system option	
	7.7 Designs the proposed system	• Logical design tools ○ Logical Data flow modeling ❖ Logical Data flow diagrams for proposed system ❖ Elementary processes and elementary process description ❖ User Interface design ○ Logical Data modeling ❖ Logical data structure for the proposed system ○ Physical design of database ❖ Table and record specifications ❖ Data dictionary	• Describes the logical design • Describes the activities involve in the logical design stage • Reconstructs logical design of the proposed system starting from elementary processes to context diagram • Writes elementary process description in pseudo code	14

Competency	Competency Level	Contents	Learning outcomes	Periods
		❖ Database design	• Specifies table and record specifications	

	7.8 Develops and tests the proposed system	• Program development
		• Database development
		• Testing
		  ○ Test cases
		  ○ White box testing
		  ○ Black box testing
		  ○ Unit testing
		  ○ Integrated testing
		  ○ System testing
		  ○ Acceptance testing
			• Lists the testing methods for a newly designed system
			• Describes the testing methods for a newly designed system
				6

	7.9 Deploys the developed system	• Deployment methods
		  ○ Parallel
		  ○ Direct
		  ○ Pilot
		  ○ Phase
		• Hardware/Software installation, data migration and user training
		• Review, support and maintenance
			• Describes the methods of deployment of the developed system.
			• Describes the activities involved after implementation of a system
				4

	7.10 Describes system implementation with off-the-shelf packaged systems	• Advantages and disadvantages of using off- the-shelf packages • Identification of package capabilities, work flows etc. • Business process gap analysis • Business process mapping • Business process reengineering	• Describes the costs and benefits of off-the-shelf packages in terms of investment, operational and maintenance cost • Describes the features and capabilities of packaged solutions related to standard business applications	4

Competency	Competency Level	Contents	Learning outcomes	Periods
			• Identifies and describes differences between a given business process and features of off-the-shelf packages • Maps business process activities onto work flow of the off-the-shelf packaged solution • Identifies changes required in the current business process • Identifies customization requirements of off-the-shelf packaged solutions	

8.0 Learning Teaching process

Information and Communication Technology is not only a dynamic subject; it is also a living subject. It is necessary to update one's knowledge in order to be alert to the latest findings in this area. ICT has taken such an important position that the percentage of literacy in ICT has come to be regarded as an index of development. It is essential that the proposed method of teaching should be student-centered as this subject is essentially practice-oriented. In view of the fact that this is an essentially practical subject, it is vital that a student is involved in self study apart from the day to day learning - teaching process in order to ensure that subject matter learned is firmly grasped. There is need for special attention to be paid to the encouragement of the student for self-study. Further, just as much as knowledge, attitudes and skills, as well as social values, legal constraints related to the subject carry with them the imperatives of a sense and spirit of self-discipline. It is essential that the learning-teaching evaluation process is so organized as to highlight the importance of computer use.

The global trend in present day education is to introduce competency-based curricula, which promote collaborative learning through student centered activities where learning predominates teaching. It is intended for the students to actively participate in activities, which enhance the development of individual social and mental skills. The following aspects are emphasized.

1. **Teachers have the freedom to follow most suitable teaching method to achieve the desired competencies.**
2. **Allow the students to acquire hands on experience through self-directed activities.**
3. **Direct students to acquire knowledge and information through reliable sources wherever necessary.**

Competency 1: Explores the basic concepts of ICT together with its role and applicability in today's knowledge based society

Competency Level 1.1: Investigates the basic building blocks of information and their characteristics

Time: 06 periods

Learning Outcomes:

- Defines data and outlines its life cycle
- Recognizes the need of a process to define data and information
- Recognizes the strong inter-relationship between data, process and information
- Lists various forms of data and their characteristics
- Describes the characteristics of quality data
- Illustrates the value of information
- Describes the characteristics of valuable information
- Recognizes big data, their needs and analysis

Contents:

- Life cycle of data
    - Data creation
    - Management
    - Removal of obsolete data
- Data vs. Information
- Definition of information
- Characteristics of valuable information: timeliness, accuracy, presented within the context, enhanced understandability and less uncertainty
- The need to handle large volumes and other complexities of data
    - Introduction

Concepts and terms to be highlighted:

- Data and Information.
- Data life cycle.
- Data and Information can be identified with respect to the processing system. In a processing system inputs can be identified as data where outputs generated and presented as information. Information generated by one system would be input into another system as data.
- Value of Information and qualities of valuable information.
- Introduction to big data and their analysis.

Guidance for lesson plans:

- Illustrate data and information using a data processing system.
- Discuss how the data gathered from student admission are kept and removed when unnecessary to stress out the life cycle of data.
- Discuss qualities of valuable information and give examples for each of them.

- Discuss how large amount of data manipulated inside an organization and need of the technology to overcome the barriers arise when analyzing big data.

Guidance for assessments and evaluations:

- Give an assignment to analyze data and information from the given data processing systems.
- Ask the student to find examples for organizations that handle big data from the Internet.

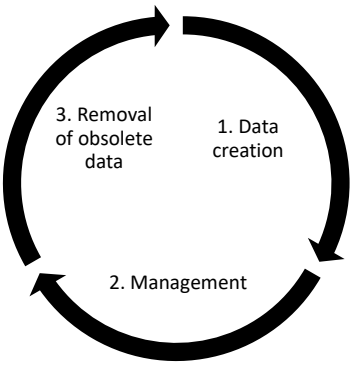
Quality inputs:

- Internet facility, Presentations on Data and Information

Reading Material

The term data is used to refer raw facts and figures which are input into a system in order to process and create meaningful information. Data consists of numbers, words, sounds and images which neither bear a particular meaning nor have organized in order to make decisions.

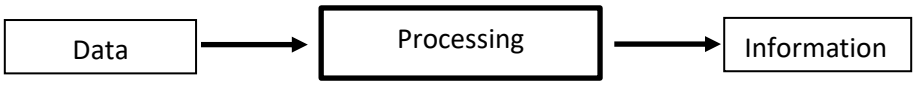
Lifecycle of data consists of data creation, management of data and removal of obsolete data.



For the purpose of creating meaningful information, data should be introduced into the system or create inside the system. Keeping data securely and making them accessible necessarily are done while management of data. Whenever data will be outdated and found to be unnecessary anymore, it's the time to remove that data from the system. This is known as the life cycle of data.

Data can be identified as the inputs into a system that intents to create meaningful information. Information can be defined as the data organized meaningfully. Creation of information can be identified as processing of data. For the purpose of processing there should be instructions to follow. After processing data according to the instructions given, information is produced which is the outcome the processed data. Although information is an output of a process the same information would be a data for another process. Thus, data and information can be identified distinctly through examining inputs and outputs of a particular process.

Data vs Information



Individual pieces of data are rarely useful alone. For data to become information, data needs to be put into context.

Data can be classified into two types as quantitative and qualitative. Quantitative data is numerical and acquired through counting or measuring. Quantitative data can be presented with numbers and which can be arranged in a numerical order or can be subjected to arithmetic process.

Qualitative data is not measurable, but can be identified their properties.

Examples:

Qualitative data – Goodwill of an organization

Quantitative data – Marks obtained for ICT paper

Valuable information should have characteristics such as relevance, timeliness, accuracy, completeness, and understandability. Valuable information assists to make smart decisions.

Relevance–Value of the information will depend on its relevance for a particular person.

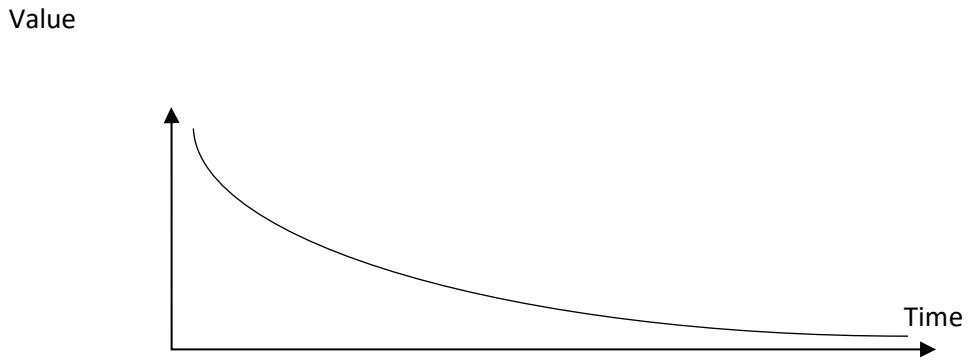
Timeliness–An information should be updated. Timely information is valuable for making effective decisions.

Accuracy – Accurate information is helpful for making correct decisions.

Completeness – Information presented with the context are useful where incomplete information is not sufficient to make decisions.

Understandability – Information should be clear and unambiguous

The golden rule of information graphically represents the value of information in its maximum level at the moment the information is created or the information is released. The value of the information is reduced gradually with the time and become less valuable.



Big Data Analytics

Organizations such as private companies and research institutions capture terabytes of data about their users' interactions in businesses and social media. The volume of data that one has to deal has been exploded to unimaginable levels with the time. The challenge of this era is to make sense of this large amount of data. This is where the big data analytics is needed to manage the data life cycle. Big Data Analytics largely involve collecting data from different sources, manage it in a way that it becomes available to be consumed by analysts and finally deliver data products to fulfil the organization's data requirements.

Competency 1: Explores the basic concepts of ICT together with its role and applicability in today's knowledge based society

Competency Level 1.2: Investigates the need of technology to create, disseminate and manage data and information

Number of Periods: 06

Learning Outcomes:

- Describes drawbacks of manual data processing methods
- Describes the importance of information in day to day life
- Lists the available technologies related to information dissemination
- Investigates the development of computer networks, the Internet and the WWW
- Describes the development of mobile communication, mobile computing and cloud computing
- Appreciates the use of technology to create, disseminate and manage, data and information
- Recognizes the usage of information in various domains
- Investigates the safety issues of human operators in various applications

Contents:

- Applicability of information in day today life
    - Decision making
    - Policy making
    - Predictions
    - Planning, scheduling and monitoring
- Drawbacks of manual methods in manipulating data and information
    - Inconsistency and duplication of data, possibility for errors and delay in processing
    - Lack of sharing information and reduced user services
- Infeasibility of applying manual methods where it can be harmful to human life
- Emergence of ICT era
    - Use of IT to overcome the drawbacks of manual methods of data manipulation
- Usage of information in various domains
- Availability of technologies related to information retrieval and sharing
- Development of computer networks, the Internet and the WWW
- Development of mobile communication, mobile computing and cloud computing

Concepts and terms to be highlighted:

- Value of a decision depends on the quality of supported information.
- Technology behind the creation of information is known as information technology whereas technology incorporates with dissemination of information from place to place is known as communication technology. Together, information technology and communication technology overcome the drawbacks of manual data processing and information dissemination methods.
- The Internet and the services of the Internet.

- The WWW as a service of the internet.
- Cloud computing and its services.

Guidance for lesson plans:

- Focus on need of information for day to day life.
- Define the Internet
- List the Internet services
- Introduce the WWW as a service of the Internet
- Introduce cloud computing and its services
- Conduct a practical class on sharing files among friends using a cloud service such as OneDrive or Google Drive.

Guidance for assessments and evaluations:

- Provide MCQ, Structured paper related to this topic.
- Ask students to search and make an article about the Internet, the WWW and Cloud computing in order to display on ICT notice board.

Quality inputs:

The Internet Accessibility

Reading Material

Information is useful for making decisions of day to day life. To make plans, schedules, and policies information are needed. Today's information would helpful to predict how it would be in the future. For an example, present information on currency exchange would be helpful to predict that for the following month or for the following year.

Data processing and information creation can be done manually. Some drawbacks occur such as consuming more time in entering and organizing data manually. Also, human errors in data processing may lead to inaccurate information. Manual methods are inefficient in sharing information and hard to provide a quality service to the customer. Data inconsistency may occur in manual methods of manipulating data and information. Data inconsistency is, occurring the same data in two different files in different formats or values. When same data exist in different files, updates cannot be done easily.

Automatic data processing in contrast to manual data processing, utilizes technology to store, process and retrieve data. Automatic data processing handles data more efficiently than manual data processing and requires considerably less human interaction than in manual data processing. Some everyday applications in which automatic data processing outperforms manual data processing are emergency broadcast signals, security updates and weather advisories. In situations such as bad weather, harmful radiation and in some scientific or space research and also in war areas in which manual data processing is not possible, automatic methods save human lives.

With the dawn of Information and Communication Era, it has turned the world into a global village. Endless connectivity, interactive technologies, information sharing and infinite access of data by means of networking eliminate drawbacks of manual data manipulation and make available a fast, easy, convenient and accurate information creation and dissemination. ICT has emerged as a key tool for influencing the process of organizations and people around the world catching up with the technological advancement such as the Internet, the WWW, mobile communication, mobile computing and cloud computing discussed below.

The Internet

The Internet is defined as a network of networks in which users at any one computer can, if they have permission, get information from any other. The U.S. Department of Defense laid the foundation of the Internet with a network called ARPANET. However, the general public did not use the Internet much until after the development of the World Wide Web in the early 1990s.

In 1957, the U.S. government formed the Advanced Research Projects Agency (ARPA), a segment of the Department of Defense charged with ensuring U.S. leadership in science and technology with military applications. In 1969, ARPA established ARPANET, the forerunner of the Internet. ARPANET was a network that connected major computers at the Universities and other educational and research institutions later.

In response to the threat of nuclear attack, ARPANET was designed to allow continued communication if one or more sites were destroyed. In the beginning ARPANET served only computer professionals, engineers, and scientists who knew their way around its complex workings. Today, the Internet is a public, cooperative, and self-sustaining facility accessible to millions of people worldwide. Physically, the Internet uses a portion of the total resources of the currently existing public telecommunication networks. The Internet uses a set of protocols called TCP/IP (Transmission Control Protocol/Internet Protocol). A protocol is an agreement or law behind the data transmission over networks. TCP is a reliable transmission protocol.

Services provided by the Internet are World Wide Web (WWW), File Transfer (FTP), email, Video conferencing, Telnet, File sharing, Internet Relay chat, IP Telephone and IPTV. Electronic mail (e-mail) has replaced the postal letters. Live conversations can be carried out with other computer users, using the Internet Relay Chat (IRC) and more recently, the Internet telephony hardware and software allows real-time voice conversations. Real time voice and video can be transmitted over network with the use of video conferencing technologies. WWW allows users to view web pages distributed over the Internet and reach to the information they wish to find from anywhere anytime. File transfer allows users to transfer files over the Internet and Telnet facilitates remote login.

World Wide Web

The World Wide Web came into being in 1991. Tim Berners-Lee is the developer of the WWW and at the moment who directs the World Wide Web Consortium (W3C), a group of industry and university representatives that oversees the standards of Web technology.

HTTP is the set of rules for exchanging files (text, graphic images, sound, video, and other multimedia files) on the World Wide Web. Hypertext is the documents that make content on the web and it is possible to connect hypertext documents by means of hyperlinks. To view files on the Web, it is needed a web browsing software. This software is used to view different documents on the Web, which are known as Web pages. A collection of one or more web pages is a Web site. The first page of a Web site is often called as the home page. Each web site in the www has a unique address which is called the Uniform Resource Locator (URL).

Mobile communication and mobile computing

Mobile communication involves the transmission of information over a distance without the help of wires, cables or any other forms of electrical conductors. Initially the mobile communication was limited between one pair of users on single channel pair. To accommodate multiple users Time Division Multiple Access (TDMA), Code Division Multiple Access (CDMA), Frequency Division Multiple Access (FDMA) and their hybrids are used.

Mobile Computing is a technology that allows transmission of data, voice and video via a computer or any other wireless enabled device without having to be connected to a fixed physical link.

Cloud Computing

The term Cloud refers to a Network or Internet. A Cloud is present at a remote location and provides services over a network. Applications such as e-mail, web conferencing, customer relationship management (CRM) run in clouds. Cloud Computing refers to manipulating, configuring, and accessing the applications online. It offers online data storage, infrastructure and application. Cloud Computing provides access to applications as utilities, over the Internet.

There are reference models on which the Cloud Computing is based. These can be categorized into three basic service models as listed below:

1. Infrastructure as a Service (IaaS) - provides access to fundamental resources such as physical machines, virtual machines, virtual storage, etc.

Ex - Customer Relationship Management, games, virtual desktop applications

2. Platform as a Service (PaaS) - provides the runtime environment for applications, development & deployment tools, etc.

Ex - Database, web server, deployment tools

3. Software as a Service (SaaS) - allows to use software applications as a service to end users.

Ex - Virtual machines, servers, storage, networks

Competency 1: Explores the basic concepts of ICT together with its role and applicability in today's knowledge based society

Competency Level 1.3: Formulates an Abstract model of information creation and evaluates its compliance with ICT

Number of Periods: 02

Learning Outcomes:

- Identifies the components of an abstract model of information creation
- Defines a system
- Analyses various systems using the system definition
- Relates the abstract model to information systems
- Matches the abstract model of information creation to the main functions of the computer
- Recognizes the role of ICT in the abstract model of information creation

Contents:

- Abstract model of information creation
    - Input, process, output
    - Its appropriateness to Computer and ICT

Concepts and terms to be highlighted:

- System concept
- Computer as a system

Guidance for lesson plans:

- Define a system
- Introduce 'Abstract model of Information'
- Introduce computer as a system and match functionalities of computer system related to 'Abstract Model of Information'

Guidance for assessments and evaluations:

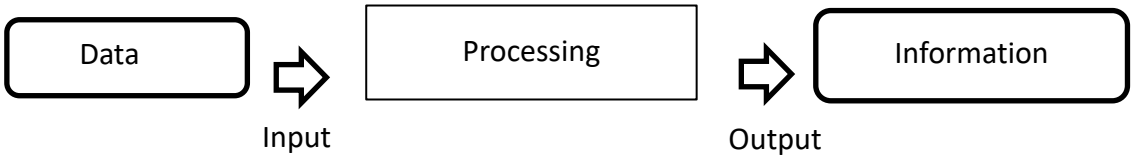
- Provide MCQ paper and structured paper related to this topic.

Quality inputs:

- Computers, Presentations

Reading Material

A system can be defined as an interrelated components work together to achieve a common objective. A system is made up of inputs, processing and output. A school, a vehicle or a bicycle can be introduced as a system. A system consists of interrelated components / sub systems and system should be analyzed to identify inputs, outputs, subsystems and their individual responsibilities. In an information system data input into the system is processed using processing instructions given and information is produced as output. This is called an abstract model of information.



Abstract Model of Information

A digital computer carries out the following five functions:

1. Takes data as input.
2. Stores the data/instructions in its memory and uses them as required.
3. Processes the data and converts it into useful information.
4. Generates the output.
5. Controls all the above four steps.

Though a computer system follows data input, processing data into information and output results, the basic functions of a computer system are well overlapped on the Abstract Model of Information.

Competency 1: Explores the basic concepts of ICT together with its role and applicability in today's knowledge based society

Competency Level 1.4: Selects and classifies the basic components of a computer system

Number of Periods: 02

Learning Outcomes:

- Defines and classifies hardware and software components
- Distinguishes proprietary software and open source software
- Describes the advantages and disadvantages of proprietary and open source software
- Identifies the role of human operators in the ICT enabled information systems

Contents:

- Hardware
  - Classification of hardware components
- Software
  - Classification of software
- Human Operators
  - Need of human operators in information systems

Concepts and terms to be highlighted:

- Hardware as physical components and software as instructions to control hardware of a computer system.
- Importance of using open source software and their freedom to use, edit or redistribution.

Guidance for lesson plans:

- Define hardware
- Classify hardware
- Identify hardware devices.
- Define software
- Classify software

Guidance for assessments and evaluations:

- Give an assignment to classify components of a computer system.
- Divide class into groups and assign each group to make a presentation on hardware devices and present them on a particular day.

Quality inputs:

https://en.wikipedia.org/wiki/Computer_hardware

Reading Material

Computer System consists of four major components called Hardware, Software, Firmware and Live ware.

Computer Hardware

Hardware components can be categorised into Input Devices, Output Devices, Processing Devices, Networking Devices and Memory Devices. In addition to those types of hardware there is a circuit board located inside a computer system called mother board by means of which every hardware component are connected to each other.

Input Devices

Input Devices correspond to input data into the computer system. Mouse, Trackball, Joystick, Touch pad, Touch screen and Light pen can be considered as pointing devices which are related to point out and select pixels on the screen. Keyboard is the most common and very popular input device which is used to input data to the computer. The layout of the keyboard is similar to that of traditional typewriter, although there are some additional keys provided for performing additional functions. Scanner is an input device that captures images from the source which are then converted into a digital form that can be stored on the disk. These images can be edited before they are printed. Microphone is an input device to input sound that is then stored in a digital form. In addition to the devices mentioned above MICR, OCR, Barcode Reader also can be considered as input devices.

Output Devices

As its name implies output devices are the devices support to present information out from the computer system. Monitors, commonly called as Visual Display Unit (VDU), are the main output device of a computer. It forms images from tiny dots, called pixels that are arranged in a rectangular form. The resolution of the image depends upon the number of pixels.

There are two kinds of viewing screens used for monitors named as Cathode-Ray Tube (CRT) and Flat-Panel Display. The flat-panel display is divided into two categories as follows.

Light Emitting Diode (LED) – These are emissive displays that convert electrical energy into light.

Liquid Crystal Display (LCD)–These are non-emissive displays which use optical effects to convert light into graphics patterns.

Printer is an output device, which is used to print information on paper which is called a hardcopy. There are two types of printers

Impact Printers - print the characters by striking them on the ribbon, which is then pressed on the paper. Dot Matrix Printer is an example for impact printers.

Non-Impact Printers - Non-impact printers do not physically strike the page. These printers print a complete page at a time, thus they are also called as Page Printers. Laser printers and Inkjet printers are laid on this type of printers.

Memory Devices

A memory is used to store data and instructions. Computer memory is the storage space in the computer system, where data is to be processed and instructions required for processing are stored. The memory is divided into large number of small parts called cells. Each location or cell has a unique address.

Memory is classified into three types -

1. Cache Memory - Cache memory is a very high speed semiconductor memory which can speed up the CPU. It acts as a buffer between the CPU and the main memory. It is used to hold those parts of data and program which are most frequently used by the CPU.
2. Primary Memory/Main Memory - Primary memory holds only those data and instructions on which the computer is currently working. It has a limited capacity and data is lost when power is switched off. It is generally made up of semiconductor device.
3. Secondary Memory - This type of memory is also known as external memory or non-volatile. It is slower than the main memory. These are used for storing data/information permanently. CPU does not access these memories directly instead they are accessed via input-output routines. The contents of secondary memories are first transferred to the main memory, and then the CPU can access it.

Processing Devices

Central Processing Unit (CPU) is the most common processing device of a computer which has the control of all other components. Arithmetic and logical operations take place inside the CPU. Graphics Processing Unit (GPU) is a specialized electronic circuit designed to rapidly manipulate and alter memory to accelerate the creation of images in a frame buffer intended for output to a display. GPUs are used in embedded systems, mobile phones, personal computers, workstations, and game consoles.

Networking Devices

Computer networking devices are physical devices which are required for communication and interaction between devices on a computer network. Specifically, they mediate data in a computer network.

Ex - Hubs, Switches, Bridges, Routes, Gateways, **Network** Interface Cards (NICs)

Computer Software

Computer software is classified as system software and application software. System software (systems software) is the computer software designed to operate and control the computer hardware and to provide a platform for running application software. System software can be separated into three different categories as follows.

1. Operating Systems –Windows, Linux, Mac OS
2. Utility Software– Virus Guard, Device drivers
3. Language Translators – Compiler, Interpreter

Application software products are designed to satisfy a particular need of a particular environment. Application software may consist of a single program, such as Microsoft's notepad for writing and editing a simple text. It may also consist of a collection of programs, often called a software package, which work together to accomplish a task.

Software can also be classified as ‘open source software’ and ‘proprietary software’.

Open Source Software –source code is available and it is free to use, modify or redistribute these type of software.

Proprietary Software – source code is not available and user should have the permission given by owner of the software to use this type of software.

Firmware

Firmware is a **computer** program that is "embedded" in a hardware device, that is, an essential part of the hardware. It is sometimes called embedded software. In computers firmware embedded in ROM and which handles booting up process of computers.

Liveware

Liveware refers computer users. According to user commands generally computers are functioning.

Competency 1: Explores the basic concepts of ICT together with its role and applicability in today's knowledge based society

Competency Level 1.5: Analyses the activities of data processing

Number of Periods: 04

Learning Outcomes:

- Lists and briefly describes the data processing steps
- Identifies data gathering methods
- Identifies data validation methods
- Lists data input methods
- Describes data processing methods
- Lists data output methods
- Describes data storage methods

Contents:

- Steps in data processing:
    - Data gathering
    - Data validation
    - Data processing
    - Data output
    - Data storage
- Data gathering methods
    - Manual methods
    - Semi-automated and automated methods
- Tools - (OMR, OCR, MICR, card/tape readers, magnetic strip readers, bar code readers, sensors and loggers)
- Data validation methods
    - Data type check
    - Presence check
    - Range check
- Modes of data input
    - Direct and remote
    - Online and offline
- Data processing
    - Batch and real time
- Output methods
    - Direct presentation to the user
    - Storing for further processing
- Storage methods
- Local and remote storage (cloud)
- Short and long term storage

Concepts and terms to be highlighted:

- Data processing cycle

- Advantages of each manual data gathering method
- Importance of automated data gathering methods
- Importance of data validation prior to processing

Guidance for lesson plans:

- Advantages and disadvantages of each data gathering methods

Guidance for assessments and evaluations:

- Let students to find examples for batch processing and real-time processing.

Quality inputs:

- Data Gathering Tools - (OMR, OCR, MICR, card/tape readers etc.)

Reading Material

Steps in data processing are Data gathering, Data validation, Data processing, Data output and Data storage.

Data gathering

Data gathering methods vary as manual methods, Semi-automated and automated methods. Tools used in automated methods.

Interviews, questionnaires and observation can be done in order to collect data manually. Using interviews detailed questions and answers may helpful for making the discussion fair enough to capture deserved data. It's a fast method to use of questionnaires which is most suitable for gathering quantitative data and answering anonymously, may helpful to gather fair and confident data.

In semi-automatic and automatic methods OMR, OCR, MICR, card/tape readers, magnetic strip readers, bar code readers, sensors and loggers are popular.

An Optical Mark Reader (OMR) is a scanning device that reads carefully placed pencil marks on a specially designed form or document. Most popular use of OMR is marking of MCQ answer sheets.

Optical Character Recognition (OCR) is done by Optical Character Reader which allows us to identify written or printed characters and extract editable text from it.

Magnetic Ink Character Recognition (MICR) is done by Magnetic Ink Character Reader which supports to input data written in special magnetic ink under cheque.

Magnetic strip readers use to read data stored in a magnetic strip attached on credit cards and bank ATM cards.

Bar code readers use visible light to scan and read barcodes which contain data to be input into computer systems.

Sensors may helpful for collecting data from different places in to a single data center fast. Sensor networks are consisting of variety of electronic sensors. Each node in a wireless sensor network is equipped with one or more sensors in addition to a microcontroller, wireless transceiver, and energy source.

Data validation methods

Data type check – Check whether correct data type (numeric/text/date/currency etc) is input into the system

Presence check – Presence of data (i.e. data entry field is not blank) is checked. It is compulsory to input important data

Range check – Check whether the data is in allowed range (i.e. Marks have to be between 0 and 100) commonly used when working with data which consists of numbers, currency or dates/times

Modes of data input

Direct and remote - In direct data input, data is input into the system directly without direct user interference. In remote entry, system is designed specially to store data. Data storing and transactions are taking place in different geographical places.

Online and offline – In online data input, the data is input at the same time transaction taking place, where data of different transactions input after a specific time period as a batch in offline method.

Data processing

Data input and processing occur as a batch in batch processing. It is easy to handle huge amount of data as a batch. So, data stored until the system comes online to process the data in one 'batch'. Batch processing is done in billing systems and pay roll system.

In real time processing of data, input, processing and output as well as data storing occur simultaneously. Any type of monitoring system, any type of booking system, computer controlled systems such as automatic production line, an aircraft auto-pilot, the system controlling a nuclear power stations uses real time processing.

Output methods

Direct presentation to the user can be done by using a monitor, multimedia projector or a printer. Soft copies are presented with monitors and multimedia projectors whereas printer output printed copies which is said to be hard copies. Storing methods are used to store data securely for further processing needs.

Storage methods

Local storages such as Hard Disks Drives, Compact Disk, Digital Versatile Disks and Tape Drives can be used to store data inside the local computer. Remote storage such as cloud space can be used to store data securely. To get remote data when needed it is required the access to the internet.

Competency 1: Explores the basic concepts of ICT together with its role and applicability in today's knowledge based society

Competency Level 1.6: Investigates the application of ICT in different domains

Number of Periods: 04

Learning Outcomes:

- Lists and briefly describes the data processing steps
- Identifies data gathering methods
- Identifies data validation methods
- Lists data input methods
- Describes data processing methods
- Lists data output methods
- Describes data storage methods

Contents:

- Application of ICT in:
    - Education
    - Healthcare
    - Agriculture
    - Business and finance
    - Engineering
    - Tourism
    - Media and journalism
    - Law enforcement

Concepts and terms to be highlighted:

- Focus on the fields where ICT is used
- Highlight the contribution of ICT in national development

Guidance for lesson plans:

- Divide the class into groups and assign each group a field where ICT is used and ask them to prepare a presentation on usage of ICT in the given field
- Ask students to identify how ICT contributes to national development

Guidance for assessments and evaluations:

- Ask students to prepare and submit an assignment on following aspects
    - The fields where ICT is used
    - The usage of ICT in that field
    - Contribution of ICT in national development

Quality inputs:

- Internet facility, Presentations

Reading Material

Education

The computer helps in providing a lot of facilities in the education system. The computer provides a tool in the education system known as CBE (Computer Based Education). CBE involves control, delivery, and evaluation of learning as follows.

1) Simulations:

Computer simulators and prototypes can be used to perform the rather impossible experiments on the subjects which seemed impossible to be done in the labs especially in the field of medicine and engineering.

2) Distance Learning and E- Learning:

This is the trend in 21st century education where the obstacles arise due to distance are being eliminated. One can attend classes and access learning materials remotely, without having to travel to the learning center.

3) Better Content Delivery:

The motivation effect that comes about due to embracing ICT in teaching and learning is a common factor. For instance, multimedia and interactive content on interactive boards remain quite engaging and motivating making students pay more attention in class.

4) Individualized Learning:

ICT help students with individual needs to have better suited assignments and making it easy to organize their learning.

Healthcare

Computers have become an important part in hospitals, labs, and dispensaries. They are being used in hospitals to keep the record of patients and medicines. It is also used in scanning and diagnosing different diseases. ECG, EEG, ultrasounds and CT scans are also done by computerized machines.

Following are some major fields of health care in which computers are used.

- Diagnostic System - Computers are used to collect data and identify the cause of illness.
- Lab-diagnostic System - All tests can be done and the reports are prepared by computer.
- Patient Monitoring System - These are used to check the patient's signs for abnormality (ECG)
- Pharmacy Information System - Computer is used to check drug labels, expiry dates, harmful side effects, etc.
- Surgery - Nowadays, computers are also used as a supporting tool for surgery.

Agriculture

ICT is applied in the field of agriculture, animal farm houses and fisheries industries. ICT is used to control light, moisture and air inside the greenhouses. Robotic machines are used to monitor plant growth levels, record them and harvesting in large scale farm lands. Crop harvesting and seedling planter robotics are also useful to keep efficiency of agriculture industry. Automatic weed removers and insect control devices protect the crop from weed plants and insects respectively. Monitoring devices are used to monitor factors affect crop production such as weather, climatic changes, rainfall, wind direction, soil fertility and water content.

Radio Frequency Identification Device (RFID) helps in identifying and counting the number of animals in farmhouses. Automated milking and examination of cows can be done with computer controlled systems which is helpful in monitoring the health status of the cows and the quality of milk.

Business and finance

A computer has high speed of calculation, diligence, accuracy, reliability, or versatility which has made it an integrated part in all business organizations.

Computer is used in business organizations for payroll calculations, budgeting, sales analysis, financial forecasting, managing employee database and maintenance of stocks etc.

Today, banking is almost totally dependent on computers. Banks provide online accounting facility, which includes checking current balance, making deposits and overdrafts, checking interest charges, shares, and trustee records. ATM machines which are completely automated are making it even easier for customers to deal with banks.

In marketing, advertising and home shopping, computers are widely used today. Advertising professionals use graphics, and animations fascinatedly to get customer attractions. Home shopping has been made possible through the use of computerized catalogues that provide access to product information and permit direct entry of orders to be filled by the customers.

Engineering

CAD (Computer Aided Design) that provides creation and modification of drawing.

3D virtualization also can be done in engineering industry before development of buildings, machinery, and vehicles also. Some machinery can be developed virtually and can be monitored functioning animations on screens.

Computer Aided Software Engineering tools (CASE) supports software engineers for designing, coding, testing and debugging of software.

Tourism

Internet has facilitated prospective tourist services, communication, and information access. Bringing a better quality of service to the tourism industry, the Internet has pulled down prices, made information widely available, and allowed sellers and buyers to connect more easily and make transactions.

Media and journalism

ICT is effectively used in media and Journalism which helps in designing of articles interactively as well as organizing information. Content sharing between broadcasters, and reaching global news fast have become easy with the use of the Internet and Internet services such as www, email, video conferencing and so on.

Law enforcement

ICT is applicable in law enforcement which facilitates information recording and storage, investigations, reporting and statistics. ICT supports the investigations carried out to apprehend criminals. Today CCTV systems, GPS, and telecommunication services provide severe support on criminal investigations.

Competency 1: Explores the basic concepts of ICT together with its role and applicability in today's knowledge based society

Competency Level 1.7: Evaluates the impact of ICT in the society

Number of Periods: 04

Learning Outcomes:

- Explains the benefits of ICT in terms of social and economic aspects
- Explains briefly the issues caused by advancement of ICT in terms of social, economic, environmental, ethical and legal aspects
- Investigates the legal situation connected with the usage of ICT.
- Explains the environmental issues associated with ICT
- Explains safe disposal methods of e-waste
- Explains briefly the ethical, Legal and social issues in the usage of ICT
- Briefly explains the role of ICT in achieving Sustainable Development Goals (SDGs)
- Investigates the approaches to eliminate digital divide

Contents:

- Benefits provided by ICT
    - Social benefits
    - Economic benefits
- Issues caused by ICT
    - Social
    - Economical
    - Environmental
    - Ethical
    - Legal
    - Privacy
    - Digital divide
- Confidentiality
- Stealing / Phishing
- Piracy
- Copyright / intellectual property laws
- Plagiarism
- Licensed / unlicensed software

Concepts and terms to be highlighted:

- Focus on ethical and legal issues and security
- Focus on precautions in using the Internet
- Focus on ethical and legal issues in social media
- Focus on safe use of ICT

Guidance for lesson plans:

- Demonstration and discussion on ethical and legal issues, ethical and legal issues in social media, security

Guidance for assessments and evaluations:

- Divide the class into groups and assign each group one of the above topics and ask them to prepare a presentation and present it.

Quality inputs:

- Documents related of copy rights, Internet facility

Reading Material

Social and economic benefits of ICT

Benefits provided by ICT such as social benefits and economic benefits would tend people to embrace the information communication technology.

ICT impact in entertainment and leisure industry has improved the way in which we can entertain ourselves by enhancing and providing people with different ways of entertaining ourselves such as online games and chat with friends etc.

A growing ICT sector can contribute to aggregate increases in productivity, GDP and trade. As people continue to embrace ICT with an aim of making their life better, it may also affect how productive they are. Increase in the size and productivity of the ICT sector, it associate growth in labor productivity, manufacturing productivity and ultimately the economy.

ICT has bridged access to information from anywhere anytime which improves information dissemination around the world. Cloud computing activates better application, services, security, reliability and availability of information.

Social, economic, environmental, ethical, legal and privacy issues caused by ICT

ICT adoption in industries causes thousands of job losses. This is because computers reduce the number of people needed to perform a particular task.

Negative impacts of entertaining using ICT are time wastage, health issues. Continuous use of ICT for entertainment such as playing games brings health issues. For instance, constant use of thumbs, wrists and eyes can lead to problems such as eyes strain, RSI and other physical problems.

“Digital divide” is an economic and social inequality with regard to access to, use of, or impact of information and communication technologies. Access to appropriate technological resources similar and improvements in ICT education will helpful to overcome digital divide.

Electronic waste or e-waste is becoming a severe problem around the world. The major problem with e-waste is that the toxic chemicals such as lead, arsenic and cadmium can leach into the soil over time and contaminate the drinking water.

Green computing, the study and practice of efficient and eco-friendly computing resources, is now under the attention of not only environmental organizations, but also businesses from other industries. As a result, most countries in the developed world have introduced regulations to prevent e-waste being dumped into landfill. The majority of components in electronic goods now have to be recycled.

Intellectual property rights, patents on academic material, music and software difficult to be protected as how fast they are distributed over networks. Net etiquette/internet ethics are not kept by all of the Internet users.

Confidentiality of data or information

Confidentiality of information can be kept with the use of password protection, encryption techniques and digital signatures.

Stealing / Phishing

Phishing is the attempt to acquire sensitive information such as usernames, passwords, and credit card details for malicious reasons, by masquerading as a trustworthy entity in an electronic communication. To protect data or information against stealing or phishing it is necessary to setup firewall, use of password, apply updates and not opening suspicious emails and clicking on links of untrusted senders.

Piracy

Software piracy is the illegal copying, distribution, or use of **software.**

Copyright / Intellectual Property laws

Intellectual property is the area of law that deals with protecting the rights of those who create original works. It covers everything from original plays and novels to inventions.

Plagiarism

Plagiarism is the stealing of someone else’s thoughts, ideas, expressions or work and the representation of them as one's own original work.

Licensed / unlicensed software

A software license is a legal instrument governing the use or redistribution of software. Two common categories for software under copyright law are proprietary software and free and open source software (FOSS). FOSS software licenses both rights to the customer and therefore bundles the modifiable source code with the software (open-source), while proprietary software typically does not license these rights and therefore keeps the source code hidden (closed source). License grants the licensee specific rights to use, edit or redistribution of software.

Unlicensed software outside the copyright protection is either public software or software which is non-distributed, non-licensed and handled as internal resource of an organization.

Competency 2: Explores the evolution of computing devices, so as to be able to describe and compare the performance of modern computers.

Competency Level 2.1: Elicits the significant changes occurred in the computers from generation to generation with more emphasis on the evolution of processors.

Number of Periods: 04

Learning Outcomes:

- Categorizes the early calculating aids with examples.
- Describes the generations of computers with their features in a table.
- Categorizes computers in terms of technology, purpose and size with examples.

Contents:

- History of computing
- Early calculating aids
    - mechanical
    - electromechanical
- Electronic age of computing
- Generation of computers
    - 1G, 2G, 3G, 4G and future
- Different types of classifications
    - Technology
        - analog, digital
    - Purpose
        - Special/general
    - Size
        - super, mainframe, mini, micro
        - (Portable devices –smart phones, tablet devices and phablets)

Concepts and terms to be highlighted:

- Evolution of computing devices.
- Generations of computers and their characteristics.
- Classification of computers based on technology, purpose and size.

Guidance for lesson plans:

- Discuss how the calculation was done in early days like BC.
- Show pictures of early calculating aids.
- Discuss computers that are used nowadays and explain how it was in the past.
- Explain the changes made in computers from period to period.
- Discuss appearance, technology, speed, capacity and efficiency of computers that are produced in every time period.
- Discuss different type of computers used in different fields.
- Discuss mobile devices currently available and their usage.

Guidance for assessments and evaluations:

- Ask students to write how characteristics have changed through the generations of computers.
- Divide the class into groups and assign each group one of the computer classification topic and ask them to list examples for them

Quality inputs:

- Internet facility, Presentations, images of computing devices

Reading Materials:

Calculating aids – Pre mechanical era – before 1450

Abacus is considered as the first calculating device in the world used by Chinese around 5000 BC.

Mechanical era – 1450-1840

The Pascaline was introduced by Blaise Pascal in 1642. It could add and subtract two numbers.

The Stepped Reckoner invented by German scientist Gottfried Wilhelm Leibniz completed in 1694. This device is carried out the operations add, subtract, multiply and divide too.

The difference engine, the first mechanical computer was developed by Charles Babbage in 1880.

He presented the concept of Input, Process and Output that is used in modern computers, for the first time. Therefore, he is considered as the “Father of the computer”.

Electro mechanical era – 1840 – 1940

Electronic valve (vacuum tube) invented by Forest in 1906.

The automatic sequence controller (Mark 1) was the first automatic computer invented by Professor Howard Aiken in 1939.

Electronic Era

1st Generation Computers (1940-1956)

The computers of first generation used vacuum tubes as the basic component.

- ENIAC (Electronic Numerical Integrator and Calculator) was the first electronic digital computer designed by John Mauchly and J. Presper Eckert in 1946.
- EDSAC **(**Electronic Delay Storage Automatic Calculator) was the first full size stored program computer developed by Maurice Wilkes in 1947. EDSAC was built according to the von Neumann machine principles.
- EDVAC (Electronic Discrete Variable Automatic Computer) is considered as the first digital computer that could store program was built in 1948.

- UNIVAC (Universal Automatic Computer) was an electrical computer containing thousands of vacuum tubes that utilized punch cards and switches to input data and punch cards to output and store data.

2nd Generation Computers (1956 – 1963)

In this generation, transistors were used as the fundamental building block.

IBM 1620, IBM 7094, CDC 1604, CDC 3600, UNIVAC 1108 were some computers developed in this generation.

3rd Generation Computers (1964 – 1975)

The computers of third generation used Integrated Circuits (ICs) in place of transistors. A single IC contains many transistors, resistors, and capacitors along with the associated circuitry.

IBM-360 series, PDP (Personal Data Processor), TDC-316 were the computers of 3rd generation.

4th Generation (1975 – 1989)

In this generation of computers VLSI (Very Large Scale Integrated) circuits were used. VLSI circuits having more transistors and other circuit elements with their associated circuits on a single chip made it possible to have microcomputers.

Eg: DEC 10, STAR 1000, PDP 11

5th Generation Computers (1989 – present)

The ULSI (Ultra Large Scale Integration) technology is used in this generation resulting in the production of microprocessor chips having millions transistors and other electronic components.

Eg: Desktop, Laptop, Notebook, Ultrabook

Classification of Computers

1. Based on the Technology
    (i) Analog Computer - An analog computer is a form of computer that handles *continuous* values such as electrical, mechanical, or hydraulic quantities.
    (ii) Digital Computer - A computer that performs calculations and logical operations with quantities represented as digits, usually in the binary number system.
2. Based on the Purpose
    (i) Special purpose computer - Computers are designed to handle a specific problem or to perform a specific task.

(ii) General purpose computer – These are designed to perform a range of tasks.

3. Based on Size

(i) Super Computer - The fastest and most powerful type of computers Supercomputers are very expensive and are employed for specialized applications that require immense amounts of computing power. (Eg: **TIANHE-1)**

(ii) Mainframe Computer - A very large and expensive computer capable of supporting hundreds, or even thousands, of users simultaneously.

(iii) Mini Computer – Mid size computers mainly used as small or mid-range servers operating business and scientific applications.

(iv) Micro Computer –

Desktop – A personal computer sufficient to fit on a desk

Laptop – A portable computer

Palmtop – A hand size computer

Notebook - A portable computer small and thinner than Laptop.

Smart phone – This is a mobile phone used for mobile communication with an operating system and other advanced facilities.

Tablet - A tablet is a wireless, portable personal computer with a touch screen interface. The tablet is typically smaller than a notebook computer, but larger than a smartphone.

Phablet - A *phablet* is a small pocket sized mobile device that is a bit larger than the size of an average smartphone and smaller than tablet. (Eg: Apple 6Plus, Galaxy Note, etc)

Competency 2: Explores the evolution of computing devices, so as to be able to describe and compare the performance of modern computers.

Competency Level 2.2: Explores the functionality of a computer in relation to the hardware and their interfaces.

Number of Periods: 06

Learning Outcomes:

- Identifies hardware peripherals and their relevant interfaces.
- Identifies the advantages of direct entry input devices over keyboard entry input devices.
- Describes the evolution of CPU and its compatibility with motherboard.
- Categorizes the storage devices.
- Briefly explains the features of each storage device.
- Identifies the need for parallel and grid computing.

Contents:

Major hardware components

- Input devices: keyboard entry and direct entry (keyboard, pointing devices, touchpad, remote control, touch screen, magnetic strip reader, barcode reader, smartcard reader, scanner, digital camera, microphone, sensors, graphic tablets, MICR, OMR and OCR readers, video camera, digitizer, webcam)
- Advantages of direct entry input devices over keyboard entry input devices
- Output devices and their features (CRT monitor, TFT monitor, LED monitor, dot matrix printer, inkjet printer, laser printer, 3Dprinter, graph plotter, speakers)
- CPU and its compatibility with motherboard
- Storage devices (fixed internal hard disk, portable external hard disk, magnetic tape, Optical discs(CD ROM/DVD ROM, CD-R/DVD-R, CD- RW/DVD-RW,DVD-RAM, Blu-Ray) flash memory card, mini disk)
- Parallel and grid computing.

Concepts and terms to be highlighted:

- Input devices of computer
- Output devices of computer
- Central processing unit and motherboard
- Storage devices of computer
- Parallel and grid computing

Guidance for lesson plans:

- Define the computer as a system.
- Discuss different hardware components that are used in a computer system.
- Show and demonstrate the components of a computer
- Discus the input devices and direct input methods used in a computer system.
- List output devices of the computer system.
- Explain what are the devices used in computers to store data.
- Discuss about parallel and grid computing.

Guidance for assessments and evaluations:

- Assignment - Divide the class into groups and assign each group one of the following and ask them to prepare a document with examples and, pictures on the usage of it.
    - Input devices
    - Output devices
    - Storage devices
    - CPU and motherboard
- Provide some MCQ related to this topic.

Quality inputs:

- Sample Input devices, output devices, storage devices, CPUs, motherboards, presentations

Reading Materials:

Input Devices

These are used to feed data and instructions to a computer system.

Key board

Pointing devices

Mouse	Touch pad	Remote control	Touch screen

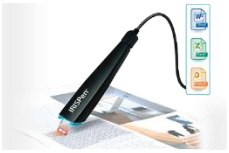
Direct entry input devices

Magnetic stripe reader	Bar code reader	Smart card reader

Image and video input devices

Video Camera	Digital Camera	Webcam	CCTV

Scanning devices

Flatbed Scanner	MICR	OMR	OCR
			

Graphic tablet	Digitizer	Microphone

Advantages of direct entry input device over key board entry input device

1. Automatically capture data, images or videos. No need human involvement to input data into the system. Therefore, data entry cost is reduced.
2. Accurate – The data can be input without any human errors.
3. Less time – Data input process is more efficient.

Output devices

Monitor

1. CRT Monitor (Cathode Ray Tube Monitor)

   In cathode ray tube monitor, images are produced when an electron beam strikes a phosphorescent surface

2. LCD Monitor (using Thin Film Transistor-TFT)

A display screen made with TFT technology is a Liquid Crystal Display (LCD) that has a transistor for each pixel, LCD monitors are widely used in notebook and laptop computers.

3. LED Monitor (Light Emitting Diode Monitor)
Flat screen monitor used as a computer monitor or television.

Advantages of LED Monitor

- Less expensive
- More reliable
- Generate low heat and consume less power
- Higher dynamic contrast ratio
- Longer lifespan and less environmental impact

Printer
Printer is used to produce a hard copy output.

1. Dot matrix printer
   It uses a print head that moves back-and-forth, or in an up-and-down motion, on the page and prints by striking an ink ribbon against the paper, much like the print mechanism on a typewriter.
2. Inkjet printer
   In the inkjet printing mechanism, the print head has several tiny nozzles, also called jets. As the paper moves past the print head, the nozzles spray ink onto it, forming the characters and images.
3. Laser printer
   When a document is sent to the printer, a laser beam draws the document on a selenium-coated drum using electrical charges. After the drum is charged, it is rolled in toner, a dry powder type of ink. The toner adheres to the charged image on the drum. The toner is then transferred onto a piece of paper and fused to the paper with heat and pressure.
4. Graphic plotter
   A plotter is a printer that interprets commands from a computer to make line drawings on paper with one or more automated pens.

CPU and its compatibility with motherboard

1. Socket support.
   The CPU has to be compatible with your motherboard's socket.

2. Chipset support.
   Need to know about the chipset to find the CPUs compatible with that chipset. Chipset manufacturers include AMD, Intel and Nvidia.

3. Motherboard wattage support must support the Thermal Design Power (TDP) of a given CPU.

Need to find out the wattage of the motherboard to determine the support from that to the CPU

4. BIOS support.
If necessary BIOS need to be upgraded to support the CPU

Storage Devices

1. Fixed internal magnetic hard disk
Hard disk is a data storage device that uses magnetic storage to store and retrieve digital information using one or more rigid rapidly rotating disks (platters) coated with some magnetic material.

2. External hard disk
An external hard drive is a portable storage device that can be attached to a computer through a USB Port

3. Magnetic tape
Magnetic tape is one of the oldest technologies for electronic data storage on a magnetic surface. Tape has largely been displaced as a primary and backup storage medium, but it remains well-suited for archiving because of its high capacity, low cost and long durability. It is a sequential recording system that is not good for random access. With tape archiving, there is no online copy for quick retrieval, as everything is vaulted for the long term.

4. Optical discs
An optical disc is an electronic data storage medium that can be written to and read using a low-powered laser beam.

Type	Capacity
CD-ROM	650-900 MB
CD-R	
CD-RW	
DVD-ROM	4.7-9.4 GB
DVD-R	
DVD-RW	
DVD-RAM	
Blu-Ray	25-128 GB

DVD-RAM - DVD-RAM is like ordinary Random Access Memory (RAM), it can be repeatedly read, written to, and erased. DVD-RAM discs can be rewritten 100 times more than a DVD-RW.

5. Flash drive

6. Memory card

Flash drives and memory cards use Electrically Erasable Programmable Read Only Memory (EEPROM) technology to store data on one or more semiconductor chips.

Parallel computing

Parallel computing is a type of computation in which many programs or processes are done simultaneously. Large problems can often be divided into smaller ones, which can then be solved at the same time.

In simple terms, parallel computing is breaking up a task into smaller pieces and executing those pieces at the same time, each on their own processor or on a set of computers that have been networked together.

The following example displays the difference between single processor and parallel processor

- Y = (4 x 5) + (1 x 6) + (5 x 3)

On a single processor, the steps needed to calculate a value for Y might look like:

- Step 1: Y = 20 + (1 x 6) + (5 x 3)
- Step 2: Y = 20 + 6 + (5 x 3)
- Step 3: Y = 20 + 6 + 15
- Step 4: Y = 41

In a parallel computing scenario, with three processors or computers, the steps look something like:

- Step 1: Y = 20 + 6 + 15
- Step 2: Y = 41

The main performance characteristic is the increase in speed. If you use a single computer, and it takes X amount of time to perform a task, then using two similar

computers should cut the time taken to perform that same task in half. If you use three, then it should take a third of the time for the same task, and so on.

However, in practical terms, this is not always true. Because:

- Some task might not be divisible.
- Some task may not be able divide equally.
- It is necessary to take overhead associated with splitting the task up also into account.

So, while there is usually a performance increase, that increase does not follow any set formula.

Grid computing

Grid computing is a distributed architecture of large numbers of computers connected to solve a complex problem. In the grid computing model, servers or personal computers run independent tasks and are loosely linked by the Internet or low-speed networks. Computers may connect directly or via scheduling systems. In Grid computing inter-connected computer systems utilize the same resources collectively. Grid computing usually consists of one main computer that distributes information and tasks to a group of networked computers to accomplish a common goal. Grid computing is often used to complete complicated or tedious mathematical or scientific calculations.

Examples of Grid Applications

- Application partitioning that involves breaking the problem into discrete pieces
- Discovery and scheduling of tasks and workflow
- Data communications distributing the problem data where and when it is required
- Provisioning and distributing application codes to specific system nodes
- Results management assisting in the decision processes of the environment
- Autonomic features such as self-configuration, self-optimization, self-recovery, and self-management

The following is an example for a grid application and its usage patterns.

Schedulers

Schedulers are types of applications responsible for the management of jobs, such as allocating resources needed for any specific job, partitioning of jobs to schedule parallel execution of tasks, data management, event correlation, and service-level management capabilities. These schedulers then form a hierarchical structure, with meta-schedulers that form the root and other lower level schedulers, while providing specific scheduling capabilities that form the leaves. These schedulers may be constructed with a local scheduler implementation approach for specific job execution, or another meta-scheduler or a cluster scheduler for parallel executions.

Competency 2: Explores the evolution of computing devices, so as to be able to describe and compare the performance of modern computers.

Competency Level 2.3: Explores the Von- Neumann Architecture**.**

Number of Periods: 06

Learning Outcomes:

- Describes the stored program concept.
- Names the major components of Von- Neumann architecture.
- Describes fetch- execute cycle.
- Briefly describes ALU, CU, Memory (Registers), data and control bus.
- Draws the Von- Neumann Architecture model and name sits components.
- Describes the need of multi-core processors.

Contents:

Von-Neumann Architecture

- Stored program control concept
- Components [input device, output device, memory, processor (control unit and ALU)]

Fetch-execute cycle

Central processing unit (CPU)

- Arithmetic and logic unit (ALU)
- Control unit (CU)
- Memory (Registers)
- Data and control bus
- Multi-core processors

Concepts and terms to be highlighted:

- Basic block diagram of a computer based on the Von Neumann Architecture.
- Fetch execute cycle.
- Multi core processors.

Guidance for lesson plans:

- Discuss about IPO model and stored program concept.
- Introduction of Von Neumann Architecture with block diagram and its components.
- Explain how the instruction is executed by a processor.
- Introduce Fetch execute cycle.
- Define parts of a CPU and functionality
- Discuss the need of multi core processor.

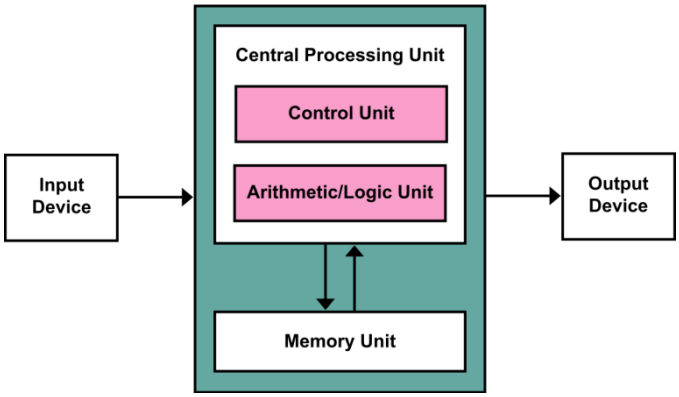
Guidance for assessments and evaluations:

- Ask students to draw and name a block diagram of Von Neumann Architecture.
- Give an assignment to classify the components of a computer

Reading Materials:

Von-Neumann Architecture

Von Neumann Architecture consists of a CPU, memory and input output devices. The program is stored in the memory. The CPU fetches an instruction from the memory at a time and executes it.



(Source; https://en.wikipedia.org/wiki/Von_Neumann_architecture)

Major components of this architecture:

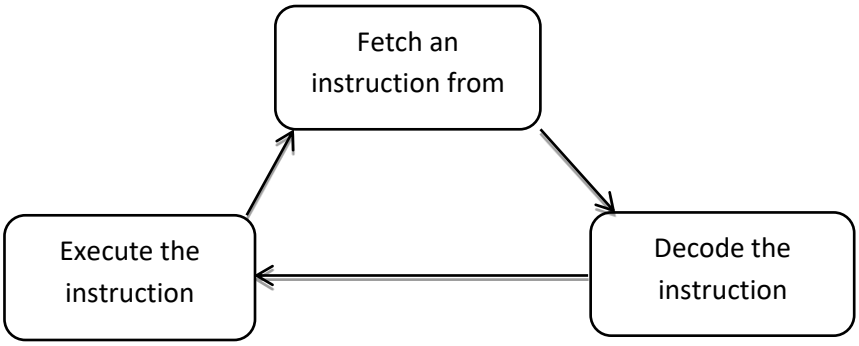
1. Central processing unit
   (i) Control unit (CU)
   This unit controls signals of all devices of a computer system.
   (ii) Arithmetic and logic unit (ALU)
   It carries out mathematical and logical operations.
   (iii) Memory register
   A CPU register is one of a small set of data holding places which is part of the computer processor. A register may hold an instruction, a storage address, or any kind of data

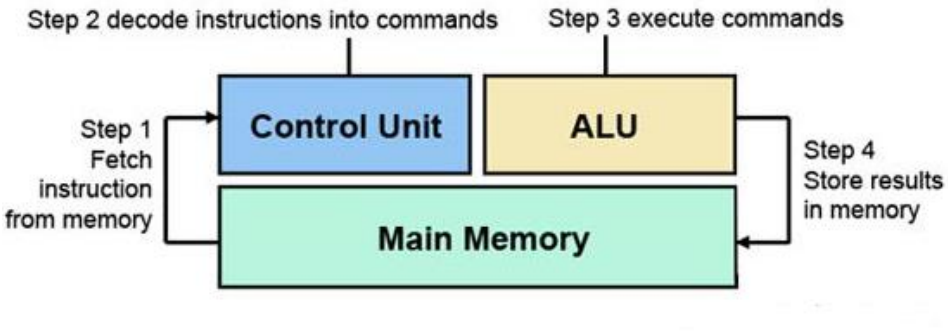
2. Memory
   (i) Primary memory
   (ii) Secondary memory
3. Input device
4. Output device

Data bus
A data bus is a system within a computer or device, consisting of a connector or set of wires, that provides transportation for data.

Control bus
Control bus is used to transmit a variety of control signals to components and devices.

Fetch execute cycle





Multi-core processors

A multi-core processor is a single computing component with two or more independent actual processing units (cores), which are units that read and execute program instructions. Therefore, the single processor can run multiple instructions on separate cores at the same time.

Need of multi-core processor

1. Can be run a program by dividing some parts. So it gets executed fast.
2. It enables parallel programming.
3. To get the high performance from a single machine.

Competency 2: Explores the evolution of computing devices, so as to be able to describe and compare the performance of modern computers.

Competency Level 2.4: Examines PC memory system to identify different types of memory and their main characteristics**.**

Number of Periods: 06

Learning Outcomes:

- Briefly explains the memory hierarchy with a suitable diagram.
- Describes the need for different types of memory and their characteristics.
- Briefly explains the volatile and non- volatile memory.
- Lists volatile and non-volatile memories in computer.
- Describes the characteristics of memory in terms of performance, location, capacity, access method, cost, physical type and physical arrangement of data (bits into words)
- Lists and briefly explains the types and characteristics of ROMs
- Compares and contrasts each type of memory in terms of access time, cost / MB, capacity (typical amount used)

Contents:

- Memory hierarchy
    - Need of memory hierarchy
    - Comparison criteria
        - Physical size/ density of data
        - Access method
        - Access time(elapsed time/delay)
        - Capacity
        - Cost
- Volatile memory and their characteristics
    - Registers
    - Types of cache memory
    - Main memory–RAM
    - Types of RAM
        - SRAM, DRAM, SDRAM
- Non-volatile memory and their characteristics
    - Types of ROMs
        - PROM, EPROM and EEPROM
    - Secondary storage
        - magnetic, optical and flash memory

Concepts and terms to be highlighted:

- Compare memories of computer system with physical size, cost per unit, capacity etc.
- Present the memory hierarchy
- Volatile and non-volatile memory

Guidance for lesson plans:

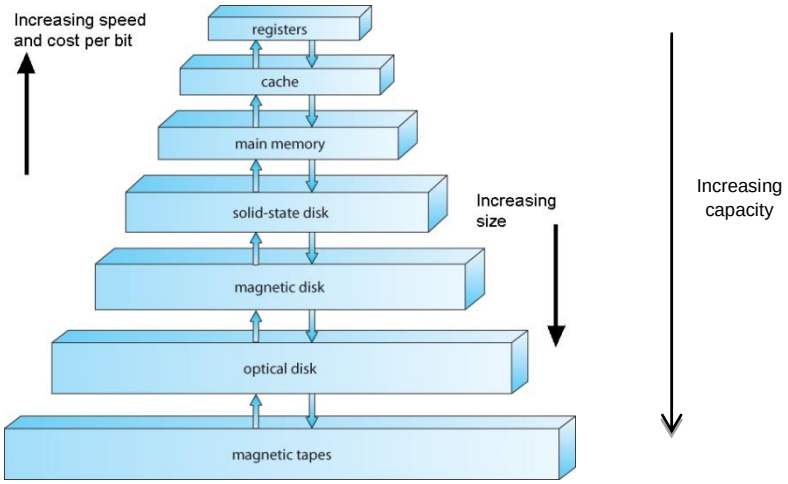
- Draw the memory hierarchy to compare memories.
- List volatile memories and why they needed in computer system.
- Discuss types of cache memory and RAM.
- List non-volatile memories and characteristics of them.
- Discuss types of ROM.
- Explain categorization of secondary storage based on the read/write technology.

Guidance for assessments and evaluations:

- Assignment - Divide the class into groups and assign each group one of the following topic and ask them to list brief description for them.
    - ✓ Register
    - ✓ Cache memory
    - ✓ Random Access Memory
    - ✓ Read Only Memory
    - ✓ Secondary storage

Reading Materials:

Memory hierarchy



Volatile memory

Volatile memory is a computer storage that only holds the data while the device is powered.
Eg: Register, Cache memory, RAM

Cache memory

The cache memory is used to store program instructions that are frequently accessed by software during operation.

Types of cache memories

- Level 1 **(L1)** cache is extremely fast but relatively small, and is usually embedded in the processor chip (CPU).
- Level 2 (L2) cache is often more capacity than L1. It may be located on the CPU or on a separate.
- Level 3 (L3) cache is typically specialized memory that works to improve the performance of L1 and L2. It can be significantly slower than L1 or L2, but is usually double the speed of RAM.

RAM (Random Access Memory)
RAM is the main memory of the computer that holds data for running applications and required data for a computer.
Types of RAM

(i) SRAM – Static RAM
SRAM is random access memory that retains data bits in its memory as long as power is being supplied. SRAM is used for cache memory and register memory.
(ii) DRAM – Dynamic RAM
This type of RAM is continuously refreshed or it will lose its contents.
(iii) SDRAM - Synchronous DRAM
It is a type of memory that synchronizes itself with the computer's system clock.

Non-volatile memory

This is a type of computer memory that has the capability to hold saved data even if the power is turned off.

Eg: ROM, Hard disk etc.

ROM – Read Only Memory

ROM retains its contents even when the computer is turned off. ROM stores essential programs such as the program that boots the computer.

Types of ROM

PROM (Programmable ROM)
It is a memory chip on which data can be written only once. Once a program has been written onto a PROM, it remains there forever.

EPROM (Erasable PROM)
EPROM is a special type of memory that retains its contents until it is exposed to ultraviolet light. The ultraviolet light clears its contents, making it possible to reprogram the memory.

EEPROM (Electrically Erasable PROM)
IT can be erased by exposing it to an electrical charge.

Secondary storage

1. Magnetic storage device
   Magnetic storage is the manipulation of magnetic fields on a medium in order to record audio, video or other data. In main computer storage mechanisms have generally involved a spinning disc or platter and read write heads on an armature. Many types of magnetic storage involve a tape medium ether on a real or in a cassette that is moved by read and write heads.
   Eg: Hard disk, Floppy disk, Magnetic tape

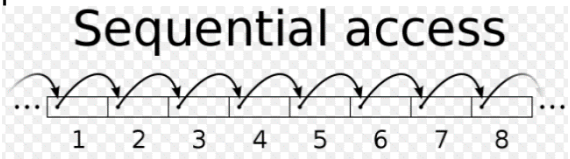
2. Optical storage device
   Optical storage is any storage method in which data is written and read with a laser for archival or backup purposes. Typically, data is written to optical media, such as CDs and DVDs. For several years, proponents have spoken of optical storage as a near-future replacement for both hard drives in personal computers and tape backup in mass storage. Optical media is more durable than tape and less vulnerable to environmental conditions. On the other hand, it tends to be slower than typical hard drive speeds, and to offer lower storage capacities.

   Eg: CD, DVD, Blu-Ray disc

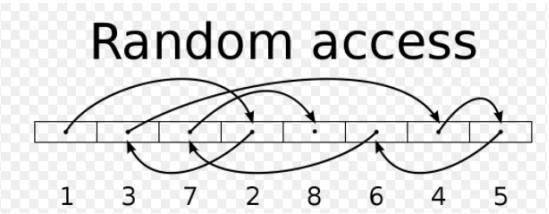
3. Solid state storage
   Solid-state storage (SSS) is a type of computer storage media made from silicon microchips. SSS stores data electronically instead of magnetically, as spinning hard disk drives (HDDs) or magnetic oxide tape do. Solid-state storage can be found in three form factors: solid-state drives (SSD), solid-state cards (SSC) and solid-state modules (SSM). An important advantage of solid-state storage is that it contains no mechanical parts, allowing data transfer to and from storage media to take place at a much higher speed and providing a more predictable lifespan for the storage media. Because there are no moving parts, SSDs produce far less heat than HDDs.
   Eg: Flash drive, Memory card

Memory Access method

(i) Sequential access
Start at the beginning and read through in order.
Eg: Tape



(ii) Random access
Individual addresses identify directly and access the data immediately,
Eg: RAM



Competency 3: Investigates how instructions and data are represented in computers and exploit them in arithmetic and logic operations

Competency level 3.1: Analyses how numbers are represented in computers

Time: 10 periods

Learning outcomes

- Describes that instructions and data are represented using two states in computers
- Explains the need of different number systems
- Converts decimal integers into binary, octal and hexadecimal numbers and vice versa
- Converts binary numbers to octal and hexadecimal, and vice versa
- Converts octal numbers to binary and hexadecimal, and vice versa
- Describes how different types of decimal numbers are stored in computers
- Explains that the Most Significant Bit (MSB) is used to indicate the sign when converting the given binary value to one's complement
- Converts a given binary value to two's complement
- Explains the usage of one's complement and two's complement

Contents:

- Need for instruction and data representation in digital devices
- Methods of instruction and data representation in computers
    - Representation of data in two states (0,1)
- Number systems used in computing
    - Binary, octal, hexadecimal
    - Conversion between number systems
- Representation of decimal numbers (signed and unsigned)
    - Signed integer representations
    - Signed magnitude
    - One's complement
    - Two's Complement

Concepts and terms to be highlighted:

- A set of rules have to be followed in converting a number from one system to another.
- A standard procedure is available to present the digits of the converted number
- The fixed point and floating point formats for decimal arithmetic
- The representation of negative numbers using sign-magnitude, one's complement and two's complement methods.

Guidance for lesson plans:

Let's inquire into methods of representing computer related numerical data.

Pay attention to the following conversions.

- Decimal Numbers convert as Binary, Octal and Hexadecimal
- Binary Numbers convert as Octal and Hexadecimal
- Octal Numbers convert as Decimal, Binary and Hexadecimal
- Hexadecimal Numbers convert as decimal Binary, and Octal

Guidance for assessments and evaluations:

- Give enough questions to get familiar with the number conversions.

Quality inputs:

- Presentations, Internet facility

Reading Material

Digital devices represent everything as numbers.
– Numbers, characters, symbols, images, audio and video and all the multimedia items and instructions are represented by numbers in digital devices.
All modern digital devices use binary numbers (base 2) instead of decimal (base 10)
Smallest unit in digital device is bit.
– A bit is a "binary digit", that is, a number that is either 0 or 1
– Computers ultimately represent and process everything as bits
Groups of bits represent larger things
– Numbers, letters, words, names, pictures, sounds, instructions,..
– The interpretation of a group of bits depends on their context

Humans need different number systems to interact with computers. Humans can't remember large set of ones and zeros ("1" and "0"). Binary files are difficult for humans to read and edit. Binary files can get confusing when transferring between computers with different architectures. By using octal and hexadecimal numbers humans can easily read.

Decimal Numbers

- The number system is extremely close to our day to day life.
- It is made up of the digits of 0,1,2,3,4,5,6,7,8,9
- It is called the decimal number system because ten digits available in this number system
- It can be believed that it has become a popular number system because humans have ten fingers in their hand.
- However, a large number can be represented using these ten digits.
- The decimal point is used to separate a fractional part of a number
- Plus "+" sign used to show positive values and negative "-" sign is used to show negative values.
  E.g. :- +10.235
  -25.321

Integers

- Integers are a number set.
- Natural numbers (0, 1, 2, 3...) and (-1,-2,-3,…) are integers.
- Neither decimal number nor fractions are integers.
  E.g. :- 0.75, 8.5

Decimal number system

- This number system has 10 digits of 0, 1, 2, 3, 4, 5, 6, 7, 8, 9.
- When the value of a particular number exceeds the largest number 9 in that number set, the multiples of 10 of the number of values are transferred to the next (left) place value. Every place value is multiplied by ten to get the next place value.

  E.g. :- $3456 = 3 \times 10^3 + 4 \times 10^2 + 5 \times 10^1 + 6 \times 10^0$
  $= 3000 + 400 + 50 + 6$
  $= 3456$

  The place values in decimal number are multiple values of 10. Therefore the base value of the decimal number system is 10.

Binary number system

- The binary number system has two digits which can be represent two states.
- These two states are, represented by digits “0” and “1”.
- Therefore a number system with the two digits can be used here.
- There are multiplications of 2 in place values of the binary number system. They are as follows.

2^4	2^3	2^2	2^1	2^0	2^{-1}	2^{-2}	2^{-3}	
16	8	4	2	1	1/2	1/4	1/8	Place values

- Therefore, the base value of the binary number system is 2.
- As the computer works on electricity and is an electronic device, its functions are controlled by two states.
- These two states are, where the power is ON and OFF (As two different levels of voltage)
- The every place value is multiply by 0 or 1 (digits of binary number system) to get the value of binary number.

E.g. :- $11010_2 = 1 \times 2^4 + 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 0 \times 2^0$
$= 1x16+1x8+0x4+1x2+0x1$
$= 26_{10}$
Therefore, $11010_2 = 26_{10}$

One location (one digits) is call a bit. There are 5 bits in the above number.

Octal number system

- The base value of the octal number system is 8.
- The digits are 0, 1, 2, 3, 4, 5, 6 and 7.
- The place values are as follows.

8^2	8^1	8^0	8^{-1}	8^{-2}	
64	8	1	1/8	1/64	place values

E.g. :- $673_8 = 6 \times 8^2 + 7 \times 8^1 + 3 \times 8^0$
$= 6x64+7x8+3x1$
$= 443_{10}$
Therefore, $673_8 = 443_{10}$

Hexadecimal number system

- The base value of hexadecimal number system is16.
- There are 16 digits in the hexadecimal number system. Digits over value 9 need two digits. Therefore, A, B, C, D, E, F also used as remaining digits. All digits are as follows.
  Digits 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F
- The minimum value is 0 and maximum value is F ($=15_{10}$).
- The values represented by the digits are as follows

Hexadecimal	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
Decimal	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

E.g. :- $BC12_{16} = B(11) \times 16^3 + C(12) \times 16^2 + 1 \times 16^1 + 2 \times 16^0$
$= 11\times16^3 + 12\times16^2 + 1\times16^1 + 2\times16^0$
$= 11x4096 + 12 x256+ 1x16+2x1$
$= 45056 + 3072 + 16 + 2$
$= 48146$
Therefore, $BC12_{16} = 48146_{10}$

The Decimal number 765.43 can be tabulated as follows.

	100	10	1	1/10	1/100	
Place Value	10^2	10^1	10^0	10^{-1}	10^{-2}	
Numbers	7	6	5	4	3	765.43
Value	700	60	5	0.4	0.03	

Most Significant Digit (MSD) and Least Significant Digit (LSD)

MSD - The Digit that contain the most positional value in a number.
LSD - The Digit that contains the least positional value in a number.

Number	MSD	LSD
2975.0	2	5
56.034	5	4

E.g.:-

0.03145	3	5
0031.0060	3	6

Conversions between number systems

1. Conversion of a decimal numbers into a binary numbers
   - Divide the given decimal number by 2
   - Write the integer answer (quotient) under the long division symbol.
   - Write the remainder (0 or 1) to the right of the dividend.
   - Continue downwards, dividing each new quotient by 2 and writing the remainders to the right of each dividend. Stop when quotient is 0.
   - Starting from bottom, write the sequence of 1's and 0's upwards to the top.

E.g.:- Converting number 12_{10} to a binary number.

First, divide this number by 2 writing the remainders.

```
2 | 12    Remainder
2 |  6    0 ↑
2 |  3    0 |
2 |  1    1 |
    0    1 |
    ↑
Quotient
```

$12_{10} = 1100_2$

2. Conversion of a decimal numbers into a Octal numbers
   - Divide the given decimal number by 8
   - Write the integer answer (quotient) under the long division symbol.
   - Write the remainder (0 to 7) to the right of the dividend.
   - Continue downwards, dividing each new quotient by 8 and writing the remainders to the right of each dividend. Stop when quotient is 0.
   - Starting from bottom, write the sequence of remainders upwards to the top.

E.g.:- Converting number 245_{10} into an octal number.

```
8 | 245   Remainder
8 |  30   5 ↑
8 |   3   6 |
    0   3 |
    ↑
Quotient
```

$245_{10} = 365_8$

3. Conversion of a decimal numbers into a Hexadecimal numbers
   - Divide the given decimal number by 16. Treat the division as an integer division.
   - Write down the remainder (in hexadecimal, i.e. if the remainder is 12, write down "C").
   - Repeat step a and b until the result is 0.

- The hexadecimal value is the digit sequence of the remainders from the bottom to top.

E.g.:- Converting number 3240_{10} into a hexadecimal number.

```
16 | 3240  Remainder
16 |  202  8
16 |   12  10 (A)
      0   12 (C)
```

$3240_{10} = CA8_{16}$

Quotient

Converting fractions to Binary

- Multiply the given decimal fraction by 2.
- Multiply by 2 until the decimal part becomes 0.
- Write the values in front of decimal point from beginning to end.

E.g.:- convert 0.3125_{10} to binary

	0.3125	x2
0	.625	x2
1	.25	x2
0	.50	x2
1	.00	

$0.3125_{10} = 0.0101_2$

Converting fractions to Octal

- Multiply the given decimal fraction by 8.
- Multiply the decimal by 8 until it becomes 0.
- Write from the beginning to end, the values in front of the decimal point.

E.g. :- convert 0.3125_{10} to binary

0	0.3125	x8
2	.50	x8
4	.0	x8

$0.3125_{10} = 0.24_8$

Converting Binary Numbers to Decimal Numbers

E.g.:- Converting number 1101_2 to a decimal number.

1	1	0	1_2
2^3	2^2	2^1	2^0 ← Place values

$1101_2 = (1x2^3) + (1x2^2) + (0x2^1) + (0x2^0)$

$= (1x8) + (1x4) + (0x2) + (1x1)$

$= 8 + 4 + 0 + 1$

$1101_2 = 13_{10}$

Converting Octal Numbers to Decimal Numbers

E.g.:- Converting number 1260_8 to a decimal number.

1	2	6	0_8	
8^3	8^2	8^1	8^0	← Place values

$1260_8 = (1x8^3) + (2x8^2) + (6x8^1) + (0x8^0)$

$= (1x512) + (2x64) + (6x8) + (0x1)$

$= 512 + 128 + 48 + 0$

$1260_8 = 688_{10}$

Converting hexadecimal Numbers to Decimal Numbers

E.g.:- Converting number $A0B1_{16}$ to a decimal number.

A(10)	0	B(11)	1_{16}	
16^3	16^2	16^1	16^0	← Place values

$A0B1_{16} = (10x16^3) + (0x16^2) + (11x16^1) + (1x16^0)$

$= (10x4096) + (0x256) + (11x16) + (1x1)$

$= 40960 + 0 + 176 + 1$

$A0B1_{16} = 41137_{10}$

Converting Binary Numbers to Octal Numbers

Group all the 1's and 0's in the binary number in sets of three, starting from the far right. Add zeros to the left of the last digit if you don't have enough digits to make a set of three. Next assuming all groups a different 3 digit binary number multiply it by place values and get the sums separately. Put everything back together to get the octal number.

E.g. :- 10011011_2

Grouping: $10,011,011_2$

Adding Zeros for Groups of Three: $010, 011, 011_2$

$=(0x2^2+ 1x2^1 + 0x2^0), (0x2^2+ 1x2^1 + 1x2^0), (0x2^2+ 1x2^1 + 1x2^0)$

$=(0+2+0), (0+2+1), (0+2+1)$

$=2, 3, 3$

$=233_8$

Converting Binary Numbers to hexadecimal Numbers

Cut your string of binary numbers into groups of four, starting from the right.
Add extra zeros to the front of the first number if it is not four digits.
Convert one 4-digit group at a time and change to hexadecimal digits. Put everything back together to get the hexadecimal number

E.g.:- Convert 11101100101001_2 to hexadecimal

Grouping: 11,1011,0010,1001

= 0011,1011,0010,1001

$=(0x2^3 +0x2^2 +1x2^1 +1x2^0), (1x2^3 +0x2^2 +1x2^1 +1x2^0), (0x2^3 + 0x2^2 +1x2^1 +0x2^0),$

$(1x2^3 + 0x2^2 + 0x2^1 + 1x2^0)$

= (0+0+2+1), (8+0+2+1), (0+0+2+0), (8+0+0+1)

= 3, 11, 2, 9

= $3B29_{16}$

Therefore $11101100101001_2 = 3B29_{16}$

Converting Octal Numbers to Binary Numbers

Octal Number (Digit)	Binary Number
0	000
1	001
2	010
3	011
4	100
5	101
6	110
7	111

Write the equivalent three binary digits groups for each octal digit. Remove the zeros from left which has no values. Put all together to get the binary equivalent number.

$137_8 = 001,011,111$

$= 001011111_2$

$= 1011111_2$

Converting hexadecimal Numbers to Binary Numbers

Write the equivalent four binary digits groups for each hexadecimal digit.

Remove the zeros from left which has no values.

Put all together to get the binary equivalent number.

$1A90_{16} = 0001,1010,1001,0000$

$= 0001101011001000_2$

$= 11010110010000_2$

For negative numbers we need an alternative interpretation of bit values.

Three interpretations have been used:

Sign-Magnitude.

The sign and magnitude method is commonly an 8 bit system that uses the most significant bit (MSB) to indicate a positive or a negative value. By convention, a ‘0’ in this position indicates that the number given by the remaining 7 bits is positive, and a most significant bit of ‘1’ indicates that the number is negative. This interpretation makes it possible to create a value of negative zero.

E.g. :- $+45_{10}$ in signed binary is 00101101_2
- 45_{10} in signed binary is 10101101_2

One's Complement and Two's Complement

The functionality of subtraction using one's complement and two's complement is described using the below formula.

$X - Y = X + 2^n - Y - 2^n$

$= X + 2^n - 1 - Y + 1 - 2^n$

($2^n - 1 - Y$: One's Complement; $+1$: Two's Complement)

$= X + ((2^n - 1 - Y) + 1) - 2^n$

One's Complement of Y $= 2^n - 1 - Y$

Two's Complement of Y $= 2^n - 1 - Y + 1$

E.g. :- X=10, Y=5

$X - Y = X + 2^n - 1 - Y + 1 - 2^n$ $10_{10}-5_{10} = 10_{10}+2^8-1-5_{10}+1-2^8$ $=10_{10}$+1s Complement of $5_{10}+1-2^8$ $=00001010_2$ + 1's Complement of 00000101_2+ $1-2^8$	$10_{10} = 00001010_2$ $5_{10} = 00000101_2$ $2^8 = 100000000_2$ $2^8-1 = 100000000_2-$ $00000001_2=11111111_2$
1's complement of $5=2^n - 1 - Y$ $=2^8-1-00000101_2$ $=11111111_2-00000101_2$	11111111_2- $\underline{00000101_2}$ 11111010_2
1's complement of $5=11111010_2$	(No deduction is required. Here, 1s become 0s and 0s become 1s in 00000101_2)
2's complement of Y $=2^n - 1 - Y + 1$ 2's complement of 5 $=11111010_2+00000001_2$ $=11111011_2$	11111010_2+ $\underline{00000001_2}$ 11111011_2
$10_{10}-5_{10} = 00001010_2+11111011_2-2^8$	$X - Y = X + (2^n - 1 - Y + 1) - 2^n$ $=X+$ Two's complement of $Y-2^n$
$= 100000101_2-2^8$	00001010_2+ $\underline{11111011_2}$ 100000101_2
$= 100000101_2-100000000_2$	100000101- $\underline{100000000}$ 00000101_2
$= 00000101_2$ $(=5_{10})$	(There is no deduction. Just only remove the first digit)

One's Complement

In one's complement, positive numbers are represented as usual in regular binary. However, negative numbers are represented differently. To negate a number, replace all zeros with ones, and ones with zeros - flip the bits. Thus, 12 would be 00001100, and -12 would be 11110011. As in signed magnitude, the leftmost bit (most significant bit-MSB) indicates the sign (1 is negative, 0 is positive). To compute the value of a negative number, flip the bits and translate as before.

When representing positive and negative numbers in 8-bit ones complement binary form, the positive numbers are the same as in signed binary notation.

E.g.: -120 is represented in one's complement form as 10000111_2 and

-60 is represented in one's complement form as 11000011_2

The ones complement system still has two ways of writing 0_{10} ($00000000_2 = +0_{10}$ and $11111111_2 = -0_{10}$);

Two's Complement.

A single set of bits is used. To form a negative number, start with a positive number, complement each bit and add one. This interpretation includes one more negative value than positive values (to accommodate zero).

E.g. :- -5 is represented in two's complement form as 11111011_2 and $+5_{10}$ as 00000101_2.

+5= 00000101_2, 1^s complement of 00000101_2 is 11111010_2

2^s complement of 00000101_2 =11111010_2+1=11111011_2

$-5_{10}$is represented in two's complement as 11111011_2 (In hexadecimal FB_{16})

	Usage
Sign Magnitude	Used only when we do not add or subtract the data. They are used in analog to digital conversions. They have limited use as they require complicated arithmetic circuits.
One's Complement	Simpler design in hardware due to simpler concept.
Two's Complement	Makes it possible to build low-cost, high-speed hardware to perform arithmetic operations.

Fixed point numbers

- In calculations involving fixed point numbers that have a fixed number of digits after the decimal point.

E.g. :- 763.2135 (The decimal point is located in the same position in each number)
179.4821
942.6956

Floating point

- The floating point number is used to represent
  - – Numbers with fractions, e.g., 3.1416
  - – Very small numbers, e.g., 0.000000001
  - – Very large numbers, e.g., 3.15576×10^9

e.g.:- -10.625 is represented in single precision floating point as below.
First convert it to binary 1010.101_2 (the whole and the fractional part separately)
Put it in standard form $1.010101x2^3$
Bias the exponent by using excess- k method (2^{k-1}-1)
K for exponent 8 = 2^{8-1}-1=128-1=127
Biased value for exponent = 3+127 = 130_{10}
exponent part in binary is 10000010_2

1	10000010	01010100000000000000000

  - – Sign, exponent, Mantissa: $(-1)^{sign} \times Mantissa \times 2^{exponent}$
  - – More bits for Mantissa give more accuracy
  - – More bits for exponent increases range

• IEEE 754 floating point standard:
  - – Single precision: 8 bit exponent, 23 bit Mantissa
  - – Double precision: 11 bit exponent, 52 bit Mantissa

	Advantage	**Disadvantage**
Fixed Point Representation	Performance good. No need to rely on additional hardware or software logic.	Limited range of values can represent.
Floating point representation	Greater range of numbers is represented. Varying degrees of precision.	More storage space needed. Slower processing times. Lack of precision.

Competency level 3.2: Analyses how characters are represented in computers

Time: 04 periods

Learning outcomes

- Lists the methods of character representation in computer
- Converts given symbols into a representation scheme
- Describes the advantage and disadvantage of different data representation schemes

Contents:

- Methods of character representation
    - BCD
    - EBCDIC
    - ASCII
    - Unicode

Concepts and terms to be highlighted:

- Character representation on computers
- The advantages of using BCD
- Comparisons between EBCDIC and ASCII
- The advantages of using Unicode.

Guidance for lesson plans:

- Discuss the need for characters to be represented on computers
- Discuss the benefits of using binary coded decimal.
- Show the ASCII and EBCDIC tables and compare it.
- Discuss the necessity of Unicode.

Guidance for assessments and evaluations:

Give assignments to find out the relevant representation of characters.

Quality inputs:

- Presentations, Internet facility, ASCII Charts

Reading Material

Characters are represented on computers using several standard methods such as ASCII, BCD,
EBCDIC and UNICODE

BCD – (Binary Coded Decimal) CODE – This is a 4 bit code used for coding numeric values (0-9) only. 2^4=16 the remaining 6 (i.e. 1010, 1011, 1100, 1101, 1110, 1111) are invalid combinations.
E.g.:- $1000111_2 = 0100\ 0111_{BCD} = 47_{10}$

BCD	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001
Decimal	0	1	2	3	4	5	6	7	8	9

ASCII – ASCII (American Standard Codes for Information Interchange) normally uses 8 bits (1 byte) to store each character. However, the 8th bit is used as a check digit, meaning that only 7 bits are available to store each character. This gives ASCII the ability to store a total of 2^7 = 128 different values . The 7 bit ASCII code was originally proposed by the American National Standard Institute (ANSI). (IBM personal computers use ASCII).

EBCDIC (Extended Binary Coded Decimal Interchange Code) – The 8 bit EBCDIC is used primarily by large IBM mainframe computers and compatible equipment. It uses 256 different characters

UNICODE – The 16 bit code provides unique code points to characters in many of the world's languages including Sinhala and Tamil. One of the promising proposals is named Unicode.

	Advantage	**Disadvantage**
BCD	• Easy to encode and decode decimals into BCD and vice versa. • Simple to implement a hardware algorithm for the BCD converter. • It is very useful in digital systems whenever decimal information is given either as inputs or displayed as outputs. • Digital voltmeters, frequency converters and digital clocks all use BCD as they display output information in decimal.	• Not space efficient. • Difficult to represent the BCD form in high speed digital computers in arithmetic operations, especially when the size and capacity of their internal registers are restricted or limited. •Require a complex design of Arithmetic and logic Unit (ALU) than the straight Binary number system. •The speed of the arithmetic operations slow due to the complete hardware circuitry involved.
ASCII	• Uses a linear ordering of letters. • Different versions are mostly compatible. • compatible with modern encodings	• Not Standardized. • Not represent world languages.
EBCDIC	• uses 8 bits while ASCII uses 7 before it was extended.	• Does not use a linear ordering of letters.

	• Contained more characters than ASCII.	• Different versions are mostly not compatible. • Not compatible with modern encodings
UNICODE	• Standardized. • Represents most written languages in the world • ASCII has its equivalent within Unicode.	• Need twice memory to store ASCII characters.

Competency level 3.3: Uses basic arithmetic and logic operations on binary numbers

Time: 04 periods

Learning outcomes

- Works out additions (multiple numbers with or without carryovers) – in binary numbers
- Works out subtraction (with or without borrowing) –in binary numbers
- Works out NOT, AND, OR, XOR bitwise operations

Contents:

- Binary arithmetic operations - (integers only)
    - Addition, subtraction
- Logical operations
    - Bitwise logical operations

Concepts and terms to be highlighted:

- Binary number addition with/ without carry overs
- Binary number subtractions
- Bitwise logical operations using NOT, AND, OR, XOR operations.

Guidance for lesson plans:

- Add two binary numbers by writing one below another according to the place values.
- Subtract binary numbers by writing the small number below the big number.
- For the given binary number do the bitwise logical operations

Guidance for assessments and evaluations:
Give enough questions to get familiar with binary addition subtraction and bitwise operations.

Quality inputs:

- presentations

Reading Material

Addition of binary numbers

$101100_2 + 1100_2 =$

$1\ 0\ 1\ 1\ 0\ 0_2$

$\underline{\quad\ 1\ 1\ 0\ 0_2}$

$1\ 1\ 1\ 0\ 0\ 0_2$

$101100_2 + 1100_2 = 111000_2$

Subtraction of binary numbers

$0010\ 110_2 - 001100_2$

$1\ 0\ 1\ 1\ 0\ 0_2$

$\underline{\quad\ 1\ 1\ 0\ 1_2}$

$0\ 1\ 1\ 1\ 1\ 1_2$

$101100_2 - 1101_2 = 011111_2$

Bitwise operations

1. NOT operation

   For unsigned integers, the bitwise complement of a number is the "mirror reflection" of the number across the half-way point of the unsigned integers range. One use is to invert a grayscale image where each pixel is stored as an unsigned integer. It uses the below bit operations.

A	NOT A
0	1
1	0

   E.g. :- **NOT** 0111_2 (7_{10}) = 1000_2 (8_{10})

2. Bitwise AND operation

   This is often called bit masking. (By analogy, the use of masking tape covers, or masks, portions that should not be altered or portions that is not of interest. In this case, the 0 values mask the bits that are not of interest.)

   It uses the below bit operation

A	B	A AND B
0	0	0
0	1	0
1	0	0
1	1	1

   E.g. :- 0101_2 (5_{10}) **AND** 0011_2 (3_{10})

   $0\ 1\ 0\ 1_2$

   $\underline{0\ 0\ 1\ 1_2}$

   $0\ 0\ 0\ 1_2$ (1_{10})

   Therefore 0101_2 **AND** 0011_2 is 0001_2

3. Bitwise OR operation
   A bitwise OR takes two bit patterns of equal length and performs the logical inclusive OR operation on each pair of corresponding bits. The result in each position is 0 if both bits are 0, while otherwise the result is 1. It uses the below bit operation

A	B	A OR B
0	0	0
0	1	1
1	0	1
1	1	1

   E.g. :- 0101_2 (5_{10}) **OR** 0011_2 (3_{10})
   $0\ 1\ 0\ 1_2$
   $0\ 0\ 1\ 1_2$
   $0\ 1\ 1\ 1_2$ (7_{10})
   Therefore 0101_2 OR 0011_2 is 0111_2

4. Bitwise XOR operation
   The bitwise XOR may be used to invert selected bits in a register (also called toggle or flip). Any bit may be toggled by XOR it with 1
   It uses the below bit operations

A	B	A XOR B
0	0	0
0	1	1
1	0	1
1	1	0

   E.g. :- 0010_2 (2_{10}) **XOR** 1010_2 (10_{10})
   $1\ 0\ 1\ 0_2$
   $0\ 0\ 1\ 0_2$
   $= 1\ 0\ 0\ 0_2$ (8_{10})
   Therefore 0010_2 **XOR** 1010_2 is 1000_2

Competency 4: Uses logic gates to design basic digital circuits and devices.

Competency Level 4.1: Analyzes basic digital logic gates in term of their unique functionalities.

Number of periods: 06

Learning Outcomes:

- Names basic logic gates and draws the appropriate symbols of them.
- Draws the truth tables for the basic logic gates
- Identify symbols that represent that negations of basic logic gates.
- Creates truth tables for given expressions
- Explains the need of universal gates.
- Explain the fabrication of any gate.

Contents:

- Digital logic gates and truth tables
  - Basic logic gates
    - NOT, AND & OR
  - Combinational gates
    - NAND, NOR, XOR and XNOR
  - Universal gates
    - NAND, NOR

Concepts and terms need to be highlighted:

Brief discussion of the use of gates in computer hardware

Guidance for lesson plans:

- Explanation of the concept of gates using day-to-day examples.
- Simulation of gates using electrical circuits.
- Explanation of the concept of combinational and universal gates
- Final output of a combination of logic gates (eg. In ICs).

Guidance for assessments and evaluations

- Drawing gates and creation of truth tables for given logic circuits

Quality inputs:

- Presentations, open source software to demonstrate the gates and its functionality

Reading Material

Logic gate is an electronic component that performs basic logical functions and it can be identified as the fundamental building block of a digital circuit.

- **What are basic logical functions?**
  - Negation (NOT)- True if input is false, False if input is true
  - Conjunction (AND) – True if, A and B are both true
  - Disjunction (OR)- True if, either A or B are true
- **Basic logic gates**
  - NOT
  - AND
  - OR
- **Basic characteristics of logic gates**
  - Each logic gate has a unique symbol and a unique logical function.
  - A gate can have multiple input(s) and an output.
  - An input can take 0 or 1 at a time.
  - Input are processed according to the function of the particular logic gate and an output is provided.
  -

What is a truth table?

Truth table represents all the input combinations and corresponding output of a logic circuit.

The following table shows all possible input combinations for two and three inputs only.

No. of Inputs	Value combinations	No. of combinations
2	0 0 0 1 1 0 1 1	$4 = 2^2$
3	0 0 0 0 0 1 0 1 0 0 1 1 1 0 0 1 0 1 1 1 0 1 1 1	$8=2^3$

Therefore,

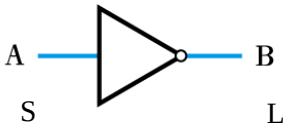
Number of input combination = $2^{\text{Number of inputs of logic gate/ circuit}}$

INTRODUCTION TO BASIC LOGIC GATES

- **NOT gate**
  - When switch A is in on state, bulb doesn't turn on. Bulb lights only if the Switch in off state.

S	L
0	1
1	0

Not gate has a single input and output. A NOT gate performs *logical negation* on its input. In other words, if the input is **true**, then the output will be **false**. Similarly, a **false** input results in a **true** output.



(a) Circuit symbol

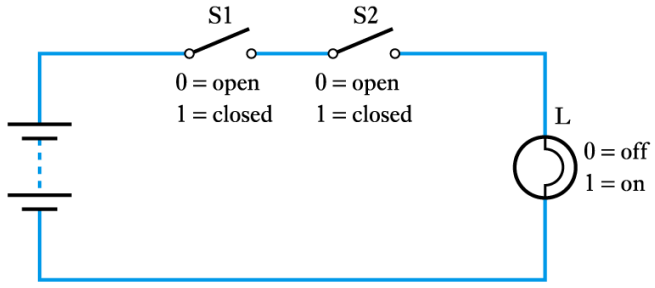
S	L
0	1
1	0

(b) Truth table

$L = \overline{S}$

(c) Boolean expression

- **AND gate**
  - In the following circuit, the bulb is lit if and only if both switches are in on state.
  - Light bulb is not lit if at least one switch is in off state.



(a) Circuit

L = S1. S2

S1	S2	L
0	0	0
0	1	0
1	0	0
1	1	1

(b) Truth table

The output of an AND gate is **true** only when all of the inputs are **true**. If one or more of an AND gate's inputs are **false**, then the output of the AND gate is **false**.

(a) Circuit symbol

S1	S2	L
0	0	0
0	1	0
1	0	0
1	1	1

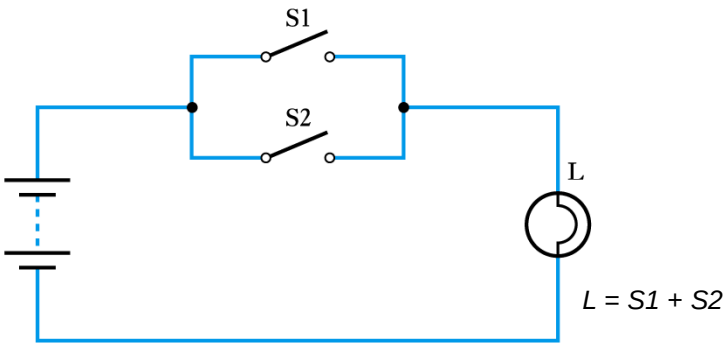
(b) Truth table

L = S1. S2

(c) Boolean expression

- **OR gate**

  In the following circuit, light bulb is lit if at least one switch is in ON state.



(a) Circuit

S1	S2	L
0	0	0
0	1	1
1	0	1
1	1	1

(b) Truth table

The output of an OR gate is true if at least one input is true. Otherwise output is false.

(a) Circuit symbol

S1	S2	L
0	0	0
0	1	1
1	0	1
1	1	1

(b) Truth table

L = S1+ S2

(c) Boolean expression

Other gates

- **Introduction to NAND gate**
  - In digital electronics, a **NAND gate** (NOT-AND) is a logic **gate** which produces false output which is false only if all its inputs are true; Otherwise it results a true output. thus, its output is the complement of AND **gate**.

(a) Circuit symbol

S1	S2	L
0	0	1
0	1	1
1	0	1
1	1	0

(b) Truth table

$L = \overline{S1.S2}$

(c) Boolean expression

- **NOR gate**
  - The **NOR gate** is a digital logic **gate** that results a true output if both inputs to the gate are false. Otherwise result is false. **NOR** is the result of the negation of the OR gate.

(a) Circuit symbol

S1	S2	L
A	B	C
0	0	1
0	1	0
1	0	0
1	1	0

(b) Truth table

L $\overline{S1.S2}$

C

(c) Boolean expression

- **XOR gate**
  - The **XOR gate** (pronounced as **Exclusive OR gate**) is a digital logic **gate** that results a true if and only one of the inputs to the gate is true. Otherwise output is false.

S1	S2	L
0	0	0
0	1	1
1	0	1
1	1	0

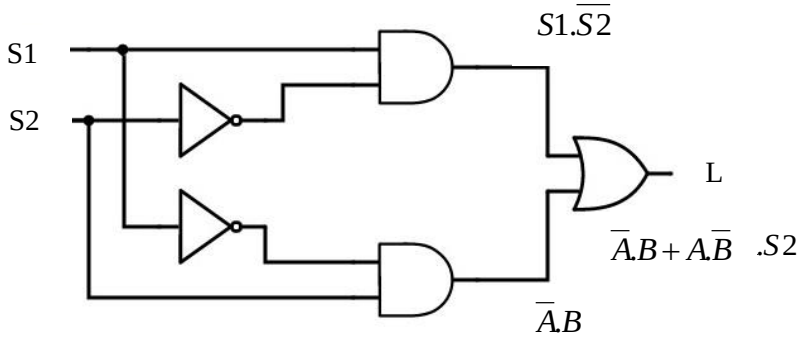
(a) Circuit symbol

(b) Truth table

L= S1 ⊕ S2

(c) Boolean expression

  - XOR gate using basic logic gates



S1	S2	$\overline{S1}$	$\overline{S2}$	$S1.\overline{S2}$	$\overline{S1}.S2$	$S1.\overline{S2} + \overline{S1}.S2$
0	0	1	1	0	0	0
0	1	1	0	0	1	1
1	0	0	1	1	0	1
1	1	0	0	0	0	0

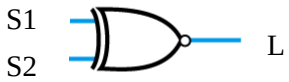
Truth table for three input XOR gate

INPUTS				**Final Output**
S1	S2	S3	S1 ⊕ S2	S1 ⊕ S2 ⊕ S3
0	0	0	0	0
0	0	1	0	1
0	1	0	1	1
0	1	1	1	0
1	0	0	1	1
1	0	1	1	0
1	1	0	0	0
1	1	1	0	1

- Compare S1 & S2 and if the inputs are same then output is zero (false). Otherwise output is one. Then compare the result of S1 ⊕ S2 with S3. if the values are same then final output is 0. else final output is 1.

Introduction to XNOR gate

- The **XNOR gate** is a digital logic gate whose function is the logical complement of the XOR gate.



(a) Circuit symbol

S1	S2	L
0	0	1
0	1	0
1	0	0
1	1	1

(b) Truth table

$L = \overline{S1 \oplus S2}$

(c) Boolean expression

Truth table for three input XNOR gate

INPUTS					**Final Output**
S1	S2	S3	S1 ⊕ S2	S1 ⊕ S2 ⊕ S3	$\overline{S1 \oplus S2 \oplus S3}$
0	0	0	0	0	1
0	0	1	0	1	0
0	1	0	1	1	0
0	1	1	1	0	1
1	0	0	1	1	0
1	0	1	1	0	1
1	1	0	0	0	1
1	1	1	0	1	0

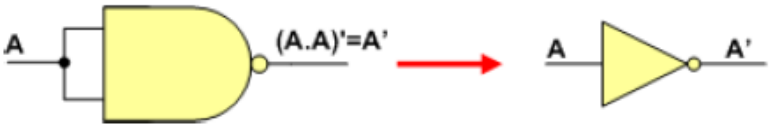
Universal Gates

A universal logic gate is a logic gate that can be used to construct all other logic gates. The NAND gate and NOR gates can be considered as universal logic gates.

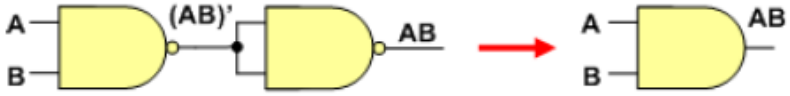
The advantage of universal gates: NAND and NOR gates are economical and easier to fabricate and are the basic gates used in all IC digital logic families.

NAND Gate

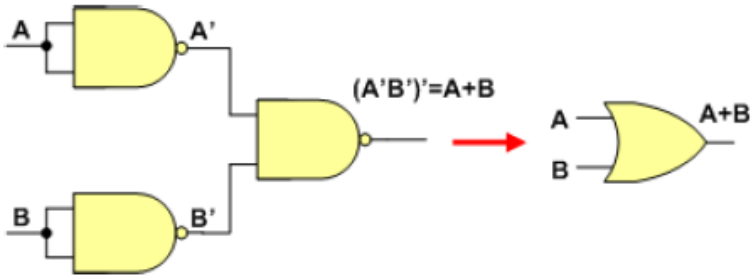
1. How to implement NOT gate using NAND gates?



2. How to implement AND gate using NAND gates?

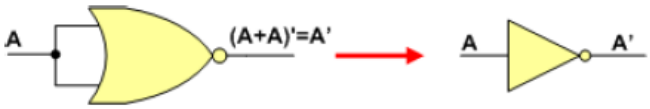


3. How to implement OR gate using NAND gates?

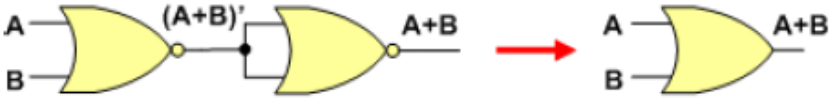


NOR Gate

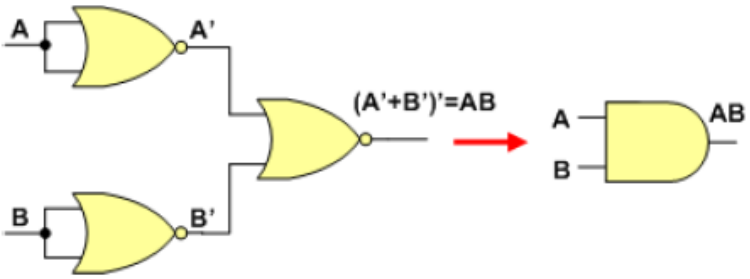
1. How to implement NOT gate using NOR gates?



2. How to implement OR gate using NOR gates?



3. How to implement AND gate using NOR gates?



Competency Level 4.2: Simplifies logic expressions using law of Boolean algebra and Karnaugh map.

Learning outcomes

- Describes the need for simplifying the Boolean expressions.
- Represents logical expressions in standard forms (SOP and POS) according to the given truth table
- Transforms SOP into POS and vice versa
- Simplifies logic expressions using Boolean theorems, axioms, De Morgan's Laws and Karnaugh map.

Number of periods: 08

Contents:

- Two state logic and Boolean algebra
- Postulates (Axioms)
- Law/ theorems
    - Commutative, associative
- Distributive
    - Identity, Redundancy
    - De Morgan's
- Standard logical expressions
    - Sum of Product and Product of Sum
    - Transforms SOP into POS and vice versa
- Simplify logic expressions using
    - Boolean theorems
    - Karnaugh maps

Concepts and terms need to be highlighted:

- Boolean algebra
- Postulates (Axioms)
- Law/ theorems
- Simplification of logic expressions
- Sum of Product and Product of Sum
- Transforms SOP into POS and vice versa

Guidance for lesson plans:

- Explanation of the concept of Boolean algebra using day-to-day examples.
- Explanation of Boolean algebra.
- Explanation and discussion of postulates and law/theorems
- Simplification of logic expressions using Boolean theorems and Karnaugh maps
- Explanation of SOP and POS
- Transformation of SOP into POS and vice versa

Guidance for assessments and evaluations

- Provide simple MCQ, structure and essay type questions on Boolean algebra
- provide logic expressions to simplify using postulates and law/theorems
- provide logic expressions to draw truth table
- Then ask the student to simply the expression using Karnaugh map
- provide a expression and ask the student to find the SOP and POS and then ask the students to transform SOP to POS and POS to SOP

Quality inputs:

- Presentations, open source software to demonstrate the gates and its functionality

Reading Material

Logical NOT, AND & OR Operators

In Boolean algebra, logical negation (NOT operation), logical conjunction (AND operation) and logical disjunction (OR operation) are performed using $\bar{}$ (bar), **.** (dot) and **+** (plus) operators respectively.

Introduction to Boolean laws

What is the requirement of Boolean algebra simplification?

Simplification of Boolean expressions reduces the number of operations and number of logic gates for the implementation.

Most laws exist in two forms. One is multiplicative form and the other is additive form. At the multiplication, variables in the boolean expression are multiplied by each other and at the addition, variables in the boolean expression are added to each other.

1. Idompotent Law

Law and its representation from a truth table

A.A=A

A	A	A.A
0	0	0
1	1	1

A+A=A

A	A	A+A
0	0	0
1	1	1

$\bar{A}.\bar{A} = \bar{A}$

A	$\bar{A}$	$\bar{A}$	$\bar{A}.A$
0	1	1	1
1	0	0	0

$\bar{A}+\bar{A} = \bar{A}$

A	$\bar{A}$	$\bar{A}$	$\bar{A}+\bar{A}$
0	1	1	1
1	0	0	0

Above highlighted columns are identical.

2. Identity Law

1.A=A

1	A	1.A
1	0	0
1	1	1

0+A=A

0	A	0+A
0	0	0
0	1	1

0.A = 0

0	A	0.A
0	0	0
0	1	0

1+A = 1

1	A	1+A
1	1	1
1	0	1

Above highlighted columns are identical.

3. Inverse/Complement Law

Multiplicative form

$A.\overline{A}=0$

A	$\overline{A}$	$A.\overline{A}$
0	1	0
1	0	0

Additive form

$A+\overline{A}=1$

A	$\overline{A}$	$A+\overline{A}$
0	1	1
1	0	1

4. De Morgan's Law

A mathematician named De Morgan developed a pair of important laws regarding group complementation in Boolean algebra.

Multiplicative form

$\overline{A.B}=\overline{A}+\overline{B}$

A	B	AB	$\overline{A.B}$	$\overline{A}$	$\overline{B}$	$\overline{A}+\overline{B}$
0	0	0	1	1	1	1
0	1	0	1	1	0	1
1	0	0	1	0	1	1
1	1	1	0	0	0	0

Additive form

$\overline{A+B}=\overline{A}.\overline{B}$

A	B	A+B	$\overline{A+B}$	$\overline{A}$	$\overline{B}$	$\overline{A}.\overline{B}$
0	0	0	1	1	1	1
0	1	1	0	1	0	0
1	0	1	0	0	1	0
1	1	1	0	0	0	0

Above highlighted columns are identical.

5. Double Complement Law

$A=\overline{\overline{A}}$

A	$\overline{A}$	$\overline{\overline{A}}$
0	1	0
0	1	0

6. Commutative Law

Multiplicative form

$AB = BA$

A	B	AB	BA
0	0	0	0
0	1	0	0
1	0	0	0
1	1	1	1

Above highlighted columns are identical.

Additive form

$A + B = B + A$

A	B	A+B	B+A
0	0	0	0
0	1	1	1
1	0	1	1
1	1	1	1

7. Associative Law

Multiplicative form

A(BC)=(AB)C

A	B	C	BC	AB	A(BC)	(AB)C
0	0	0	0	0	0	0
0	0	1	0	0	0	0
0	1	0	0	0	0	0
0	1	1	1	0	0	0
1	0	0	0	0	0	0
1	0	1	0	0	0	0
1	1	0	0	1	0	0
1	1	1	1	1	1	1

Above highlighted columns are identical.

Additive form.

A + (B + C) = (A + B) + C

A	B	C	B+C	A+B	A+(B+C)	(A+B)+C
0	0	0	0	0	0	0
0	0	1	1	0	1	1
0	1	0	1	1	1	1
0	1	1	1	1	1	1
1	0	0	0	1	1	1
1	0	1	1	1	1	1
1	1	0	1	1	1	1
1	1	1	1	1	1	1

Above highlighted columns are identical.

8. Distributive Law

A (B+C) = AB+AC

A	B	C	B+C	AB	AC	A (B+C)	AB+AC
0	0	0	0	0	0	0	0
0	0	1	1	0	0	0	0
0	1	0	1	0	0	0	0
0	1	1	1	0	0	0	0
1	0	0	0	0	0	0	0
1	0	1	1	0	1	1	1
1	1	0	1	1	0	1	1
1	1	1	1	1	1	1	1

Above highlighted columns are identical.

9. Redundancy Law

Form 1

A + AB =A

A	B	AB	A+AB
0	0	0	0
0	1	0	0
1	0	0	1
1	1	1	1

Above highlighted columns are identical.

Form 2

$A + \overline{A}B = A + B$

A	B	A'	A'B	A+A'B	A+B
0	0	1	0	0	0
0	1	1	1	1	1
1	0	0	0	1	1
1	1	0	0	1	1

Simplifying logic expressions using Boolean theorems

E.g. 01

Q = ABC + A'BC + $AB\overline{C}$

= AB (C+$\overline{C}$) + $\overline{A}$BC Distributive Law

= AB (1) + $\overline{A}$BC Inverse Law

= AB + $\overline{A}$BC Distributive Law

= B (A+$\overline{A}$C) Distributive Law

= B (A+C) Redundancy Law

E.g. 03

F=C+ $\overline{BC}$

= C+ $\overline{B}$ +$\overline{C}$ - De Morgan's Law

= C + $\overline{C}$ + $\overline{B}$

= 1+$\overline{B}$ - Inverse Law

= 1 - Identity Law

E.g. 02

F = (A+B) (A+C)

= AA + AC + BA + BC - Distributive Law

= A+ AC +BA + BC - Idempotent Law

= A (1+C+B) + BC - Distributive Law

= A (1+B) + BC - Identity Law

= A (1) + BC - Identity Law

= A + BC - Distributive Law

E.g. 04

F= X(X+Y)

= X.X + X.Y - Distributive Law

= X + X.Y - Idempotent Law

= X (1+Y) - Distributive Law

= X (1) - Null/ Identity Law

= X - Distributive Law

Standard forms in Boolean expressions

There exist two standard forms of Boolean expressions

-SOP (Sum Of Products)

-POS (Product of Sum)

The Sum-of-Products (SOP) Form

- An SOP expression → when two or more product terms are summed by Boolean summation.
  - Examples:

    $AB + ABC$

    $ABC + CDE + \overline{B}C\overline{D}$

    $\overline{A}B + \overline{A}B\overline{C} + AC$

  - Also:

    $A + \overline{A}\overline{B}C + BC\overline{D}$

In an SOP form, a single overbar cannot extend over more than one variable; however, more than one variable in a term can have an overbar:

example: $\overline{A}\overline{B}\overline{C}$ is correct

But $\overline{ABC}$ is not correct

- A standard SOP expression is one in which *all* the variables in the domain appear in each product term in the expression.
  - Example:

    $A\overline{B}CD + \overline{A}\overline{B}C\overline{D} + AB\overline{C}\overline{D}$

  - Standard SOP expressions are important in:
    - Constructing truth tables
    - The Karnaugh map simplification method

The Product-of-Sum (POS) Form

- When two or more sum terms are multiplied, the result expression is a product-of-sums (POS):
  - Examples:

    $(\overline{A} + B)(A + \overline{B} + C)$

    $(\overline{A} + \overline{B} + \overline{C})(C + \overline{D} + E)(\overline{B} + C + D)$

    $(A + B)(A + \overline{B} + C)(\overline{A} + C)$

  - Also: → $\overline{A}(\overline{A} + \overline{B} + C)(B + C + \overline{D})$

In a POS form, a single overbar cannot extend over more than one variable; however, more than one variable in a term can have an overbar:

example: $\overline{A}+\overline{B}+\overline{C}$ is correct.

However, $\overline{A+B+C}$ is not correct

Minterms and Maxterms

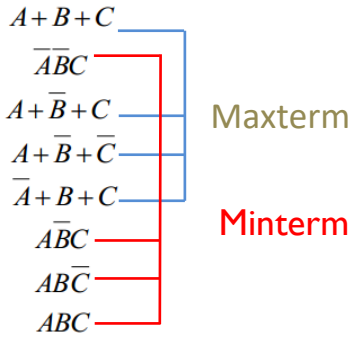
Minterm

Each row of a truth table can be associated with a *minterm,* which is a product (AND) of all variables in the function, in direct or complemented form. A minterm has the property that it is equal to 1 on exactly one row of the truth table.

Maxterm

Each row of a truth table is also associated with a *maxterm,* which is a sum (OR) of all the variables in the function, in direct or complemented form. A maxterm has the property that it is equal to 0 on exactly one row of the truth table.

A	B	C	Z
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1



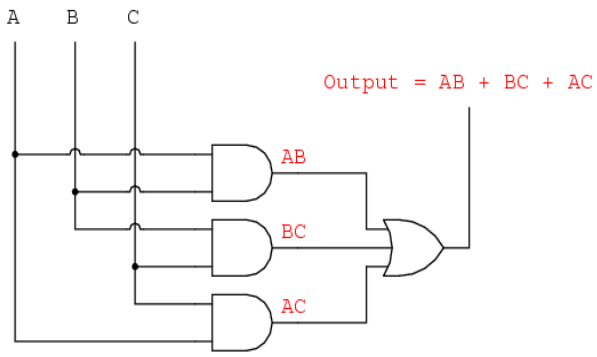
Boolean equation based on SOP method

$$Z=\overline{A}\overline{B}C+A\overline{B}C+AB\overline{C}+ABC$$

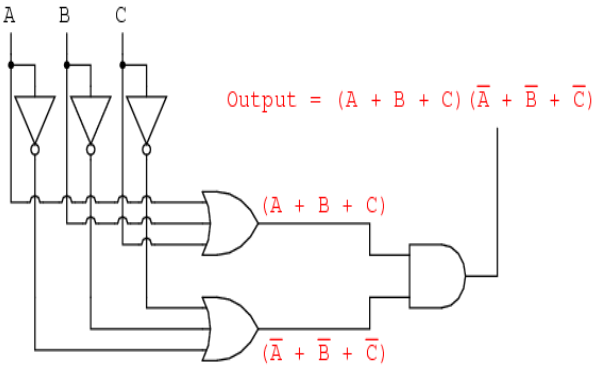
Boolean equation based on POS method

$$Z=(A+B+C)(A+\overline{B}+C)$$
$$(A+\overline{B}+\overline{C})(\overline{A}+B+C)$$

Logic circuit based on SOP



Logic circuit based on POS



Transforms SOP into POS and vice versa

SOP TO POS	
$F = A.\overline{B} + B.\overline{C} + \overline{A}.C$	*Obtain the compliment of whole equation by adding an over bar to the whole*
$= \overline{A.\overline{B} + B.\overline{C} + \overline{A}C}$	
$= \overline{A.\overline{B}} + \overline{B.\overline{C}} + \overline{\overline{A}C}$	De Morgan's Law
$= (\overline{A} + \overline{\overline{B}}).(\overline{B} + \overline{\overline{C}}) + (\overline{\overline{A}} + \overline{C})$	De Morgan's Law
$= \underline{(\overline{A} + B).(\overline{B} + C).(A + \overline{C})}$	Double Inverse
POS TO SOP	
$F = (\overline{A} + B).(\overline{B} + C).(A + \overline{C})$	*Obtain the compliment of whole equation by adding an over bar to the whole*
$= \overline{(\overline{A} + B).(\overline{B} + C).(A + \overline{C})}$	
$= (\overline{\overline{A} + B}) + (\overline{\overline{B} + C}) + (\overline{A + \overline{C}})$	De Morgan's Law
$= (\overline{\overline{A}.B}) + (\overline{\overline{B}.\overline{C}}) + (\overline{A}.\overline{\overline{C}})$	De Morgan's Law
$= \underline{A.\overline{B} + B.\overline{C} + \overline{A}.C}$	Double Inverse

Karnaugh Maps

Karnaugh maps provide an alternative way of simplifying logic circuits.

Instead of using Boolean algebra simplification techniques, you can transfer logic values from a Boolean statement or a truth table into a Karnaugh map.

The arrangement of 0's and 1's within the map helps you to visualize the logic relationships between the variables and leads directly to a simplified Boolean statement.

Cell = 2^n where n is a number of variables

Two input K-Map
Cell = 2^2 =4

B \ A	0	1
0		
1		

Three input K-Map
Cell = 2^3 =8

C \ AB	00	01	11
0			
1			

Four input K-Map
Cell = 2^4 =16

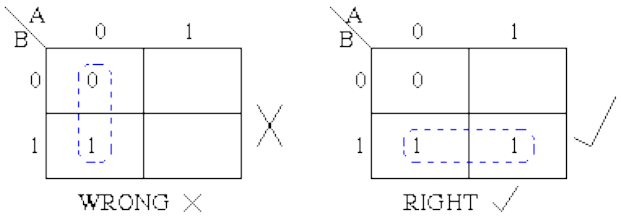
CD \ AB	00	01	11	10
00				
11				
11				
10				

Rules of K- map simplification

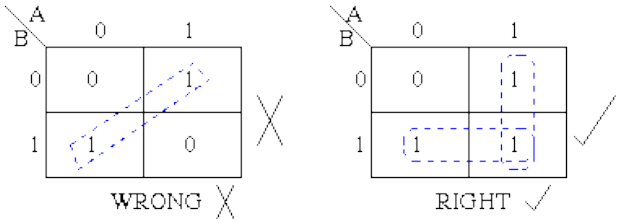
1. No zeros allowed. 2. No diagonals. 3. Only power of 2 number of cells in each group. 4. Groups should be as large as possible.	5. Every "one" must be in at least one group. 6. Overlapping allowed. 7. Wrap around allowed. 8. Fewest number of groups possible.

The Karnaugh map uses the following rules for the simplification of expressions by *grouping* together adjacent cells containing *ones*

- Groups may not include any cell containing a zero

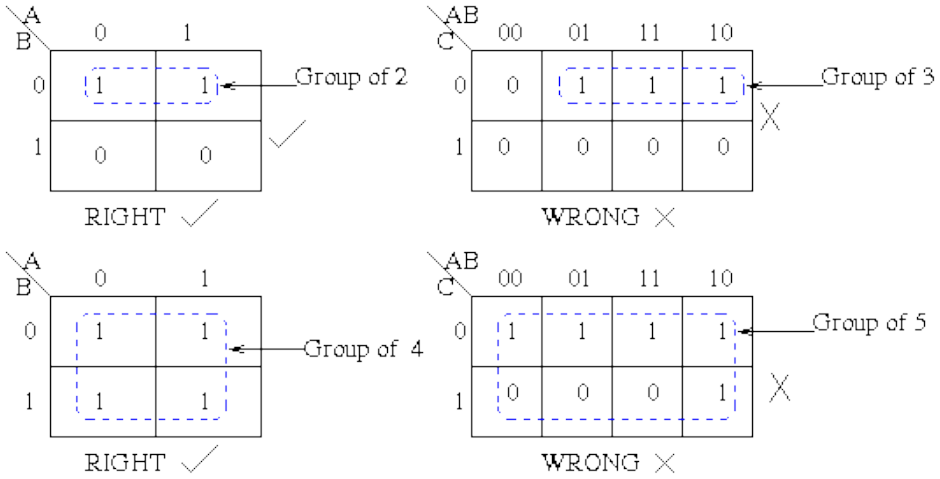


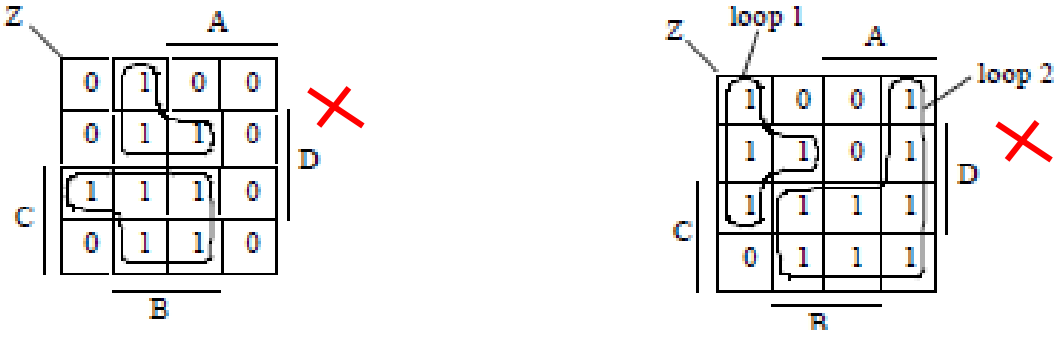
- Groups may be horizontal or vertical, but not diagonal.



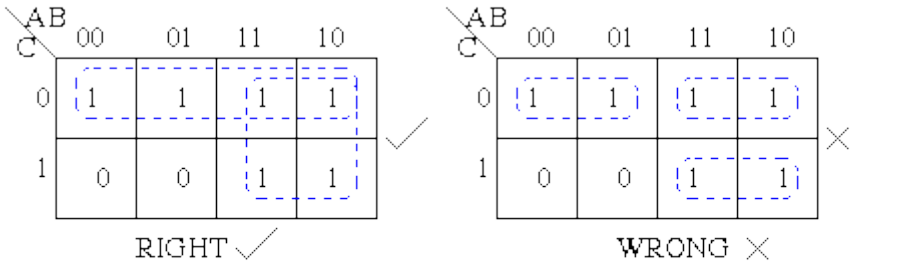
- Groups must contain 1, 2, 4, 8, or in general 2^n cells.

- That is if n = 1, a group will contain two 1's since $2^1 = 2$.
  If n = 2, a group will contain four 1's since $2^2 = 4$.





- **Each group should be as large as possible.**



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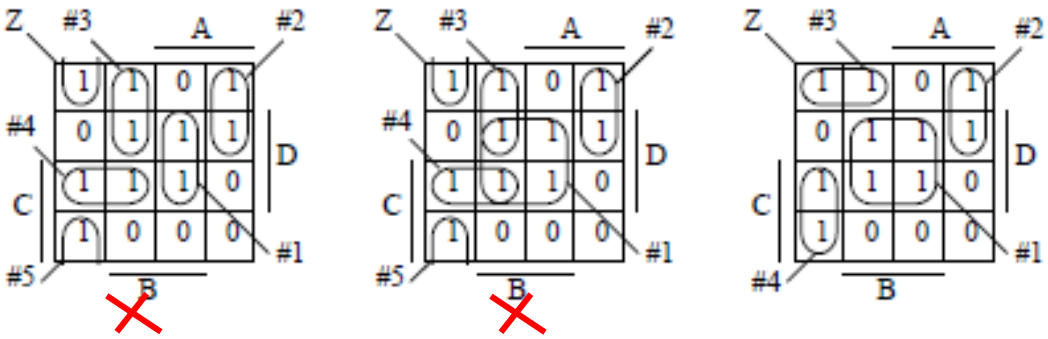
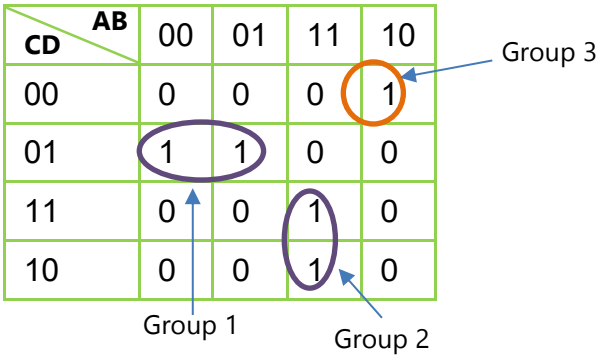
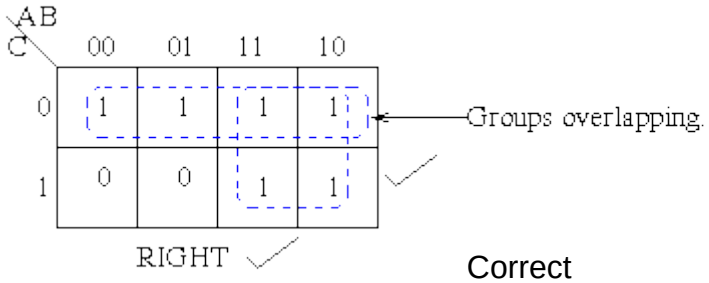


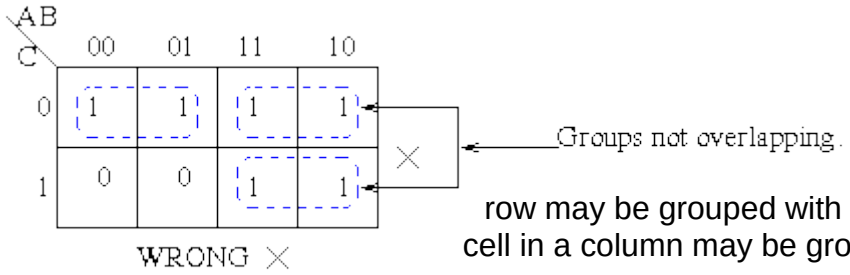
- Each cell containing a *one* must be in at least one group.



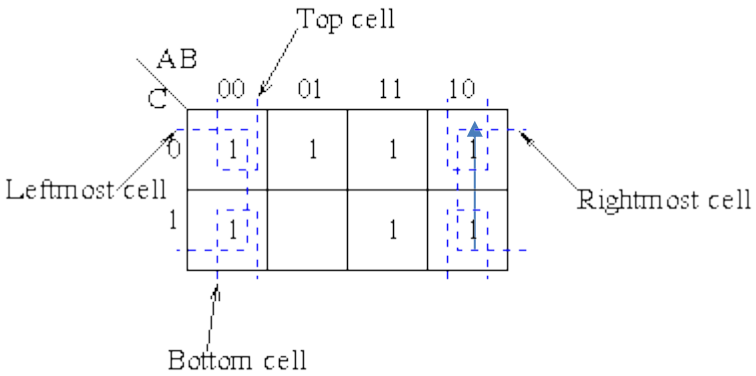
Groups may overlap.



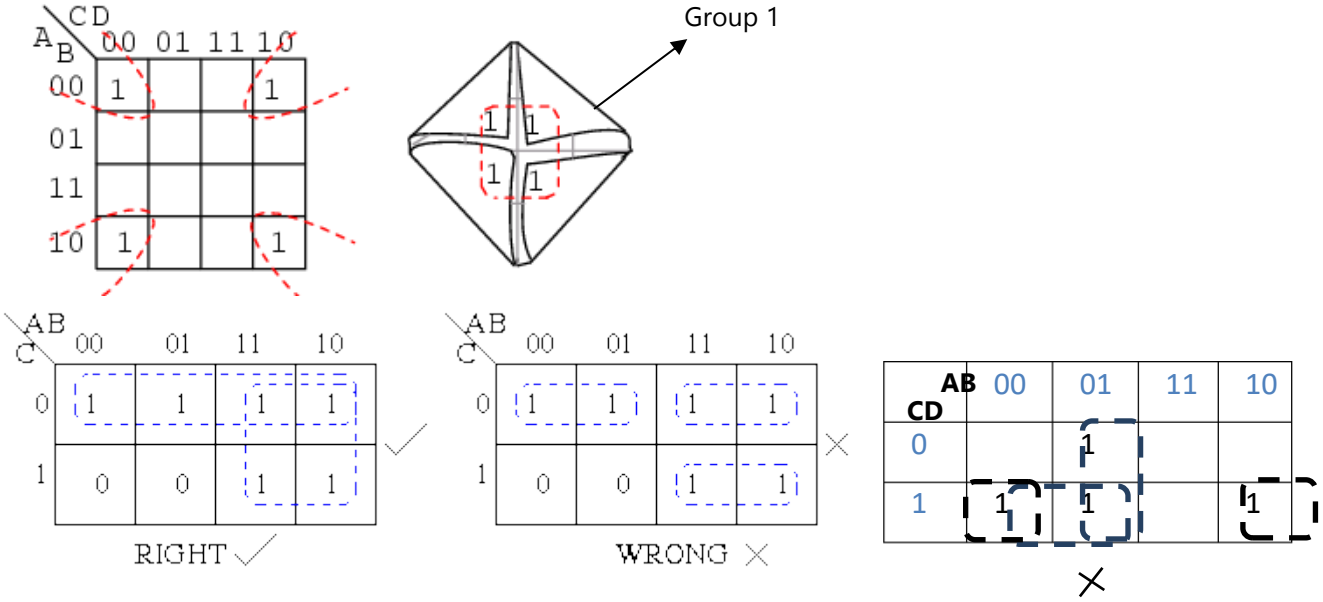
Correct



Groups may wrap around the table. The leftmost cell in a row may be grouped with the rightmost cell and the top cell in a column may be grouped with the bottom cell.



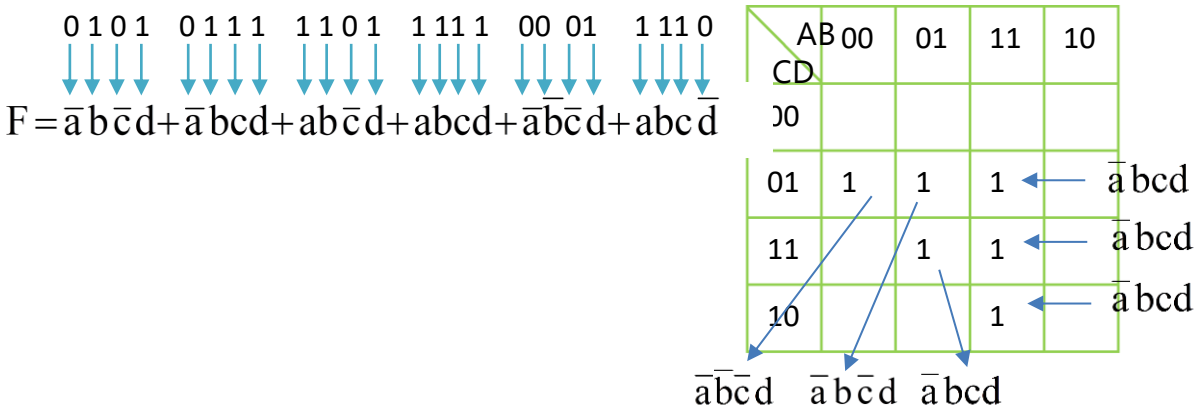
There should be as few groups as possible, as long as this does not contradict any of the previous rules.



How to simplify logic expression using K-maps

How to map four variable logic expression using K-map

In a Boolean expression any variable with a bar, is considered as a 0 and others are considered as 1



K-Map simplification step 2 → Grouping

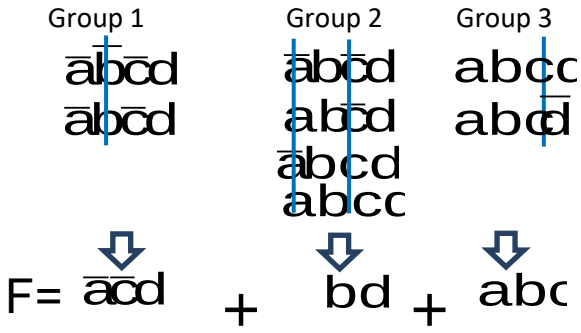
CD \ AB	00	01	11	10
00	0	0	0	0
01	1	1	1	0
11	0	1	1	0
10	0	0	1	0

Group 2

Group 3

Group 1

Step 3



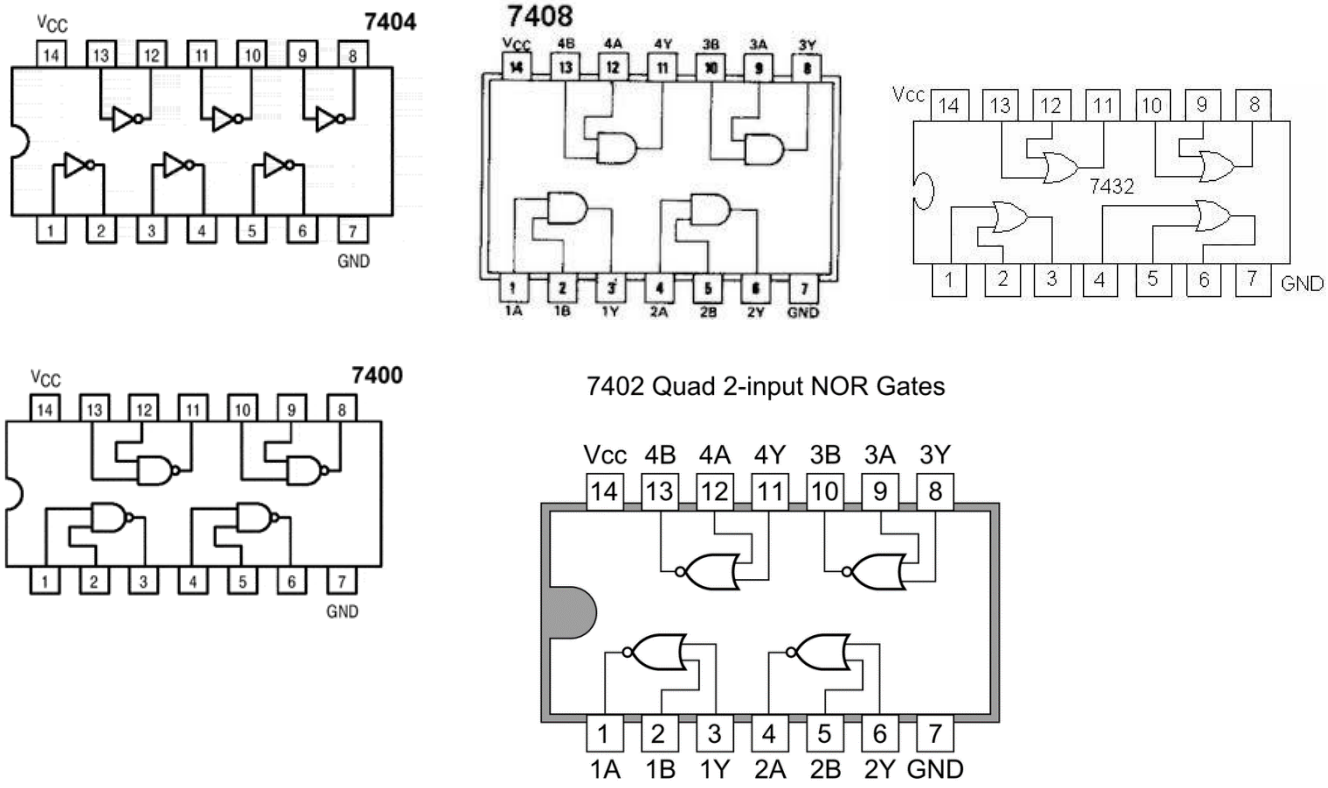
Competency Level 4.3: Designs simple digital circuits using logic gates

Learning outcomes:

- Identifies situation to apply logic circuits in day to day life.
- Design logic expressions and truth table for identified applications
- Designs digital circuits.

Content:

- Truth tables and logic expressions for their designs (up to three inputs)
- Digital circuit design.



Above figure Illustrates the pin connections on three commercially available integrated circuits that implement logic gates. Pins 7 and 14 supply power (zero volts and five volts) to run the circuit.

Design simple logic circuits

E.g. 01 Draw a logic circuit diagram that identifies four-bit prime number.

i. Draw the truth table

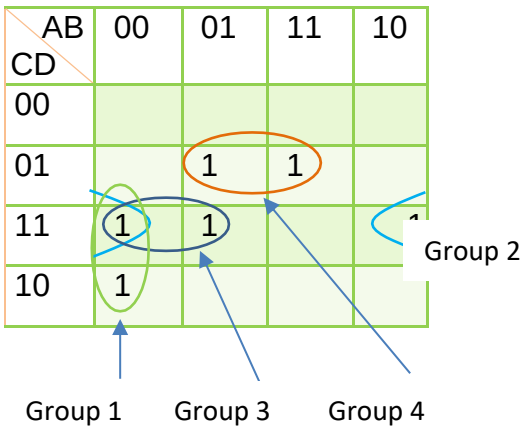
A= First bit, B- Second bit, C- Third bit, D- Fourth bit, F- Prime Number (Output)

	A	B	C	D	F	Minterm
0	0	0	0	0	0	
1	0	0	0	1	0	
2	0	0	1	0	1	A’B’CD’
3	0	0	1	1	1	A’B’CD
4	0	1	0	0	0	
5	0	1	0	1	1	A’BC’D
6	0	1	1	0	0	
7	0	1	1	1	1	A’BCD
8	1	0	0	0	0	
9	1	0	0	1	0	
10	1	0	1	0	0	
11	1	0	1	1	1	AB’CD
12	1	1	0	0	0	
13	1	1	0	1	1	ABC’D
14	1	1	1	0	0	
15	1	1	1	1	0	

ii. Obtain the SOP

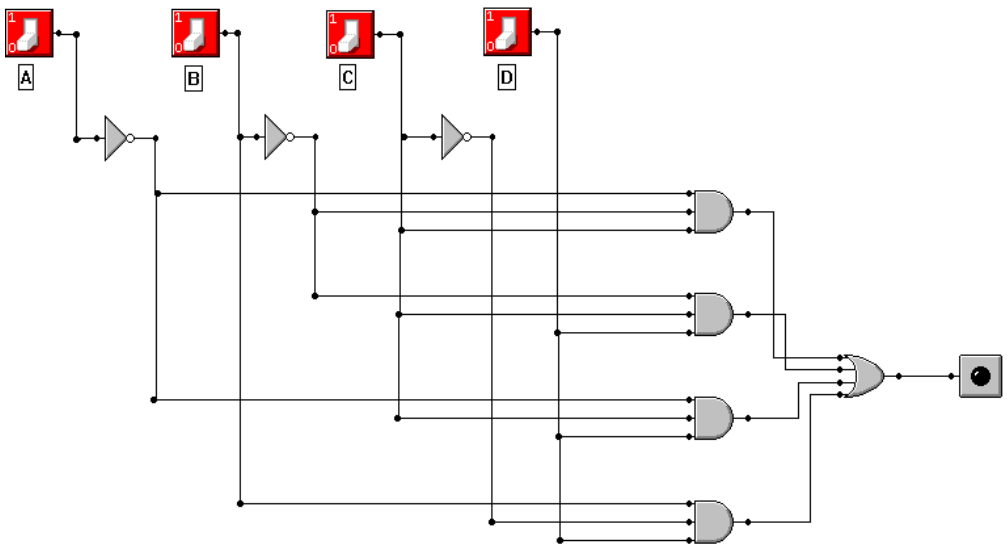
F= A’B’CD’ + A’B’CD + A’BC’D + A’BCD + AB’CD + ABC’D

Simplify using K-map



A’B’CD A’B’CD’ | A B’CD A’B’CD | A’B’CD A’B CD | A’BC’D A BC’D

iii. Draw Logic circuit for the simplified version

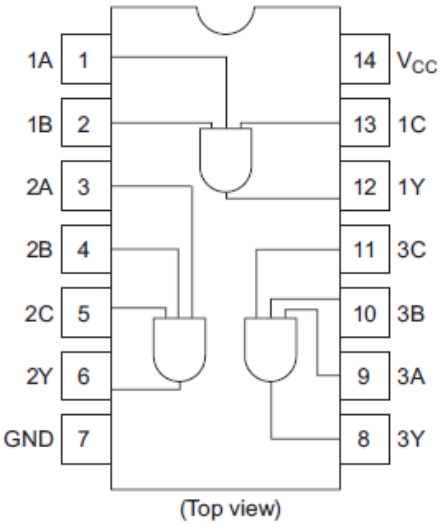


In-order to implement this circuit, following circuitry equipment is required.

• Project board 1 • ON/OFF Switch 5v DC- 6 • Resistors 1K-10 • Project board jumper wire set 1 • LED Large size-4	• DC 5V Power pack-1 • Logic IC HD74HC11-2 (TRIPPLE THREE INPUT AND GATE) • Logic IC CD4069UBC (HEX INVERTER) • Logic IC TC4072BP (DUAL FOUR INPUT OR GATE)

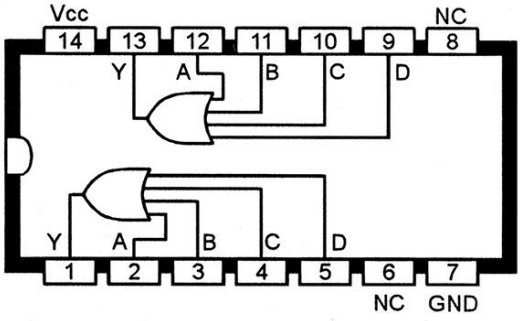
Pin arrangement

HD74HC11

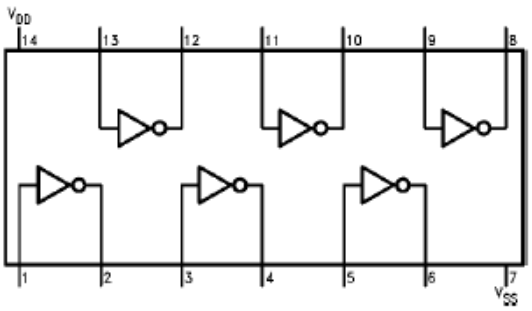


(Top view)

TC4072BP



CD4069UB



E.g. 02

A lamp outside a front door comes on automatically when it is dark **and** someone stands on the doormat outside the front door.

- A pressure sensor (A) under the mat changes from OFF (0) to ON (1) when someone stands on the doormat.
- The light sensor (B) is ON (1) when it is light and OFF (0) when it is dark.
- There is an on/off switch (C) for a user to manually switch off the system. Consider switching off process as Boolean (1) and switching on as Boolean (0).

- Based on the following conditions the lamp is in off state.

    - Any time user manually switches off the system: lamp (0)
    - When it is not dark: lamp (0).

A (pressure sensor)	B (Light sensor)	C (Switch)	X (Lamp)	SOP
0	0	0	0	
0	0	1	0	
0	1	0	0	
0	1	1	0	
1	0	0	1	AB'C'
1	0	1	0	
1	1	0	0	
1	1	1	0	

Prepare a truth table that represents the above scenario.

i. Write the standard Sum of Product (SOP) that represents the above requirement.
X=AB'C'

Example 3:

1. A bank vault has 3 locks with a key for each lock. Key A is owned by the bank manager. Key B is owned by the senior bank teller. Key C is owned by the trainee bank teller. In order to open the vault door at least two people must insert their keys into the assigned locks at the same time. The trainee bank teller) can only open the vault when the bank manager is present in the opening.

    i) Determine the truth table for such a digital locking system
    X= Bank Manager
    Y= Senior Bank teller
    Z= Trainee bank teller

X	Y	Z	Vault (F)	Minterm
0	0	0	0	
0	0	1	0	
0	1	0	0	
0	1	1	0	
1	0	0	0	
1	0	1	1	XY'Z
1	1	0	1	XYZ'
1	1	1	1	XYZ

ii) Design, using Boolean algebra techniques, a minimum AND-OR gate network to realize this locking system.

F= XY'Z+XYZ'+XYZ
= XY'Z + XY (Z' + Z) Distributive Law
= XY'Z + XY (1) Inverse Law
= XY'Z + XY Distributive Law
= X (Y'Z + Y) Distributive Law
= X (Z + Y) Redundancy Law

E.g. 04

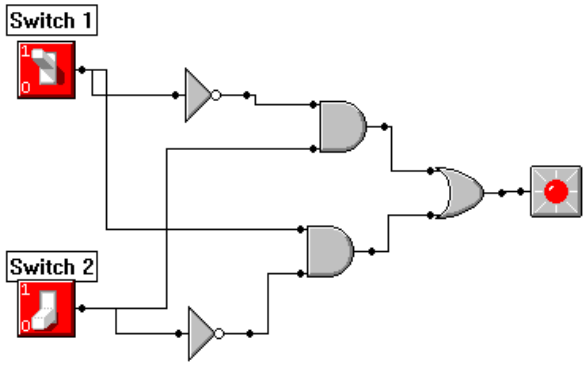
A house has two lights to illuminate the stairs leading from the hall to the upstairs landing. The lights can be switched OFF and ON by either one of two switches, one in the hall and one in the landing. The lights are to be OFF when both switches are either ON or OFF together, and the lights are to be ON when one switch is ON and the other is OFF.

i) Obtain the truth table of the system

A (Switch 1)	B (Switch 2)	F (Bulb)	Minterm
0	0		
0	1	1	A'B
1	0	1	AB'
1	1		

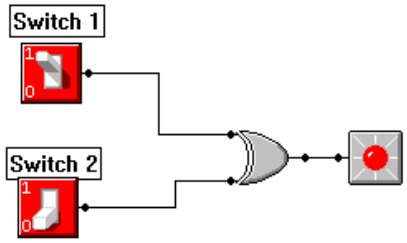
ii) Obtain the sum of products (SOP) Boolean expression for the system.
A'B + AB'

iii) Implement the system using AND, NOT and OR logic gates.



iv) Implement the system using exactly ONE logic gate.

XOR Gate



Competency 4.4: Explores how combinational logic circuits are used in CPU and sequential circuits in physical

Number of periods: 06

Learning Outcomes:

- Identifies the major building blocks of CPU
- Creates truth table and logical expression for half adder circuit
- Creates truth table and logical expression for full adder circuit
- Briefly describes the usage of flip-flops.

Contents:

- Building blocks of CPU
    - Half Adder
    - Full Adder
- Storing bits in digital circuits
    - Feedback loop
    - Flip=flops

Concepts and terms to be highlighted:

- CPU
- Half Adder
- Full Adder
- Storing bits in digital circuits, feedback loop, flip flops

Guidance for lesson plans:

- provide some example of the usage of number systems in computers (colour code etc.)
- Then discuss the Half adder, full adder, storing bits in digital circuits, feedback loop and flip flops to provide the concept about the usage of binary number system in computers

Guidance for assessments and evaluations:

- Divide the students into groups and ask the each group to find the usage of number systems in computer and present the findings.

Quality inputs:

- Computers with some graphic software, Internet facility

Reading Materials

Half Adder

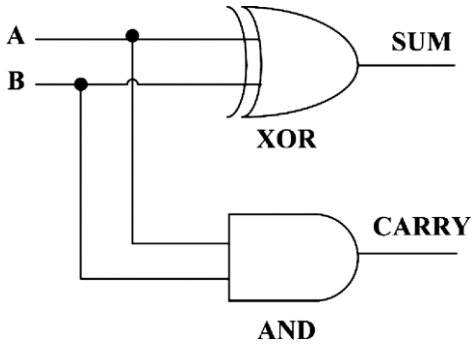
- With the help of half adder, we can design circuits that are capable of performing simple addition with the help of logic gates.
- Let us first take a look at the addition of single bits.
  - 0+0 = 0
  - 0+1 = 1
  - 1+0 = 1
  - 1+1 = 10

These are the least possible single-bit combinations. However, the result for 1+1 is 10. Therefore, the sum result must be re-written as a 2-bit output. Thus, the above equations can be written as

0+0 = 00
0+1 = 01
1+0 = 01
1+1 = 10

Here the output '1'of '10' becomes the carry-out. The result is shown in a truth-table below. 'SUM' is the normal output and 'CARRY' is the carry-out.

INPUTS		OUTPUTS	
A	**B**	**SUM**	**CARRY**
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

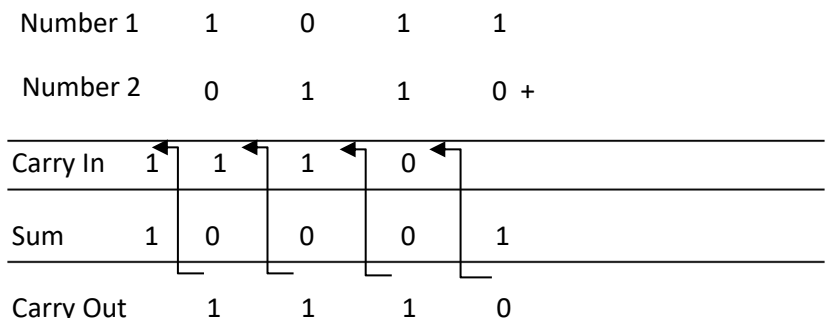


Full Adder

The main difference between a half-adder and a full-adder is that the **full-adder has three inputs and two outputs**. The first two inputs are A and B and the third input is an input carry designated as Carry In. When a full adder logic is designed we will be able to string eight of them together to create a 8- bit adder and cascade the carry bit from one adder to the next.

The carry is designated as Carry Out and the sum is designated as Sum. The truth-table is given below.

Example: Application of half adder and full adder in number addition is shown below. There are two bits additions and three bits addition.



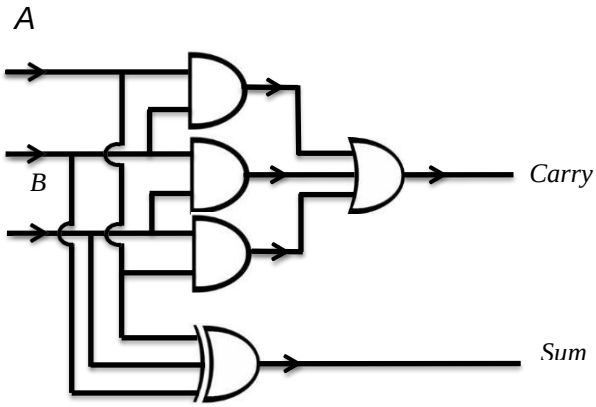
In here when first two bits are added only half adder is required because unavailability of carry in bit. In-order to add rest of the bits, full adder is required because availability of carry in bit. Full adder is a combination of two half adders.

How to represent a full adder from truth table and a logic circuit?

The carry can be obtained by A.B + B.C + A.C. The sum can be obtained by A XOR B XOR C. The truth table is as follows.

1	2	3	4	5	6	7	8	9	10	11
A	B	C	Sum	Carry	A.B	B.C	A.C	A.B+B.C+A.C	A XOR B	A XOR B XOR C
				Carry In				Sum		Carry Out
0	0	0	0	0	0	0	0	0	0	0
0	0	1	1	0	0	0	0	0	0	1
0	1	0	1	0	0	0	0	0	1	1
0	1	1	0	1	0	1	0	1	1	0
1	0	0	1	0	0	0	0	0	1	1
1	0	1	0	1	0	0	1	1	1	0
1	1	0	0	1	1	0	0	1	0	0
1	1	1	1	1	1	1	1	1	0	1

The above truth table shows output values for all alternative input values. The columns of number 5 and 9 are identical. Then the sum can be taken from the Boolean expression of A.B+B.C+A.C. Similarly, the columns of number 5 and 11 are identical. Therefore, carry out can be taken from A XOR B XOR C. Then the logic circuit for the full adder is as follows.



Full Adder Circuit

Combinational circuits: Output depends only on the input of that time.

Sequential Circuit: Output depends not only on the present inputs but also on the previous inputs and outputs. This type of circuit is required to perform sequence of actions without getting any further inputs. Use for memory storage (SRAM)

Flip Flops

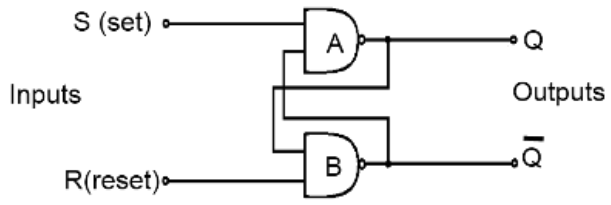
Flip flops are actually an application of logic gates. With the help of Boolean logic, you can create memory with them. Flip flops can also be considered as the most basic idea of a Random-Access Memory. When a certain input value is given to them, they will be remembered.

One form of flip-flop acts exactly like the power switch on a computer: the first time its input becomes *1*, the flip flop turns on the output, and the second time its input becomes *1*, the flip-flop turns off the output. That is, receiving an input of 1 causes the flip-flop to change the output from the current state to the opposite. Like a push-button switch used to control power, a flip-flop does not respond to a continuous input — the input must return to *0* before a value of 1 will cause the flip-flop to change state. Below figure shows a sequence of inputs and the resulting output.

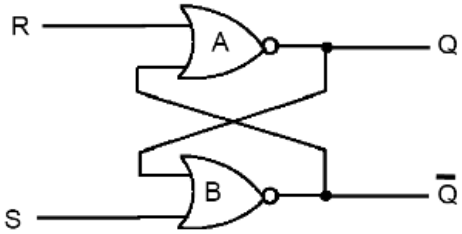
Latch Flip-flop

R-S (Reset Set) flip flop is the simplest flip flop of all and easiest to understand. It is basically a device which has two outputs one output being the inverse or complement of the other, and two inputs. A pulse on one of the inputs to take on a particular logical state. The outputs will then remain in this state until a similar pulse is applied to the other input. The two inputs are called the Set and Reset input (sometimes called the preset and clear inputs)

Such flip flop can be made simply by cross coupling two inverting gates either NAND or NOR gate could be used Figure 1(a) shows on RS flip flop using NAND gate and Figure (b)



(a) Latch Flip Flop NAND Gate



(b) RS Latch Flip Flop NOR Gate

Competency 5: Uses operating systems to manage the functionality of computers.

Competency Level 5.1: Defines the term computer operating system (OS) and investigates its need in computer systems.

Time: 04 periods

Learning Outcomes:

- Defines the computer operating system
- Briefly describes the evolution of OS
- Identifies the main functions and the abstractions (directories, files and data) provided by the operating system to the user
- Describes how the operating system manages the resources of a computer.
- Classifies the operating systems based on their users and tasks

Contents:

- Introduction to computer Operating System
- Evaluation of OS
- Main functions of an operating system:
    - providing interfaces
    - Process management
    - Resource management
    - Security and protection
- Classification of operating systems
    - Single user – single task
    - Single user – multi task
    - Multi user – multi task
    - Multi-threading
    - Real time
    - Time sharing systems

Concepts and terms to be highlighted:

- Definition of operating system
- Main functions of operating system
- Classification of operating systems.

Guidance for lesson plans:

- Discussion on the need of computer operating systems.
- Discussion on the main functionality of computer operating systems
- Discuss and demonstrate the types of operating systems

Guidance for assessments and evaluations:

- Divide the class into groups and provide the topics (need of OS, main functions of OS, Types of OS etc.) to each group ask them to prepare presentation and present it.

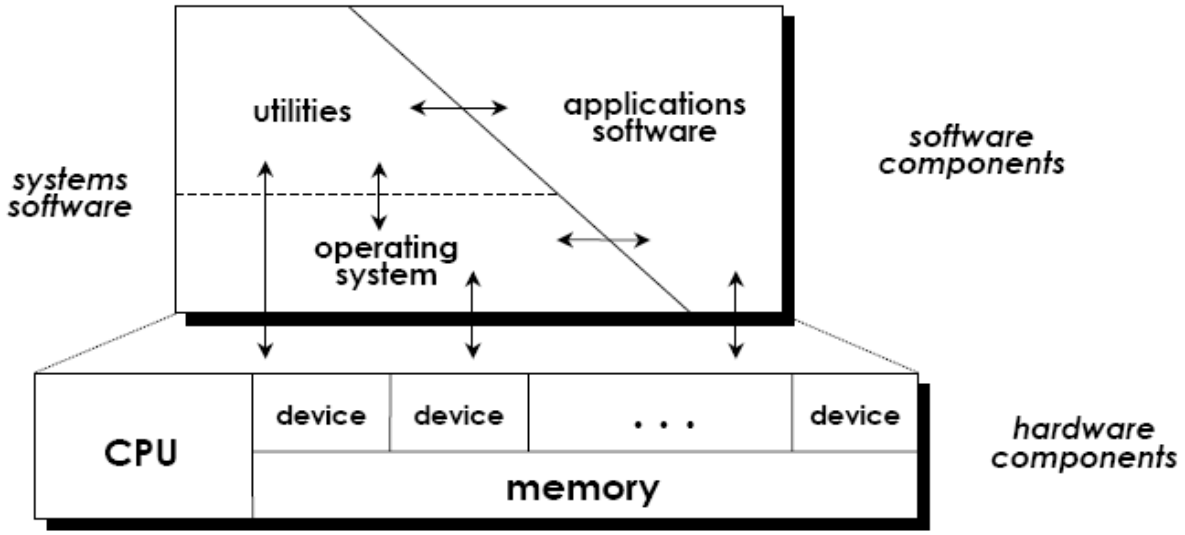
Quality inputs:

Computers, OS CDs or DVDs, Internet facility

Reading Material

Introduction to Computer operating system

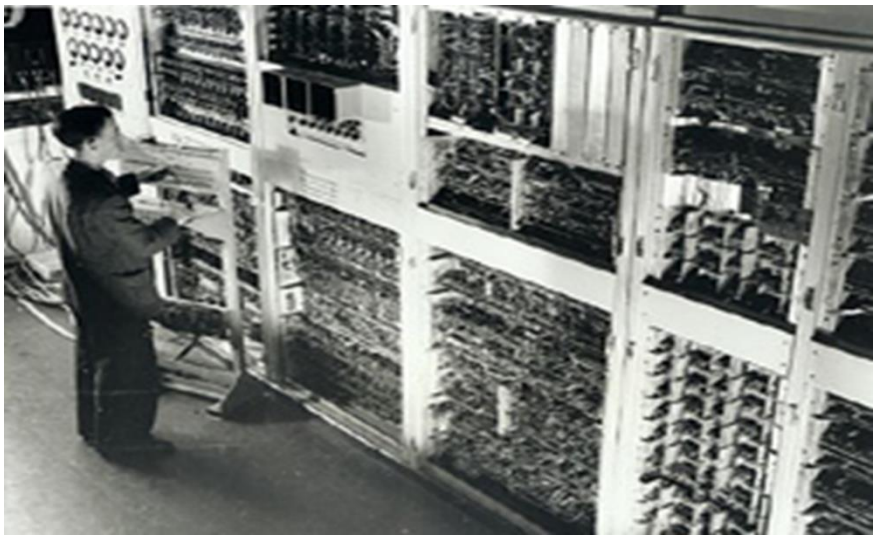
An operating system (OS) is a system software that provides a virtual machine(hides hardware details, provides an interface to applications and end users), manages computing resources (keeps track of resource usage, grants/revokes permissions for resources), and executes application software.



Evolution of Operating System

1) **No OS (late 1940s – mid 1950s)**

- Serial Processing – processed programs one after another
- Single user system.
- Programmer/User directly interacted with the hardware.
- No operating system.
- Programs loaded directly into computer
- Machines run from a console with display lights, toggle switches.

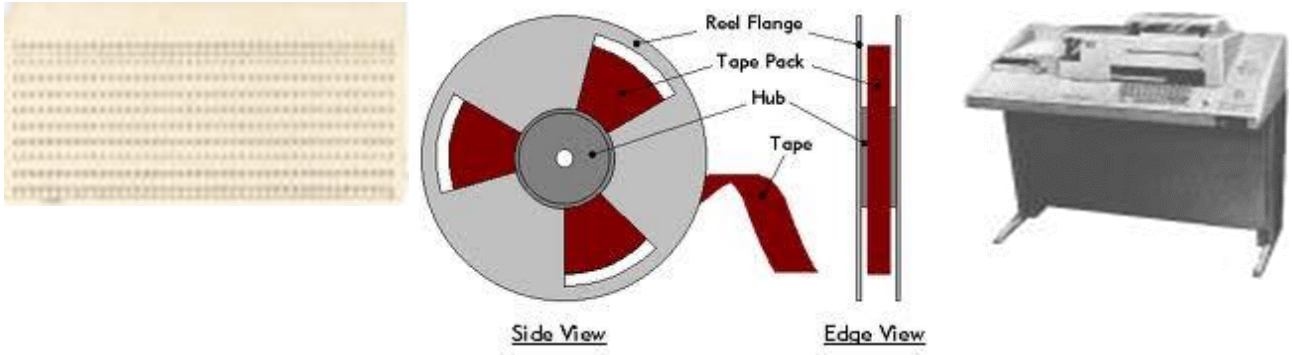


Features:

- Manual Program Scheduling
- uniprogramming
- processor sat idle when loading programs and doing I/O

2) Simple Batch System

- Introduced to maximize the processor utilization
- Programs recorded in a magnetic tape with an inexpensive machine
- OS loaded and executed programs in tape one at a time
- When the current program ended execution, its output was written to another tape and OS loaded next program
- At the end of entire batch of programs, output tape was printed with an inexpensive machine



(Source: https://www.clir.org/pubs/reports/pub54/2what_wrong.html)

Features

- No direct access to hardware
- Uniprogramming
- High response time
- Processor sat idle during I/O

3) **Multi-Programmed batch Systems**

- Central theme of modern OS
- Introduce in 3rd generation to minimize the processor idle time during I/O
- Memory is partitioned to hold multiple programs
- When current program waiting for I/O, OS switches processor to execute another program in memory

- If memory is large enough to hold more programs, processor could keep 100% busy

4) **Time Sharing System**

- Introduced to minimize the response time and maximize the user interaction during program execution
- Uses context switching
- Enables to share the processor time among multiple programs
- Rapidly switching among programs, credits illusion of concurrent execution of multiple programs

Following are some of important functions of an operating System.

- Process Management
- Resource Management ,(Memory, I/O device, Storage)
- User Interfacing
- Security Protection

Different types of Operating Systems
(Based on the users and Tasks)

Different types of Operating Systems(Based on the users)

- Single user - Facilitates single user to use the system at a time
- Multi User-Facilitates multiple users to use the system at a time

Different types of Operating Systems(Based on Number of tasks)

- Single Task – Executes only one program at atime
- Multi Task - Executes multiple programs at atime

Different types of Operating Systems

- Single user-single task– A single task is performed by one user at a time.

- Single user-Multi task- Several programs are run at the same time by a single user.

- Multi user-Multi task – A multi-user operating system has been designed for more than one user to access the computer at the same or different time.

- Multi-threading –
  A thread is also called a sub process. Threads provide a way to improve application performance through the parallel execution of sub process.
- Real Time – OS is designed to run applications with very precise timing and with a high degree of reliability.
  - The main objective of real-time operating systems is their quick and predictable response to events.
  - These types of OS are needed in situations where downtime is costly or a program delay could cause a safety hazard.
  - Time Sharing Systems–
    - Processor's time is shared among multiple users/applications

Features of Timesharing operating systems are as follows:

- Provides quick response
- Reduces CPU idle time

Competency 5: Uses operating systems to manage the functionality of computers.

Competency Level 5.2: Explores how an operating system manages directories/folders and files in computers.

Time: 06 periods

Learning Outcomes:

- Describes files and directories
- Briefly describes the need of disk formatting
- Identifies the need for file types
- Lists attributes of file and directories
- Describes the structure of the file systems
- Illustrates the organization of files and directories
- Briefly describes the methods used in file security
- Briefly describes how an operating system manages file security
- Briefly explains
    - Contiguous allocation
    - Linked allocation and
    - Indexed allocation
- Describes defragmentation and explains how it occurs

Contents:

- File types
    - Need for file types (.exe, .jpg .txt, etc.)
- Directory and file organization
    - File hierarchy
    - File systems – FAT etc.
- File security
    - Passwords and access privileges
- File storage management
    - Storage allocation
        - Contiguous allocation
        - Linked allocation
        - Indexed allocation
- Defragmentation
- Maintenance of secondary storage
    - Need and outcome of disk formatting

Concepts and terms to be highlighted:

- Different file types with their extension
- File storage management and storage allocations
- Needs for maintenance of secondary storage

Guidance for lesson plans:

- Discuss on files and directories
- Group the students and provide them various types of files and ask the group them and present their findings
- Then discuss the file types
- Discuss the file storage management and file storage allocation
- Discuss the need for maintenance of secondary storage

Guidance for assessments and evaluations:

- Divide the class into groups and provide assignments, to collect various files and group them according to the types and ask them develop presentation and present them

Quality inputs:

- Computers, Internet facility, a collection of different types of files

Reading Material

Files

A file is a *named* collection of related information, usually a sequence of bytes

A file can be viewed in two different ways.

• *Logical (programmer's) view*: how the users see the file.
  - Liners collection of records.
  - Image File – cells(pixels) of intensity values
  - Linear sequence of bytes.
• *Physical (operating system) view*: how the file is stored on secondary storage.
  - Many possibilities, not necessarily contiguous

File Attributes

Each file has an associated collection of information(*attributes*)

- file name
- type (e.g., source, data, executable)
- Owner
- location(s) on the secondary storage.
- organization (e.g. sequential, indexed, random)
- access permissions – who is permitted to read/write/delete data in the file.
- time and date of creation, modification, last access
- file size

File Types

One of the possible implementation techniques of file type is to include the type as an extension to the file name.

File can be classified into various types based on the content.

- Executable(.exe)
- Text(.txt, .docx, …etc)
- Image(.bmp, .png, .jpeg, …etc)
- Video (.vob, .flv, .swf,…etc)
- Audio (.wav, .mp3,…etc)
- Compressed(.rar, .zip,…etc)

Directory and file organization

Directories are continues used to organize files logically.

File Structure

A File Structure is a format that the operating system can understand.

- A file has a certain defined structure according to its type.
- A text file is a sequence of characters organized into lines.
- An object file is a sequence of bytes organized into blocks that are understandable by the machine.

File Systems

A file system is used to control how data is stored and retrieved.

FAT (File Allocation Table)

- FAT is the file systems introduced with Microsoft Disk Operating System (MS DOS).
- FAT uses a File Allocation Table (FAT) to keep track of files in the storage devices
- FAT and the root directory reside at a fixed location of the volume so that the system's boot files can be correctly located.
  To protect a volume, two copies of the FAT are kept.

NTFS (**New Technology File System**) is a proprietary file system developed by Microsoft. This is improvement of FAT.

This improvement includes

- The capability to recover from some disk-related errors automatically, which FAT cannot.
- Support with Unicode encoding system
- Improved support for larger hard disks.
- Better security as permissions and encryptions are used to restrict access to specific files to approved users.

File Security

- Passwords
- Access privileges

Authentication

Authentication refers to identifying each user of the system and associating the executing programs with those users. It is the responsibility of the Operating System to create a protection system which ensures that a user who is running a particular program is authentic. Operating Systems generally identifies/ authenticates users using following three ways:

- **Username / Password** - User need to enter a registered username and password with Operating system to login into the system.
- **User attribute - fingerprint/ eye retina pattern/ signature** - User need to pass his/her attribute via designated input device used by operating system to login into the system.

Disk Fragmentation

Fragmentation is the unintentional division of Disk into many small free areas that cannot be used effectively due to scattered storage of file fragments.

Defragmentation

Defragmentation is a process that locates and eliminates file fragments by rearranging them.

Before Defragmentation After Defragmentation

(Source: https://www.auslogics.com/en/articles/defragmentation/)

File Storage Management

- **Space Allocation**

Files are allocated disk spaces by operating system. Operating systems deploy following three main ways to allocate disk space to files.

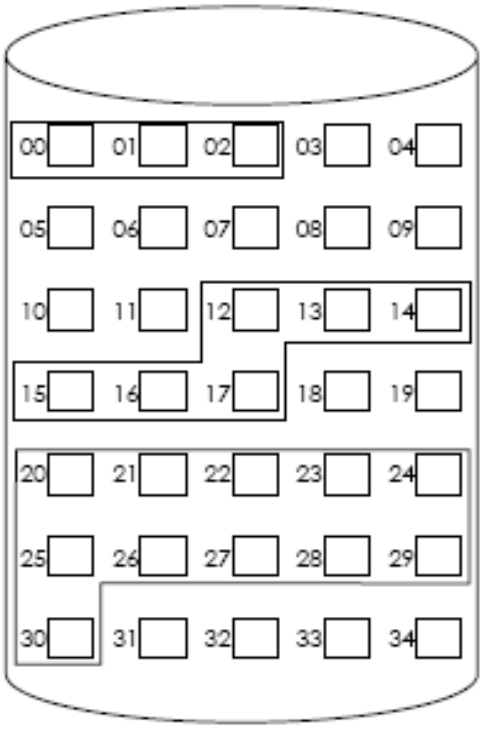
- Contiguous Allocation
- Linked Allocation
- Indexed Allocation

Contiguous Allocation

Allocate disk space as a collection of adjacent/contiguous blocks. This technique needs to keep track of unused disk space.

Features:

- Simple.
- Easy Access.
- File size is not known at the time of creation.
- Extending file size is difficult
- External fragmentation (free unusable space between allocation)



Linked Allocation

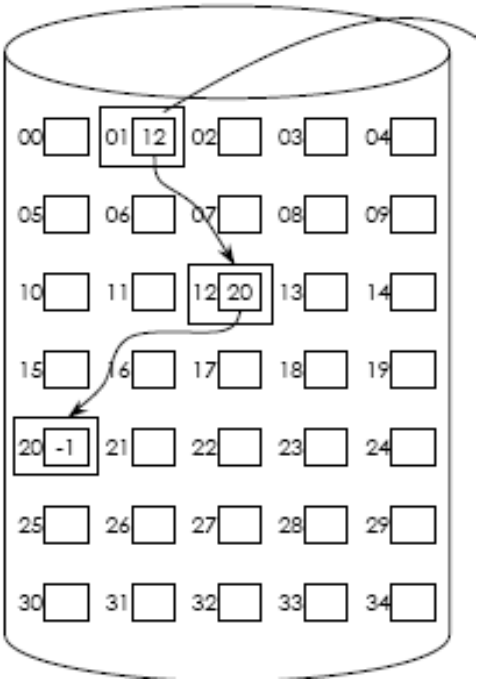
Inside each block a link is maintained to point to where the next block of the file is.

Features:

- No external fragmentation.
- Files can grow easily.
- Many seek are required to access file

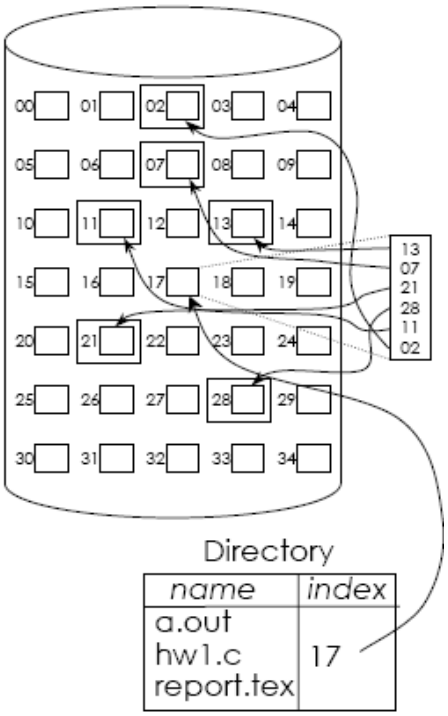
  Example:

  MSDOS FAT file system



Indexed Allocation

Creates a table of pointers(index) at the time of the file creation. This table is modified as new blocks are allocated for the file or removed from the file.
The index table is also saved in a block/s.
Example : UNIX file system



Features

- File ends at nil pointer
- No external fragmentation
- Each block contains pointer to next block
- No compaction, external fragmentation

Maintenance of Secondary storage

Secondary storage is the *non-volatile* repository for both user and system data and programs.

Secondary storage is typically used to store

- Source program
- Executable programs
- Data for the program
- Temporary data

Disk formatting

Formatting is the process of preparing a data storage device for initial use which may also create one or more new file systems.

The first part of the formatting process that performs basic medium preparation is often referred to as "low-level formatting". Partitioning is the common term for the second part of the process, making the data storage device visible to an operating system.

The third part of the process, usually termed "high-level formatting" most often refers to the process of generating a new file system.

1. **Recovery of data from a formatted disk**

As file deletion is done by the operating system, data on a disk are not fully erased during every high-level format. Instead, links to the files are deleted and the area on the disk containing the data is retains until it is overwritten.

Competency 5: Uses operating systems to manage the functionality of computers.

Competency Level 5.3: Explores how an operating system manages processes in computers.

Time: 06 periods

Learning Outcomes:

- Explains processes
- Lists the operating system tasks when a process is created
- Lists the types of processes
- Lists the process states
- Explains process termination
- Distinguishes a process and a program
- Explains process states using the seven state process transition diagrams
- Describes process schedulers and scheduling policies
- Compares long, short and medium term schedulers
- Describes multi programming and its needs
- Describes time sharing systems
- Compares multi programming vs. time sharing systems
- Defines context switch
- Briefly explains turnaround time, response time, throughput time and waiting time
- Briefly explains the process control block and lists its contents

Contents:

- Definition of process
- Interrupts and interrupts handling
- Process management
- Process states
- Process Transitions
- Process control block
- Context switching
- Process schedulers

Concepts and terms to be highlighted:

- Definition of process
- Difference between process and program
- Concept of interrupt and interrupt handling
- Five states of process
- The need and the contents of process control block
- Types of process schedulers

Guidance for lesson plans:

- Discussion on the need of computer operating systems.

- Discussion on the main functionality of computer operating systems
- Discuss and demonstrate the types of operating systems

Guidance for assessments and evaluations:

- Divide the class into groups and provide the topics (need of OS, main functions of OS, Types of OS etc.) to each group ask them to prepare presentation and present it.

Quality inputs:

Computers, OS CDs or DVDs, Internet facility

Reading Material

What is Process?

- Process is a fundamental concept in modern operating systems.
- A process is basically a program in execution.
- Process is not a program. A program may have many processes.

Type of processes

- I/O bound processes
- Processor bound processes

Process requirements

The process must have (at least):

- ID
- Executable code
- Data needed for execution
- Execution context (PC, priorities, waiting for I/O or not)

Process creation

Reasons for process creation:

- New batch job
- User starts a program
- OS creates process to provide a service
- Running program starts another process

Process Termination

- On process termination, OS reclaims all resources assigned to the process.
- Reasons for process termination:
  - Normal termination,
  - Execution time-limit exceeded,
  - A resource requested is unavailable,
  - An execution error
  - A memory access violation,
  - An operating system or parent process request
  - Parent process has terminated.

These and many other events may either terminate the process, or simply return an error indication to the running process. In all cases, the operating system will provide a default action which may or may not be process termination.

Interrupts

- Interrupt is an event that alters the sequence of execution of process.
- Interrupt can occur due to a time expiry an OS service request I/O completion.
- For example when a disk driver has finished transferring the requested data, it generates an interrupt to the OS to inform the OS that the task is over.
- Interrupts occur asynchronously to the ongoing activity of the processor. Thus the times at which interrupts occur are unpredictable.

Interrupt Handling

Generally I/O models are slower than CPU. After each I/O call, CPU has to sit idle until I/O device complete the operation, and so processor saves the status of current process and executes some other process. When I/O operation is over, I/O devices issue an interrupt to CPU then stores the original process and reserves execution.

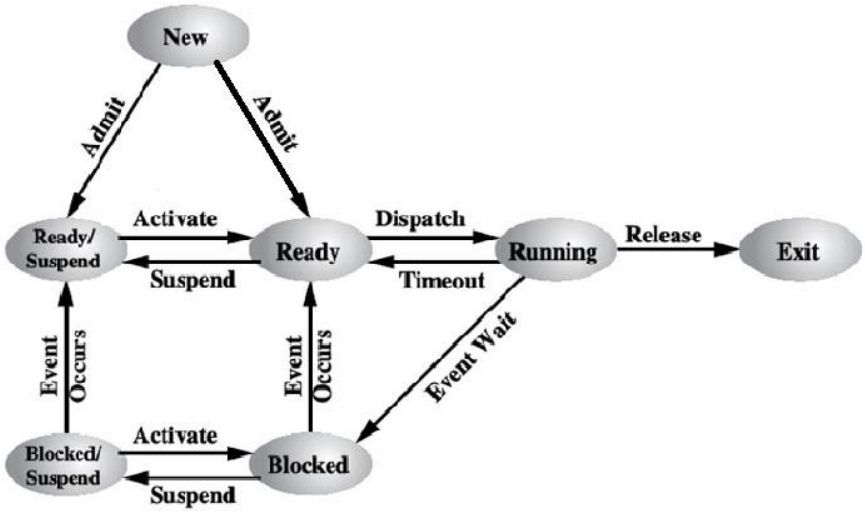
Process Management

In multiprogramming environment, the OS decides which process gets the processor when and for how much time. This function is called process scheduling. An Operating System does the following activities for processor managements:

- Keeps tracks of processor and status of process. The program responsible for this task is known as traffic controller.
- Allocates the processor (CPU) to a process.
- De-allocates processor when a process is no longer required.

Process State

❖ **Seven State Process Transition diagrams**



(Source: http://faculty.simpson.edu/lydia.sinapova/www/cmsc335/cmsc335-01/CH03-Processes.html)

Process Transitions

The operating system's role is to manage the execution of existing and newly created processes by moving them between the two states until they finish.
For simplicity (of both understanding and implementation) modern operating systems support the idle process which is always ready to run, and never terminates.
Newly created processes are created and marked as ready, and are queued to run.
As the single running process terminates or is interrupted, it is marked as
Ready by the operating system, and the next Ready process is commenced
(or continued).
Here the operating system has the role of a dispatcher: dispatching work for the processor according to some defined policy addressing fairness, priority, apparent "interactivity'"

Process Control Block (PCB)
A Process Control Block is a data structure maintained by the Operating System for every process. The PCB is identified by an integer process ID (PID). A PCB keeps all the information needed to keep track of a process as listed below in the table:

NO	Information & Description
1	**Process State** The current state of the process i.e., whether it is ready, running, waiting, or whatever.
2	**Process ID** Unique identification for each of the process in the operating system.
3	**Program Counter** Program Counter is a pointer to the address of the next instruction to be executed for this process.
4	**CPU registers** Various CPU registers where process need to be stored for execution for running state.
5	**Memory management information** This includes the information of page table, memory limits, Segment table depending on memory used by the operating system.
6	**IO status information** This includes a list of I/O devices allocated to the process.

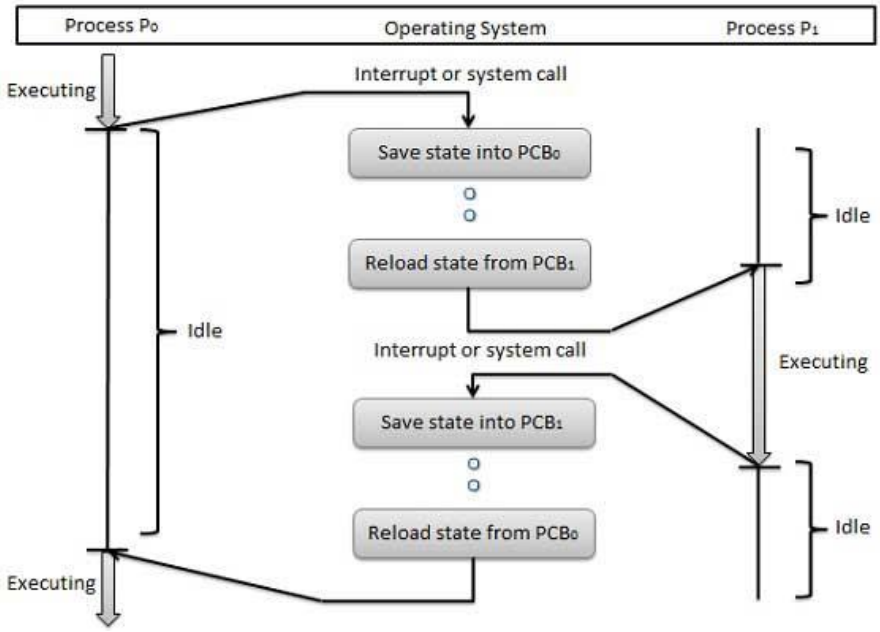
The architecture of a PCB is completely dependent on Operating System and may contain different information in different operating systems.
Here is a simplified diagram of a PCB:

Process ID
State
Pointer
Priority
Program Counter
CPU Register
I/O Information
Accounting Information
etc

The PCB is maintained for a process throughout its lifetime, and is deleted once the process terminates.
Generally I/O models are slower than CPU. After each I/O call, CPU has to sit idle until I/O device complete the operation, and so processor saves the status of current process and executes some other process. When I/O operation is over, I/O devices issue an interrupt to CPU then stores the original process and reserves execution.

Context Switching

- A context switch is the mechanism to store and restore the state or context of a CPU in Process Control block so that a process execution can be resumed from the same point at a later time.
- Using this technique a context switcher enables multiple processes to share a single CPU. Context switching is an essential part of a multitasking operating system features.
- When the scheduler switches the CPU from executing one process to execute another, the context switcher saves the content of all processor registers for the process being removed from the CPU, in its process control block.
- Context switch time is pure overhead.
- Context switching can significantly affect performance as modern computers have a lot of general and status registers to be saved.



Types of Scheduling

- Long-term scheduling (Job scheduling): It determines which programs are admitted to the system for processing. Job scheduler selects processes from the queue and loads them into memory for execution. Process loads into the memory for CPU scheduling.
- Medium-term scheduling: Medium term scheduling is in charge of swapping processes between the main memory and the secondary storage.
- Short-term scheduling (low-level scheduling): Determines which ready process will be assigned the CPU when it next becomes available.

Long-term scheduling (Job scheduling)

- Determines which processes are admitted to the system for processing
- Controls the degree of multiprogramming
    - If more processes are admitted
        - better CPU usage
        - less likely that all processes will be blocked
- The long term scheduler may attempt to keep a mix of processor-bound and I/O-bound processes.

Medium-Term Scheduling

- Swapping decisions based on the need to manage multiprogramming
- Done by memory management software

Short-Term Scheduling

- Determines which process is going to execute next (also called CPU scheduling)
- The short term scheduler is known as the dispatcher
    - Dispatching the CPU to the process

Scheduler Comparison

Long Term Scheduler	Short Term Scheduler	Medium Term Scheduler
Job Scheduler	CPU scheduler	Processes swapping scheduler
Selects processes from a pool and loads them into the memory for execution	Selects those processes which are ready to execute for dispatching	Swapped out/Re-introduces the processes into memory and execution can be continued.
Controls the degree of multiprogramming	Provides lesser control over the degree of multiprogramming	Controls the degree of multiprogramming
Speed is lesser than short term scheduler	Speed is fastest among other two	Speed is in between (short and long term schedulers)

Process Schedulers

Assigning the processor to the processes.

- Turnaround time : Time required for a particular process to complete, from submission time to completion.
- Response time : The time taken in an interactive program from the issuance of a command to the ***commence*** of a response to that command.
- Throughput : Number of processes completed per unit time. May range from 10 / second to 1 / hour depending on the specific processes.
- Waiting time : How much time a process spends in the ready queue waiting its turn to get on the CPU.

Scheduling Policies

- Non-preemptive
  - Once a process is in the running state, it will continue until it terminates or blocks itself for I/O.
- Preemptive
  - Currently running process may be interrupted and moved to the Ready state by the OS.
  - Allows for better service since any one process cannot monopolize the processor for very long

Competency 5: Uses operating systems to manage the functionality of computers.

Competency Level 5.4: Explores how an operating system manages the resources

Time: 06 periods

Learning Outcomes:

- Briefly explains the need of memory management and memory management unit (MMU).
- Briefly explains the virtual memory.
- Briefly explains paging and mapping
- Briefly describes how an OS manages Input and output devices
- Briefly describes device drivers
- Briefly describes the need of device drivers
- Briefly describes spooling
- Installs appropriate device drivers when connecting a peripheral

Contents:

- Memory management
    - Memory management unit(MMU)
    - Physical Memory
    - Virtual memory
- Input and output device management
    - Device drivers
    - Spooling

Reading Material

Memory Management

Memory management is the functionality of an operating system which handles or manages primary memory and moves processes back and forth between main memory and disk during execution.

Memory management keeps track of each and every memory location, regardless of either it is allocated to some process or it is free. It checks how much memory is to be allocated to processes. It decides which process will get memory at what time. It tracks whenever some memory gets freed or unallocated and correspondingly it updates the status.

An Operating System does the following activities for memory management:

- Keeps tracks of primary memory, i.e., what part of it are in use by whom, what part are not in use.

- In multiprogramming, the OS decides which process will get memory when andhow much.

- Allocates the memory when a process requests it to do so.
- De-allocates the memory when a process no longer needs it or has been terminated.

Memory Management Unit (MMU)

Hardware device that maps virtual to physical address

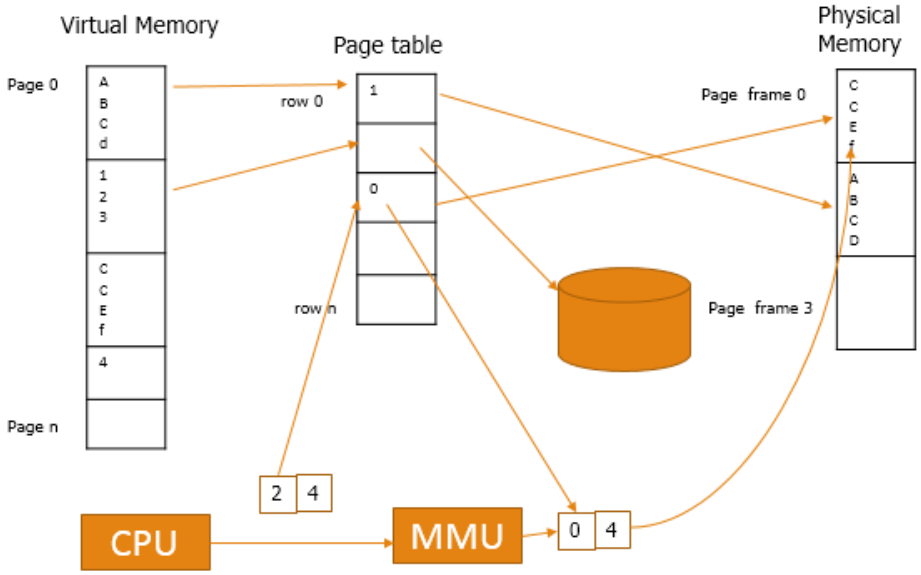
■In MMU scheme, the value in the relocation register is added to every address generated by a user process at the time it is sent to memory.
■The user program deals with *logical* addresses; it never sees the *Real* physical addresses.

MMU uses the following mechanism to convert virtual address to physical address.

- ❖ The value in the base register is added to every address generated by a user process, which is treated as offset at the time it is sent to memory. For example, if the base register value is 10000, then an attempt by the user to use address location 100 will be dynamically reallocated to location 10100.
- ❖ The user program deals with virtual addresses; it never sees the real physical addresses.

Paging

- ❖ Logical address space of a process can be non-contiguous; process is allocated physical memory whenever the latter is available
- ❖ Divide physical memory into fixed-sized blocks called **frames** (size is power of 2, between 512 bytes and 8192 bytes)
- ❖ Divide logical memory into blocks of same size called **pages**.
- ❖ Keep track of all free frames
- ❖ To run a program of size *n* pages, need to find *n* free frames and load program"
- ❖ Set up a page table to translate logical to physical addresses"
- ❖ Internal fragmentation"

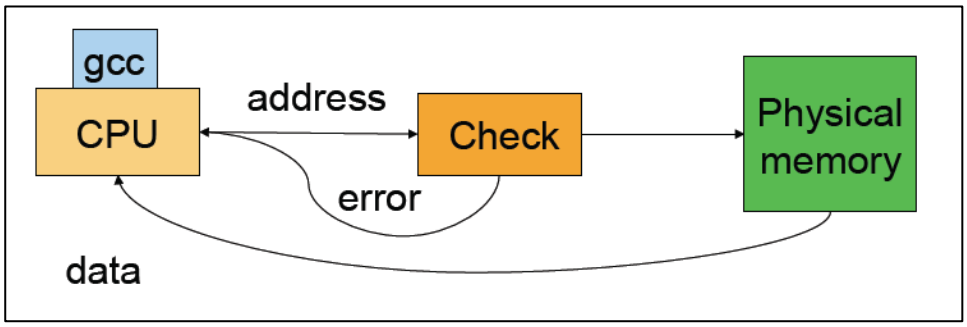


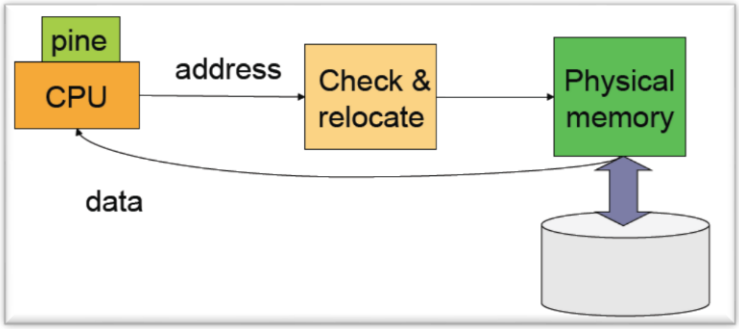
Mapping
The operating system takes care of mapping the logical addresses to physical addresses at the time of memory allocation to the program.

The runtime mapping from virtual to physical address is done by the memory management unit (MMU) which is a hardware device.

Virtual memory

- Is it necessary to load an entire program to the memory for execution?
- If the size of the program is larger than the available memory how can it be execute?





Virtual memory is partitioned in to equal size pages.
Main memory is also partitions into equal size page frames.
Size of a page = size of a page frame
Programs are also partitioned into pages at the time of loading.

- Process runs on a *virtual machine* as defined by the underlying hardware.
- Focus is on Hardware support for a *virtual address space*
    - virtual addresses independent of physical memory
- Key hardware component is the Memory Management Unit (*MMU*)
        - *address translation:* virtual to physical memory
        - ensures virtual address space protection

Virtual memory serves two purposes.
First, it allows us to extend the use of physical memory by using disk.
Second, it allows us to have memory protection, because each virtual address is translated to a physical address.

Virtual memory – Goals

- Allow applications *larger than physical memory to execute*.
- Run *partially loaded* programs – Entire program need not to be in memory all the time.
- *Degree of Multiprogramming*: Many programs simultaneously reside in memory.
- *Application Portability*:
    - Applications should not have to manage memory resources
    - Program should not depend on memory architecture.
- Permit *sharing* of memory segments or regions.
    - For example, read-only code segments should be shared between program instances.

Input and output Device Management

❖ **Device driver**

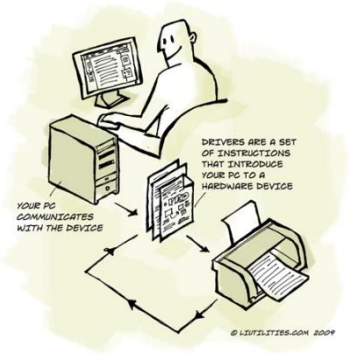
Device driver is software.

The computer communicates with peripheral devices through device drivers.

A driver provides a software interface to hardware devices, enabling operating systems and other computer programs to access hardware functions without knowing the precise hardware details.

Device drivers depends on both the hardware and the operating system loaded in to the computer

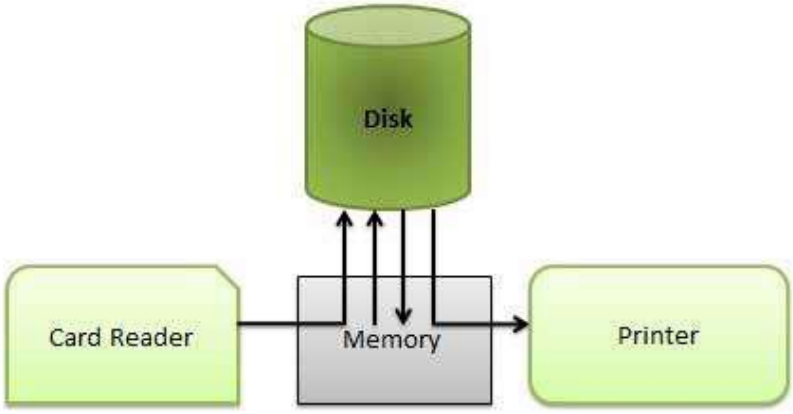
❖ **Spooling**



Spooling is an acronym for simultaneous peripheral operations on line. Spooling refers to putting data of various I/O jobs in a buffer. This buffer is a special area in memory or hard disk which is accessible to I/O devices.
An operating system does the following activities related to distributed environment:

- Handles I/O device data spooling as devices have different data access rates.
- Maintains the spooling buffer which provides a waiting station where data can rest while the slower device catches up.

- Maintains parallel computation because of spooling process as a computer can perform I/O in parallel fashion. It becomes possible to have the computer read data from a tape, write data to disk and to write out to a tape printer while it is doing its computing task.



(Source: https://www.tutorialspoint.com/operating_system/os_quick_guide.htm)

Advantages

- The spooling operation uses a disk as a very large buffer.
- Spooling is capable of overlapping I/O operation for one job with processor operations for another job.

Competency 6:

Explores the data communication and computer networking technologies to share information effectively

Competency Level 6.1 -Explores signals and their properties:
No of periods: 03
Learning Outcomes:

- Graphically represents digital and analog signals and their properties
- Solves problems related to the relationship between signal properties

Contents:

- Signal Type
  - Digital
  - Analog
- Properties
  - Amplitude
  - Frequency
  - Wave length
  - Propagation speed in a media

Reading Material

Introduction to data communication

Data communication is the process of transmitting data between two or more communicating devices over some transmission media. Establishing such connections between computing devices is called computer networking.

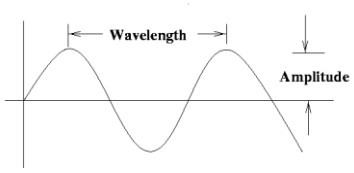
A Communication Model

Source (Sender) - Generates and prepares data to be transmitted
Transmission System - Responsible for transmitting data towards destination
Destination (Receiver) - Receives data from the transmission system and hands over it to the application

Computer Network: A computer network consists of two or more computers that are linked together using a communication medium in order to share resources.

Signals: A signal is an electronic voltage or current, which varies with time. It is used to transfer data from one end to another.

Analog signal: Analog signals are in continuous wave form in nature and represented by continuous electromagnetic waves. Examples of such signals are sound, light and temperature etc.



An analog signal

The Digital signal

Digital signal: Digital stands for discrete values and hence it means that they use specific values to represent any information. In digital signal, only two values are used to represent something i-e: 1 and 0 (binary values).

Properties of signals

Amplitude : The height of the wave measured in meters
Frequency : The number of complete waves that pass a point in one Second, Measured in Hertz (Hz)
Wavelength : The distance between adjacent crests, measured in meters
Phase : phase is a position of a point in time (instant) on a waveform cycle.

- Propagation speed in a media

The **speed** at which a wave propagates through a given **medium** .The propagation speed also varies from medium to medium depending on the properties of the medium.

Competency Level 6.2 – Explores signal transmission media

No of periods: 03

Learning Outcomes:

Describes how latency, bandwidth, noise, attenuation, and distortion affect signal transmission
Describes how latency, bandwidth, noise, attenuation, and distortion affect signal transmission

Contents:

Wires – Guided media (Twisted pair, coaxial cable, Fiber optics etc.)

- Free space – Unguided media
- Properties
  - Latency
  - Bandwidth
  - Noise
  - Attenuation
  - Distortion
- Simple topology: point-to-point connection

Reading Material

- Wires – A wire is the physical medium used to transfer data from one network device to another. Wires are often called guided media because they guide the data transfer data from one point to another without altering the frequencies, data impairment are therefore reduced. Examples of guided media include Twisted pair (UTP and STP), Coaxial Cables, Fiber Optic Cables etc.
- Free space – (wireless transmission or unguided media): signals are spread in to the atmosphere (air), data can spread to any direction. Examples for wireless communication include radio transmission, satellite transmission etc.

Signal Properties

- Latency: Network Latency is an expression of how much time it takes for a unit of data to travel from one point to another. Latency is usually measured in milliseconds.
- Bandwidth: Bandwidth is a range of frequencies and measured in Hertz.
- Noise: Noise is a received signal that makes no sense.
- Attenuation: attenuation is the reduction of the signal energy as it travels through the given medium.
- Distortion: Distortion is alteration (distort) of properties of a transferred signal caused by the capacitance and inductance of the communication medium.
- Simple topology: point-to-point connection: A Point-to-point topology connects two networking devices such as computers, switches, routers, or servers connected back to back using a single piece of cable.

Competency Level 6.3

No of periods: 04

- **Learning Outcomes:**
- Graphically represents encoding of digital data using two voltage levels as well as Manchester encoding
- Describes the possibility of using the changes in frequency and phase as signal elements
- Explains the need for synchronization and describes the problems that arise when the transmitter and the receiver are not synchronized
- Describes how the parity bit enables detecting a bit error

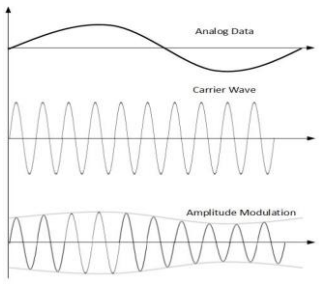
Contents:

- Agreeing on signal elements to represent data (a protocol)
    - Two simple elements – two voltage levels (amplitudes)
    - Other possibilities (briefly)
        - Frequency
        - Phase
- Changing speed of signal elements.
- Need for synchronization
    - Timing/Clocks
    - ❖ Manchester encoding
- Handling errors
    - ❖ Example: Parity

Reading Material

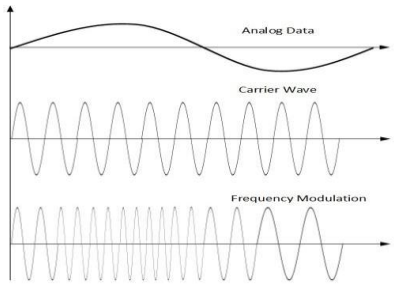
- Modulations: Modulation is the technique used to send information by modifying the basic characteristics such as frequency, amplitude and phase, of an electromagnetic signal (modulating signal) by attaching it to a higher frequency signal (carrier signal), producing a modulated signal. The most commonly used method is the Pulse Code Modulation (PCM).

- Amplitude Modulation (AM)



Amplitude of carrier signal varies according to the amplitude of modulating signal. The frequency or phase of the carrier signal remains unchanged.

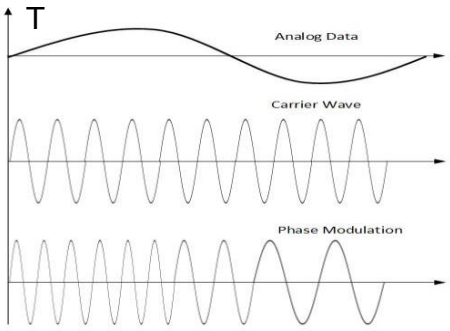
- Frequency Modulation (FM)



The carrier signal frequency changes according to the frequency of the Modulating signal.

- Phase Modulation (PM)

  The phase of a carrier signal is modulated in order to reflect the changes in voltage (amplitude) of an analog data signal



- **Digital-to-Analog Conversion**

If the modulating signal is a digital signal, then three modulation schemes can be used:

- Amplitude Shift Keying (ASK)

  In this conversion technique, the amplitude of an analog carrier signal is modified to reflect binary data. When binary data represents digit 1, the amplitude is held at 1, otherwise it is set to 0. Both frequency and phase remain same as in the original carrier signal

- Frequency Shift Keying (FSK)

In this conversion technique, the frequency of the analog carrier signal is modified to reflect
binary data.

- Phase Shift Keying (PSK)

  In this conversion scheme, the phase of the original carrier signal is altered to reflect the binary data.

  - Synchronization: synchronization is used to ensure that the data streams are received and transmitted correctly between two devices. Usually a clock signal is transmitted in sequence with a data stream to maintain proper signal timing.

  -

Data	Syn	Data	Syn	Data	Syn

- Signal Encoding Schemes:
  - **Non-return to Zero Level (NRZ-L):** is an encoding scheme in which two different voltages for 0 and 1 bits are used to represent data and remain constant during a bit interval.
  - **Non-return to Zero Inverted (NRZ-I**): in this encoding scheme, in which a “1" is represented by a transition of the physical level, while a "0" has no transition.
  - **Manchester encoding:** in Manchester encoding voltage changes from low to high
    or high to low in the middle of the signal.

- Error Control: During data transmission, sometimes data bits may get flipped due to various reasons. In such situations the data bit received is in error. **Error detection** is the process of identifying that the data bit has been altered during transmission. **Error correction** and recovery mechanisms are used to correct the data bits received in error and to recover the actual data bits.
- **Parity Check:** is one simple error detection mechanism where an extra bit of data is added and sent along with the original data bits to make number of 1s in the data as either even in the case of even parity, or odd in the case of odd parity

Competency Level 6.4: Explores the use of Public Switched Telephone Network (PSTN) to connect two remote devices

No of periods: 04

Learning Outcomes:

- Describes a PSTN as an analog voice carrying line
- Describes how modems modulate analog signals so that they can be sent along a PSTN line
- Draws a schematic diagram depicting two computers connected using modems via a PSTN line

Contents:

- Public Switched Telephone network
- Providing a circuit between two points that can carry analog voice
- Modulation, Demodulation and Modems
- Encoding data using analog signal elements
- Connecting two devices using Modems

Reading Material

- Public Switched Telephone network (PSTN)
    - PSTN – Dial Up Connections: Requires a modem and a phone line to dial into a service provider's node, in order to get the connection
- Modulation, Demodulation and Modems: Modems are the devices used to modulate the digital signal in to analog signal (called modulation) and then send the modulated signal over the telephone lines. At the receiver, the modems are then used again to convert the analog signal to digital signal (Demodulation) therefore the receiving device can receive the data correctly.
- Different modulation schemes are used to modulate data and Pulse Code Modulation (PCM) is one method in which the samples of an analog signal are taken (called a pulse amplitude modulated signal) and then are shown that the original signal can be constructed at the receive end using these samples.

Competency Level 6.5

No of periods: 03

Learning Outcomes:

- Public Switched Telephone network
    - Providing a circuit between two points that can carry analog voice
- Modulation, Demodulation and Modems
    - Encoding data using analog signal elements
- Connecting two devices using Modems
    - Demonstrate the simplicity of a Bus
    - Draws diagrams of different topologies
- Describes the use of Hubs and Switches to simplify the wiring of a network and compares/ contrasts their functionalities

Contents:

- All-to-all connections are impractical
- A solution: Bus Topology
    - Simple
    - Problem: Controlling access to the bus (media)
- Other topologies
    - Star
    - Ring
    - Switches

Reading Materials

- **Bus Topology:** A bus topology consists of a main run of cable with terminators at each end. All nodes (file server, workstations, and peripherals) are connected to the linear cable. Access to the shared common communication medium by nodes is a problem when multiple nodes try to access the medium at the same time.
- **Star Topology:** A star topology is designed with each node is (file server, workstations, and peripherals) connected directly to a central network hub or switch.
- **Ring Topology:** in a ring topology each station is directly connected only to two of its neighbors. Messages sent between two stations pass through all of the stations in between (clockwise or counterclockwise).
- **Mesh Topology:** In this type of topology, a host is connected to one or multiple hosts. This topology has hosts in point-to-point connection with every other host or may also have hosts which are in point-to-point connection with few hosts only.
- **Switches and hubs:** Hubs and switches are common network devices that function as a common connection point for network devices that make up a network. A switch receives data in one of its incoming connections and forwards the data only on the outgoing connection which connects to the destination device. A hub receives data in one of its incoming connections and then shall forward the data to all of its outgoing connection. In this way a switch is a more intelligent device than a hub.

Competency Level 6.6- Explores the role of a Media Access Control (MAC) protocol

No of periods: 04

Learning Outcomes:

- Describes the need to uniquely name devices (addresses) so that the sender and the receiver can be identified
- Explains the role of frames as the unit of transmission
- Describes the need of a protocol to ensure orderly access to media with respect to a bus
- Briefly describes the evolution of MAC protocols from ALOHA to Ethernet

Contents:

- Local Area Network (LAN)
- Identifying devices
  - Addresses – MAC addresses
- Frames
- Orderly access to the media
  - Very simple protocol as an example – ALOHA
  - Improvements from ALOHA to Ethernet
- Broadcasting and unicasting messages

Reading Materials

- Local Area Network (LAN): A local area network is a computer network that interconnects computers within a limited area such as a residence, school, laboratory, or a university campus.
- Identifying devices: MAC addresses are unique addresses assigned each network interface of a communicating device. MAC addresses are 48 bits long and are divided in to 6 blocks separated by colons. Each block is 8 bits long and is further divided in to two 4 bit blocks. Each four bit address is converted to hexadecimal number and a typical Mac address would look like 4A:8F:3C:4F:9E:3D. When devices send and receive data over a network, MAC addresses enable the unique identification of the device interface and the correct delivery of the data to the receivers interface.
- Frames: When data is generated at the source to be sent to the receiver over the communication link, at the Data link layer, data are encapsulated in to the Frame, where the data is inserted in to the frame and the MAC addresses of the sending device and the MAC address of the adjacent node are included in the header of the frame. Each frame is made depending on the quality of the link connecting ea pair of devices.
- Protocol: a communication network protocol defines the order and the format of data when the data is exchanged between two networking devices. Many protocols exist in the networking world and medium access control protocols enable the orderly access to a common shared medium of communication. In bus topology, a

common medium is shared by many devices and a medium access control protocol can ensure that the medium is accessed in an orderly manner therefore data collisions are avoided.

- ALOHA, Slotted ALOHA and Ethernet
    - Introduction to ALOHA and then the evolution of the slotted ALOHA
    - Ethernet, allows multiple access a common shared medium with the use of CSMA/CD
- Broadcast and Unicast of messages: Broadcast of messages involves sending a message to larger set of recipients, whereas in unicast data is sent from one computer to another computer by including the unique address of the recipient in the message itself.

Competency Level 6.7- Explores how the multiple networks are interconnected to form the Internet

No of periods: 05

Learning Outcomes:

- Explains the role of a gateway device in inter connecting two LANs
- Explain the need for a uniform, MAC protocol independent addressing scheme and how IP addresses play that role
- Describes the role of subnet masks
- Calculates subnet masks and IP address ranges given a block of IP addresses and network sizes
- Describes the how DHCP is used to dynamically assign IP addresses
- Describes the role of routers in finding a suitable path from the sender to the receiver
- Explains packet switching and best effort delivery in IP networks

Contents:

- A device connected two or more networks – gateway
- Need for globally unique uniform addressing independent of MAC addresses and LAN technology
    - IPv4 addresses
    - Assigning IPs to networks
        - ❖ Sub-netting
        - ❖ Subnet masks
        - ❖ CIDR notation
        - ❖ Private IP addresses
        - ❖ DHCP
        - Scarcity of IPv4 addresses and IPv6 as a solution(an overview)
    - Finding the path to the destination
        - Routing and routers
        - Packet switching
- Best effort delivery

Reading Material

- Gateway - A gateway is a router equipped with all the information which leads to route packets to the destination host.
- IP Address - IP addresses are unique addresses assigned to each device on

  the network. IP Version 4 (IPv4) is 32 bits long and can address up to 4 billion devices. IP Version 6 (IPv6) is 128 bits long and is plenty enough to address a huge number of networkable devices.

- **Dotted decimal notation**
  • For human convenience the IP address is written in dotted decimal notation
- The 32-bit address is divided into 4 groups of 8 bits (an octet or a byte)
- Each octet is written as a decimal number ranging from 0 to 255
- The decimal numbers are separated by periods, or dots

  eg. 11000000 10100000 00100000 0000101
  192.160.32.5

- **Class A networks**
  • first octet starts with bit **0**
  • first octet value ranges from **1 through 126**
  • network mask is **8 bits,** written **/8** or **255.0.0.0**
  • **1.0.0.0 through 126.0.0.0** are **class A** networks with **16777214** hosts each (2^24)

- **Class B networks**
  • first octet starts with binary pattern **10**
  • first octet value range from **128 through 191**
  • network mask is **16 bits,** written **/16** or **255.255.0.0**
  • **128.0.0.0 through 191.255.0.0** are **class B** networks with **65534** hosts each (2^16)

- **Class C networks**
  • first octet starts with binary pattern **110**
  • first octet value range from **192 through 223**
  • network mask is **24 bits,** written **/24** or **255.255.255.0**
  • **192.0.0.0 through 223.255.255.0** are **class C** networks with **254** hosts each (2^8)

- Two additional classes are **class D** and **class E**

- **Assignment of IP addresses**: All hosts in the same network are assigned the same address prefix. Address prefixes are assigned by central authority and are obtained from ISPs. Within a network each host is assigned a unique suffix locally by the network administrator.

- **Sub-netting:** sub-netting is a technique used to overcome the problem of depletion of network address of a 32 bit addressing scheme. In sub-netting each physical network is assigned 32-bit address mask, which is used to identify networks among other networks. All machines in the subnet should have the same subnet mask.
- **Classless Inter Domain Routing (CDIR):** instead of full class A, B or C networks, organizations can be allocated any number of addresses using this scheme. This scheme can help reducing the growth of the router tables.
- **The vanishing IP address space:** IPv4 has only 2^32 addresses.

With the ever-increasing demand for public IP addresses for Internet accesses, Internet would run out of available IP addresses. IPV6 is proposed to fix the problem of the limited address space of IPV4.

- **Private IPs:** Three sets of address ranges are used for private use.

  10.0.0.0 – 10.255.255.255 (10.0.0.0/8) – 16M addresses

  772.16.0.0 – 172.31.255.255 (172.16.0.0/12) - 1M addresses

  192.168.0.0 – 192.168.255.255 (192.168.0.0/16) – 64k addresses

- **Dynamic Host Configuration Protocol (DHCP) server:** is a protocol used to assign IP addresses to arriving hosts. Rather than a network administrator manually assigning an IP address to each arriving host, the DHCP will assign IP addresses automatically.

  - Finding path to the Destination: When data leaves the source towards the destination, it needs to be routed through a series of networking devices to reach the destination. Routers take care of the job of routing the data from the source to destinations. Routing is the process of finding an efficient path from a source to a given destination through the network. Routers are special networking devices that are capable of communicating with similar devices over the network, collaborate among themselves and find paths for arriving data. Routers maintain a table of reachable destinations through them and these tables are called routing tables. Routers exchange these routing tables with other routers in the network from time to time to update the route details.
  - Packet Switching: When a message is generated at the source it is broken down into smaller chunks called packets. Each packet is assigned unique information to identify itself, switching information is added in the header of each packet and the transmitted independent of other packets.

Competency Level- 6.8 Explores the role of transport protocols in the Internet
No of periods: **03**

Learning Outcomes:

- Explains that it is not sufficient to deliver a message from one IP address to another by demonstrating that the communication is from process to a process
- Explains that it is not sufficient to deliver a message from one IP address to another by demonstrating that the communication is from process to a process
- Explains the need for multiplexing messages and how port numbers identify the end points

- Briefly describes the functionality of TCP and lists applications that use it

Contents:

- Delivering data from an application process to another application process
  - Multiple applications at a host identified by an IP
    Multiplexing – multiple end points at the same IP
    - Ports and port numbers
    - UDP
      - Properties
      - Applications
    - TCP
      - Properties
      - Applications

- **Reading Material**

Since many network applications may be running on the same machine, computers need something to make sure the correct software application on the destination computer gets the data packets from the source machine and some way to make sure replies get routed to the correct application on the source computer. Each process of a running application communicates to the underlying network through a specially assigned interface called a port. Each port is assigned a unique number called port number and it is used in combination with the IP address of the device to identify each process uniquely that is running on a given host. When processes running on different computers send data to the same destination, the port numbers of different processes and the IP addresses are used to identify the processes correctly. The process of combining the port numbers and the IP addresses and the identifying the correct process is called multiplexing.

- **User Datagram Protocol:** UDP is the no frills transport protocol for several well-known application layer protocols such as DNS and SNMP. UDP is simple and suitable for query based communications and it is not connection oriented. UDP

does not provide congestion control mechanism. UDP does not guarantee ordered delivery of data.

- **Transmission Control Protocol: TCP** provides a reliable in order delivery of data. It is a connection oriented protocol and uses sequenced acknowledgment with retransmission of packets when necessary. TCP is used for applications such as web, and email.

Competency Level 6.9: Explores some applications on the Internet

No of periods: 04

Learning Outcomes:

- Describes the need for human friendly names instead of IP addresses
- Explains the role of DNS in translating names to IP addresses
- Graphically represent the hierarchical and distributed structure of the DNS
- Describes a simple GET request and its response in HTTP
- Describes the client server model using DNS and HTTP

Contents:

- Domain Name System (DNS)
  - IP addresses are hard to remember
  - Human friendly names
  - Hierarchical name space
  - Each domain is responsible for managing the names under it
  - Top level domains
  - HTTP
  - Client Server model

Reading Material

- Domain Name System (DNS): DNS provides directory lookup service for given urls and the web addresses. The HTTP protocol uses the services of DNS to identify the matching web addresses of given URLs.

HTTP -

The Hypertext Transfer Protocol (HTTP) is an application layer protocol for distributed, collaborative, and hypermedia information systems. HTTP is the foundation of data communication for the World Wide Web.

Client Server model: The client–server model is a distributed application structure that partitions tasks or workloads between the providers of a resource or service, called servers, and service requesters, called clients.

Competency Level :6.10 Investigates the role of reference models to describe the network architecture

No of periods: 04

Learning Outcomes:

- Describes the functions of layers of TCP/IP and OSI models
- Describes the data units in different layers(packet, frame and bit)
- Describes the data flow in a network using TCP/IP and OSI models

Contents:

- TCP/IP model
  - Application
  - Transport
  - Internet
  - Host to network
- OSI model
- Application
- Presentation
- Session
- Transport
- Network
- Data link
- Physical

Reading Material

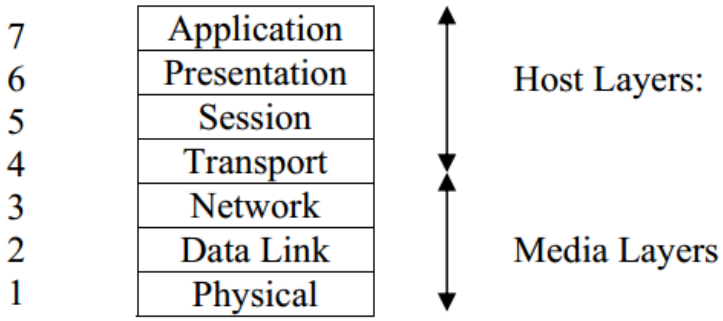
TCP/IP Protocol Architecture

4	Application Layer- Consists of applications and processes that uses the net work.
3	Host- Host Transport Layer- Provides end to end data delivery services
2	Internet layer –Defines the datagram and handles the routing of data
1	Network Access Layer – consists of routing for accessing physical network

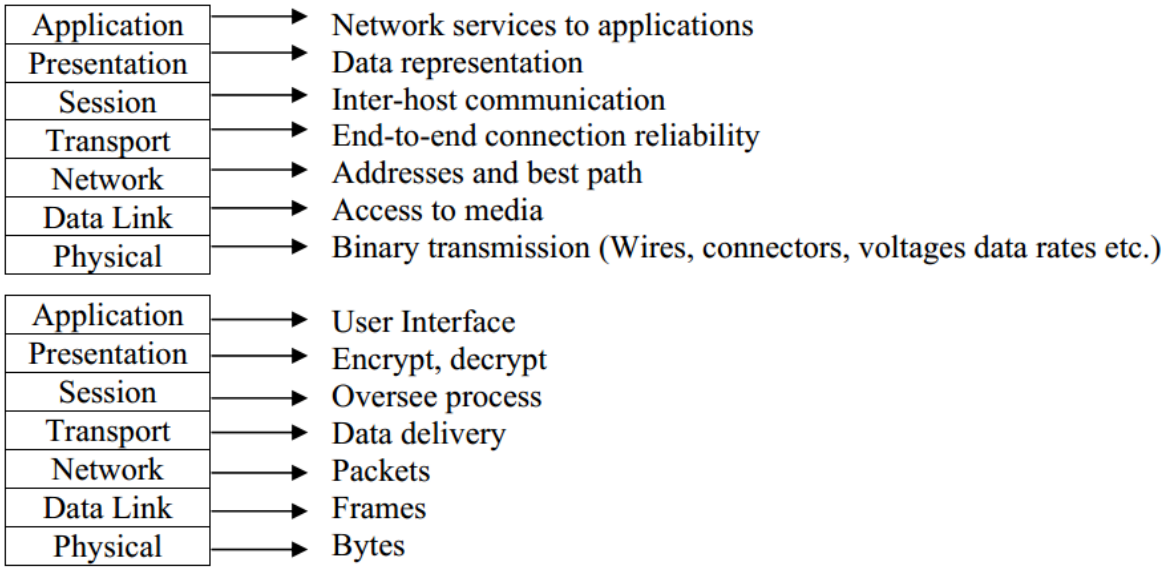
- **Network Access Layer**
  - lowest layer in TCP/IP hierarchy
  - provides the means to deliver data to the other devices on the network
  - defines how to use the network to transmit IP datagram
  - encapsulates IP datagram into frames
  - maps IP addresses to physical addresses in Ethernet
- **Internet Layer**
  - manages connections across the network and isolates the upper layer protocols
  - handles addressing and delivery of data
  - Internet Protocol (IP) does all these functions

- **Application layer**
    - Applications run at this layer
    - File Transfer Protocol (FTP), Remote Login (Telnet), E-mail (SMTP)
        - **Transport layer**
    - Transport Control Protocol (TCP)
    - User Datagram Protocol (UDP)

- **Layered Network Model (OSI – Open System Interconnection Model)**



- **OSI Layer Functions**



- **Comparison of OSI Reference Model and TCP/IP Reference Model**

<table>
<tr><th>OSI</th><th>TCP/IP</th></tr>
<tr><td>Application (Layer7)</td><td rowspan="3">Application</td></tr>
<tr><td>Presentation (Layer6)</td></tr>
<tr><td>Session(Layer5)</td></tr>
<tr><td>Transport(Layer4)</td><td>Host to Host Transport Layer</td></tr>
<tr><td>Network(Layer3)</td><td>Internet Layer</td></tr>
<tr><td>Data link(Layer2)</td><td rowspan="2">Network Access Layer</td></tr>
<tr><td>Physical (Layer1)</td></tr>
</table>

Competency Level 6.11- Investigates the security aspects of communication and protection of devices connected to the Internet

No of periods: 04

Learning Outcomes:

- Identifies the need for confidentiality and authentication of messages and notes that the Internet does not provide
- Briefly explains the use of the public and private keys to encrypt and sign messages
- Describes different threats faced by networked systems and protection against them

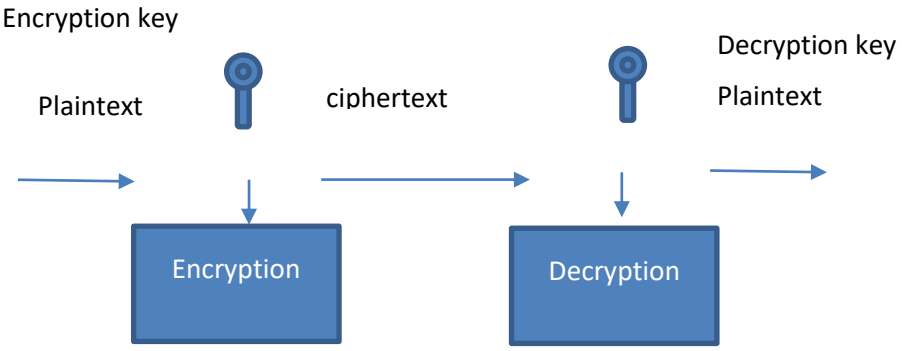
Contents:

- Encryption and digital signature – basic idea
    - Public Key
    - Private Key
    - Signing
- Threats
    - Viruses
    - Trojans
    - Malware
    - Phishing
- Protection
- Firewalls
- Antivirus software
- Education/ better awareness/ good practices

Encryption and digital signature:

Encryption is a technique used in cryptography which provides confidentiality of transmitting data.

There are two types of encryption: Symmetric Key Encryption - The encryption process where same keys are used for encrypting and decrypting the information is known as Symmetric Key Encryption. When using symmetric key encryption users must share a common key prior to exchange of information. Asymmetric Key Encryption - The encryption process where different keys are used for encrypting and decrypting the information is known as Asymmetric Key Encryption. Every user in this system needs to have a pair of dissimilar keys, **private key** and **public key**. These keys are mathematically related − when one key is used for encryption, the other can decrypt the cipher text back to the original plaintext.



Signing

Usually a validity document contains a signature under it and which makes the receiver to trust the content in it. Similar to usual documents, digital documents should also have a signature. Thus digital signatures help to authenticate the sources of messages. Digital signatures allow us to verify the author, date and time of signatures, authenticate the message contents.

Threats

o Viruses - A program which enters into the system, runs and performs malicious activities unknowingly.

o Trojans - Any malicious computer program used to invade into a computer by misleading users

o Malware- The software that is written for malicious purposes

o Phishing – An attempt to obtain sensitive information such as usernames, passwords, and credit card details by pretending as a trustworthy person.

Protection against unauthorized malicious accesses

- **Firewalls**: are systems that act against unauthorized accesses to protected data.
- **Antivirus software:** are software that detect and quarantine the malicious software that tries to harm a computer.
- **Computer users** must be properly educated to protect the network devices against malicious attacks and unauthorized accesses. Passwords must be chosen with utmost care and antivirus software must be periodically updated to protect the system from attacks.

Competency Level 6.12- Explores the role of ISPs and technologies used for connecting Home Networks to the Internet

No of periods: 04

Learning Outcomes:

- Describes the role of an ISP
- Explains the use of modems and dialup lines to connect a home machine to an ISPs network
- Explains the advantages of DSL/ADSL lines
- Explains the roles of NATs and Proxies in a LAN that uses private IPs

Contents:

- ISPs
- Connecting to ISP
    - Modems
    - DSL/ADSL
        - A home LAN that uses private IPs
        - Network Address Translation /Proxies

Reading Material

ISPs: An **Internet service provider** (**ISP**) is an organization that provides services to accessing and using the Internet services. Internet service providers may be organized in various forms.

Use of MODEMs

- DSL: Refers collectively to all types of ***d****igital* ***s****ubscriber* ***l****ines and* ADSL is the ***a****symmetric* ***d****igital* ***s****ubscriber* ***l****ine*, ADSL is a type of DSL broadband communications technology used for connecting to the Internet. ADSL allows more data to be sent over existing copper telephone lines, when compared to traditional modem lines.

Advantages of DSL

Independent services: Loss of high speed data does not mean you lose your telephone service. Imagine your telephone, television, and Internet access going out when a cable company amplifier/repeater dies.

Security: Unlike cable modems, each subscriber can be configured so that it will not be on the same network. In some cable modem networks, other computers on the cable modem network are left visibly vulnerable and are easily susceptible to break ins as well as data destruction.

Integration: DSL will easily interface with ATM, Nx64, and WAN technology. Telecommuting may get even easier.

Advantages ADSL

- **Cheaper rates**. Internet service providers (ISPs) provide a simple ADSL connection to the Internet, using the highest possible speed with usually a static IP address.
- **Fully configurable**. WAN engineers have total control over the VPN tunnel created between sites. They are able to perform on-the-fly configuration changes to compensate for any network problems or help rectify any problem that might arise.
- **High-speed access which enables easy net surfing and fast streaming contents access**: ADSL is a broadband service. It offers data transmission at much greater speeds and capacity than narrowband services like ISDN and dial-up analog modems. ADSL enables you to download high-volume data files effortlessly.

- **A home LAN that uses private IPs:**

  A public IP address is an IP address that can be accessed over the Internet. Like postal address used to deliver a postal mail to your home, a public IP address is the globally unique IP address assigned to a computing device. Your public IP address can be found at What is my IP Address page. Private IP address, on the other hand, is used to assign computers within your private space without letting them directly expose to the Internet.

  For example, if you have multiple computers within your home you may want to use private IP addresses to address each computer within your home. In this scenario, your router gets the public IP address, and each of the computers, tablets and smartphones connected to your router (via wired or wifi) gets a private IP address from your router via DHCP protocol.

- **Network Address Translation /Proxies**

  Network address translation (NAT) is a method of remapping one IP address space into another by modifying network address information in Internet Protocol (IP) datagram packet headers while they are in transit across a traffic routing device. The technique was originally used for ease of rerouting traffic in IP networks without readdressing every host.

- Proxies in a LAN that uses private IPs

  A proxy server is a computer that acts as an intermediary between the user's computer and the Internet. It allows client computers to make indirect network connections to other network services. A Proxy server solves the IP address issues when connecting a large corporation to the internet.

Competency 7: Explores the systems concept and uses systems analysis and design methodology in developing information system

Competency Level 7.1: Explores Characteristics of Systems

Number of Periods: 04

Learning Outcomes:

- Recalls the definition of systems
- Lists and describes the characteristics of systems
- Classifies and describes systems with examples

Contents:

- System concept
- Classification of systems
  - Open and closed systems
  - Natural and manmade systems
  - Living and physical systems

Concepts and terms to be highlighted:

- Focus on system concept
- Focus on difference between open and closed system
- Focus on natural and manmade systems
- Focus on living and physical systems

Guidance for lesson plans:

- Define system
- List open systems and closed systems
- List natural systems and manmade systems
- List living and physical systems

Guidance for assessments and evaluations:

Divide the class into groups and assign each group one of the system classification and ask them to list examples for them

Quality inputs:

Reading Materials:

A system is an orderly grouping of interrelated and interdependent components linked together according to a plan to achieve a specific objective.

An open system has many interfaces with its environment. It permits interaction across system boundary. The system receives inputs from and delivers outputs to its environment.

A closed system is isolated from environmental influences.

Ex. Human Respiratory System - Open system
Human Blood Circulation System - Closed System

The systems which are made by man are called manmade systems whereas nature made systems are called natural systems.

Ex. Transportation System of a Country - Manmade System
Human Blood Circulation System - Natural System

Living systems are open self-organizing **living** things that interact with their environment. The systems consist of non-living things are categorized into nonliving systems.

Ex. Solar System - Nonliving System
Human Respiratory System - Living System

Competency 7: Explores the systems concept and uses systems analysis and design methodology in developing information system

Competency Level 7.2: Compares and contrasts different types of manmade systems in terms of their objectives and functionality

Number of Periods: 04

Learning Outcomes:

- Compares the objectives and functionality of different types of manmade systems
- Distinguishes the different types of manmade systems in terms of objectives and functionality

Contents:

Information systems

- Office Automation Systems (OAS)
- Transaction Processing Systems (TPS)
- Management Information Systems (MIS)
- Decisions Support Systems (DSS)
- Executive Support Systems (ESS)
- Geographical Information Systems (GIS)
- Knowledge Management Systems (KMS)
- Content Management Systems (CMS)
- Enterprise Resource Planning Systems (ERPS)
- Expert Systems
- Smart Systems

Concepts and terms to be highlighted:

- Information system
- Focus on functionalities of different information systems

Guidance for lesson plans:

- Define information system
- Focus on each type of information systems

Guidance for assessments and evaluations:

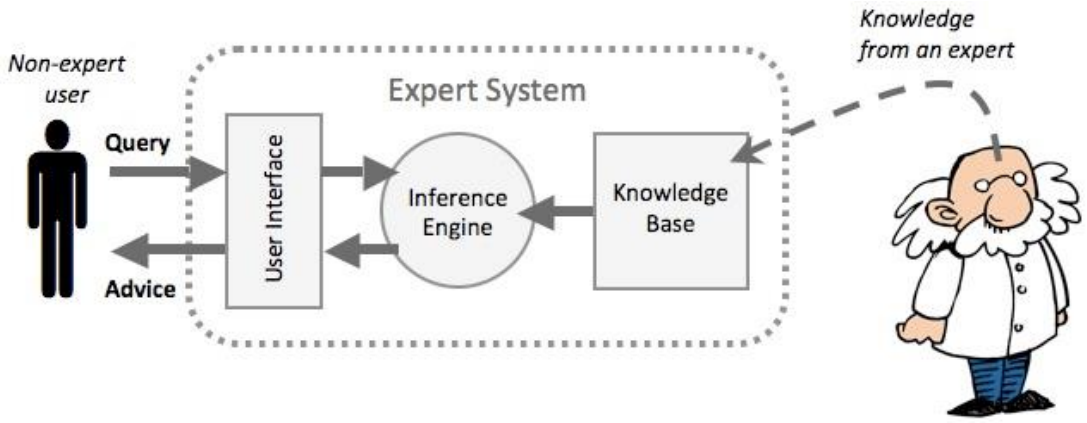
Divide the class into groups and assign each group one type of the information systems and ask them to do presentation

Quality inputs:

Presentation software, access to the Internet

Reading Material

- Office Automation Systems (OAS) are computer systems such as word processing, electronic mail and work scheduling systems that are designed to increase the productivity of employees in an office.
- Transaction Processing Systems (TPS) are computerized systems that perform and record the daily routine transactions necessary to conduct a business and serve the operational level users of an organization
- Management Information Systems (MIS) are information systems that serve the functions of planning, controlling, and decision making by providing routine summary and exception reports for the management level users of an organization.
- Decision Support Systems (DSS) are information systems that combine data and sophisticated analytical models or data analysis tools to support semi-structured and unstructured decision making for the management level users of an organization.
- Executive Support Systems (ESS) are information systems that address unstructured decision making through advanced graphics and communications for the strategic level users of an organization.
- Geographic Information Systems (GIS) are computer systems that allow to map, model, query and analyze large quantities of data within a single database according to their location. GIS facilitates to create maps, integrate information, visualize scenarios, present powerful ideas and develop effective solutions.
- Knowledge Management Systems (KMS) comprise a range of practices used in an organization to identify, create, represent, distribute and enable adoption of insight and experiences. Such insights and experiences comprise knowledge, either embodied in individual or embedded in organizational processes and practices.
- Content Management Systems (CMS) are computer applications that support the creation and modification of digital content. It supports to multiple users working in a collaborative environment. Examples for CMS are web-based publishing, format management, history editing and version control, indexing, search and retrieval etc. CMS supports the separation of content and presentation.
- Enterprise Resource Planning (ERP) Systems are business process management systems that allow organizations to use integrated applications to manage the businesses. An ERP system automates many back office functions related to technology, services and human resources. ERP software integrates product planning, development, manufacturing, sales and marketing.
- Expert Systems are computer applications that use artificial intelligence. To design an expert system, one needs a knowledge engineer, an individual who studies how human experts make decisions and translates the rules into terms that a computer can understand.



Source: http://www.igcseict.info/theory/7_2/expert/

- Smart Systems make decisions based on the available data in a predictive or adaptive manner, by means of sensing, actuating and controlling. Smart actions incorporate the ways to describe and analyze a situation. Smart systems can be attributed to autonomous operation based on closed loop control, energy efficiency, and networking capabilities.

Competency 7: Explores the systems concept and uses systems analysis and design methodology in developing information system

Competency Level 7.3: Explores different information system development models and methods

Number of Periods: 08

Learning Outcomes:

- Lists and briefly describes system development models
- Investigates the applicability of each model
- Lists and describes the stages of System Development Life Cycle (SDLC) in Waterfall model
- Lists and describes phases of the SDLC in Spiral model
- Lists and briefly describes system development methodologies

Contents:

System development life cycle models

- Waterfall
- Spiral
- Agile
- Prototyping
  - Rapid Application Development (RAD)

System development methodologies

- Structured
- Object Oriented

Concepts and terms to be highlighted:

- System development life cycle
- System development life cycle models
- System development methodologies

Guidance for lesson plans:

- Introduce the process of constructing a house and what are the steps to construct the house
- Discuss the development of an information system in comparison to the construction of a house
- Explain system development life cycle models and their stages
- Discuss what are the methodologies used in system development
- Discuss the differences among such methodologies

Guidance for assessments and evaluations:

Divide the class into groups and assign each group one of the following software development models and ask them to draw and explain them to the class

- Waterfall model
- Spiral model

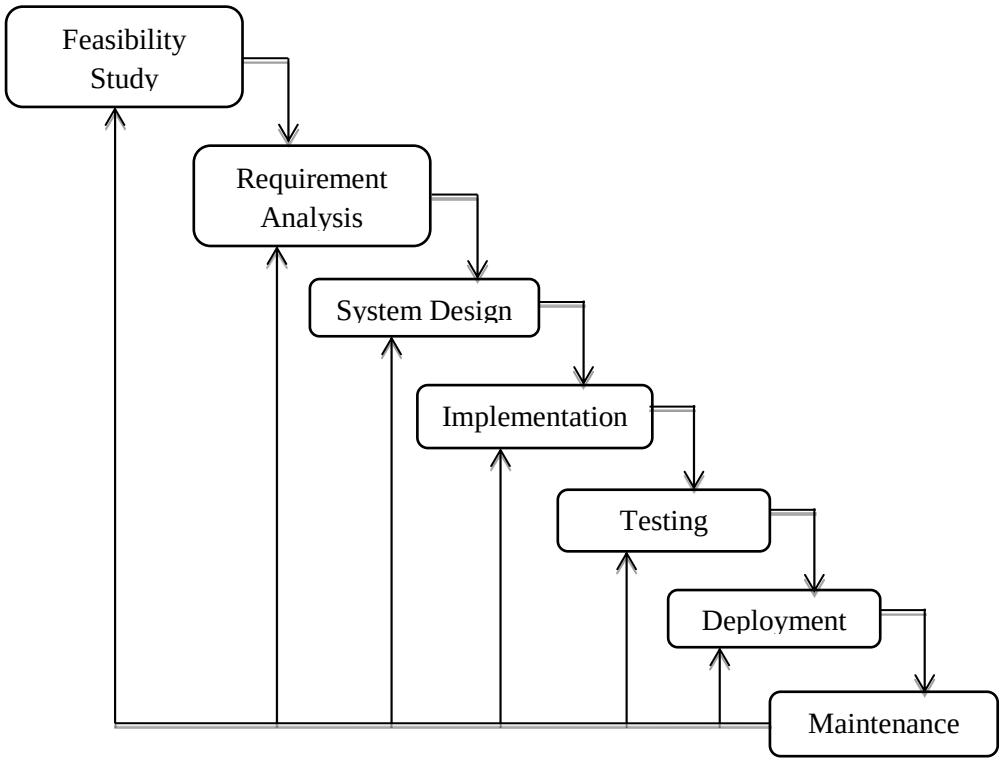
- Agile model
- Prototyping

Quality inputs:

Reading Materials:

Waterfall model

The waterfall model is a sequential process model used in software development. As the name implies, outcome of each stage flows into the next stage.



This model is suitable for systems where requirements are clear and stable.

Spiral model

This Spiral model is a combination of iterative development process and sequential linear development process.

Spiral model is suitable for systems where project risk is medium to high, requirements are complex, need an evaluation to get cleared them and significant changes are expected during the development.

Agile method

Agile method uses the existing methods and modifies them to suit the project requirements.

The tasks are divided to time slices to deliver specific features for a release.

This is an iterative approach and the software build is delivered after each iteration. Each build is an increment and the final product contains all the functionalities that the user requested.

The agile model is suitable for systems where requirements are fixed or changing.

Prototyping

Prototype is used to displays the functionality of a product under development, but not the full functionality.

It enables to understand the customer requirements in the early stages of software development as the prototype is demonstrated to the users to get their feedback. This helps developers to understand the exact user requirements.

Rapid Application Development (RAD)

In this model, the functional modules are developed in parallel as prototypes and the final product is made by integrating them enabling a rapid delivery.

System development methodologies

- Structured methodology
  Provides a framework (structure) with a set of well-defined guidelines through steps of tasks
- Object Oriented methodology
  Models system as a collection of objects that work interactively

Competency 7: Explores the systems concept and uses systems analysis and design methodology in developing information system

Competency Level 7.4: Examines the Structured System Analysis and Design Methodology (SSADM)

Number of Periods: 02

Learning Outcomes:

- Defines SSADM
- Lists and briefly describes the stages of SDLC covered by SSADM

Contents:

- Introduction to SSADM
- Stages of the SDLC covered by SSADM

Concepts and terms to be highlighted:

- Structured System Analysis and Design Methodology (SSADM)
- Stages of the SDLC covered by SSADM.

Guidance for lesson plans:

- Discuss the importance of system analysis and design as a part of the system development
- Explain the modules of SSADM

Guidance for assessments and evaluations:

- Assignment - ask students to prepare and submit an assignment on modules in SSADM

Quality inputs:

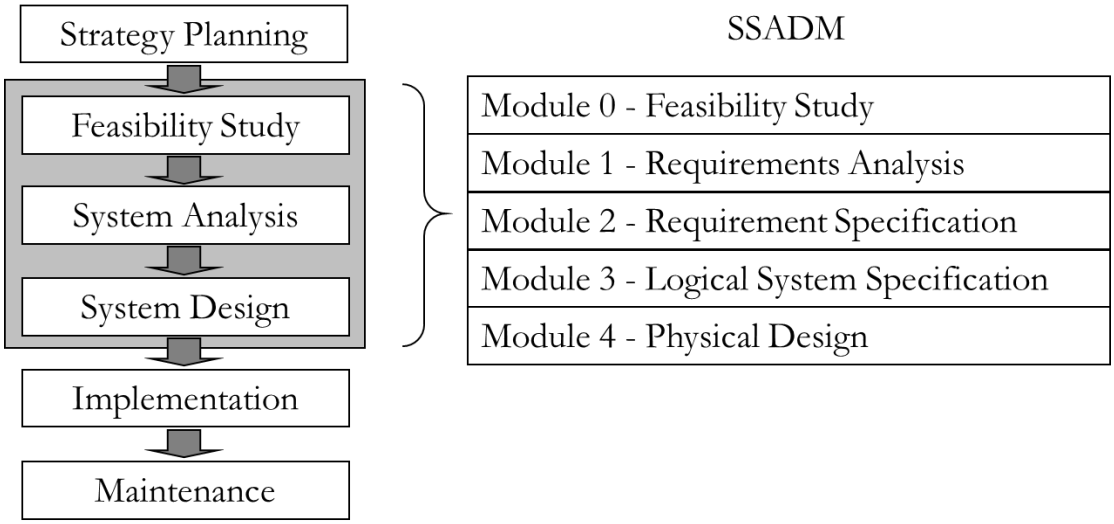
Reading Materials:

Introduction to Structured System Analysis & Design Methodology (SSADM)

SSADM,

- Involves study the present system and sketches a blueprint to develop a new system or to modify the existing system
- Introduced in early 1980s
- One of the structured methods for System Analysis & Design
- Adopted as a standard by Central Computer and Telecommunications Agency (CCTA), UK
- Covers most of the System Development Life Cycle (SDLC) from Feasibility Study to System Design
- More focus on analysis and design

Stages of the SDLC covered by SSADM



Feasibility Study

The business area is analyzed to determine whether the system development is feasible\

Requirements Analysis

The requirements of the system to be developed are identified and the current business environment is modeled in terms of the processes carried out and the data stored

Requirements Specification

Detailed functional and non-functional requirements are defined and new processes are introduced to define the required processing and data storage

Logical System Specification

System to be developed as specified logically without taking technical constraints into consideration

Physical Design

Logical design is transformed into a physical design taking technical constraints into consideration

Competency 7: Explores the systems concept and uses systems analysis and design methodology in developing information system

Competency Level 7.5: Investigates the need for a new information system and its feasibility

Number of Periods:

Learning Outcomes:

- Describes the tasks in preliminary investigation stage
- Identifies information problems in an organization
- Identifies priorities of the problems to be solved

Content:

- Preliminary investigation
- Identification of the problems in the current system
- Prioritizing information systems needs
- Feasibility study
  - Technical feasibility
  - Economic feasibility
  - Operational feasibility
  - Organizational feasibility

Preliminary Investigation

This is the first stage of system development life cycle. This gives a clear picture of what actually the physical system is? Preliminary investigation is done in two phases namely, problem definition and feasibility study. In the problem definition, a preliminary survey of the system is carried out to identify the scope of the system.

In the feasibility study, the proposed system is evaluated for its feasibility. Feasibility of a system means whether the development of a new or improved system is practical and beneficial.

Feasibility is evaluated from developers' and users' point of view. Developers see whether they have the required technology and manpower to develop the new system. Is the new system really going to be beneficial to the users? Does the user have the financial ability to get developed that type of a system? The feasibility of the system is evaluated on the three main aspects: technical, economical, operational and organizational.

Technical feasibility: this evaluates whether the developers have ability to construct the proposed system. The technical assessment helps answer the question such as whether the technology needed for the system exists, how difficult system will be to develop, and whether the developers have enough experience using that technology

Economic feasibility: this studies cost and benefits to evaluate whether the benefits justify the investments in the system development. Can the development cost be justified? An important outcome of the economic feasibility study is the cost benefit analysis.

Operational feasibility: this assesses the willingness and ability of the users to support and use the proposed system. Will the system be used when it is developed and installed? Will there be resistance from users to the system development?

Organization feasibility: this determines the extent to which the proposed system supports the objectives of the organization's strategy. In here, the system is taken as a subset of the whole organization.

The result of the feasibility study is a formal document, a report detailing the nature and scope of the proposed solution.

Once the feasibility study is done, the project is approved or disapproved according to the results of the study. If the project seems feasible and desirable, then the project is finally approved otherwise no further work is carried out.

Competency 7: Explores the systems concept and uses systems analysis and design methodology in developing information system

Competency Level 7.6: Uses different methods to analyze the current system

Number of Periods:

Learning Outcomes:

- Describes the need of requirement analysis
- Describes type of requirements with examples for a given system
- Defines requirements in IEEE standard
- Lists and describes the purpose of analytical tools
- Draws business activity model, context diagram, document flow diagram, data flow diagrams and logical data structure for a given system
- Writes elementary process descriptions
- Describes the need for business system options
- Proposes business system options

Content:

Requirement analysis

- Functional requirements
- Non - functional requirements

Analytical Tools

- Business Activity Modeling
  - Business activity model
- Data Flow Modeling (DFM)
  - Data Flow Diagrams (DFD)
  - Elementary Process Descriptions (EPD)
- Logical Data Modeling (LDM)
  - Logical Data Structure (LDS)

Business System Options (BSO)

Requirement analysis

Requirement analysis is the process of studying and analyzing the user needs to arrive at a definition of the problem domain and system requirements. The main objective of requirement analysis is to discover the boundaries of the new system and how system must interact within the new problem domain. Requirement analysis helps to detect and resolve conflicts between (user) requirements.

- Functional requirements: What activities that the system should carry out.
- Describe the requested functionality/behavior of the system
- Non Functional requirements: How well or with in what limits requirement should be satisfied
- IEEE standard for requirement definition
- Essential requirements are defined with “Shall” whereas nice to have requirements are defined with “Should”

Analytical Tools

Business Activity Modeling

A start-off technique for understanding what's going on in the system under investigation. It is used to show the business activities that the actors in the system's environment do and their associations.

Data Flow Modeling (DFM)

DFM is used to model data processing in the system. It is used to define partitions into sub systems. DFM consists of a set of Data Flow Diagrams (DFD) and associated textual descriptions.

DFD illustrates the way in which the data is passed around the system, how data is processed within the system, where data is stored in the system.

Components of a DFD

- External Entities
  - ❖ represents people, organizations or other systems external to the system under investigation
  - ❖ acts as a source or a recipient of data
  - ❖ name should refer to a generic type, not to an instance of that type
- Data Flows
  - ❖ show flows of data to, from and within the system
  - ❖ link other components in a DFD
  - ❖ could be one-way or two-way
  - ❖ represented with solid arrows, however between two external components are shown by dashed arrows and intersections should be avoided
- Processes
  - ❖ represents business activities carried out in the system
  - ❖ each process has three properties: Id, Name and Location
  - ❖ processes that don't need any further decomposition is called elementary processes
- Data Stores
  - ❖ used to hold data within the system
  - ❖ four types: Manual (M), Computerized (D), Temporary (T) and Manual Temporary T(M)
  - ❖ each data store has three properties: Id, Type and Name

Context Diagram

- a DFD with the highest level of abstraction
- represents the entire system as a single process
- shows how system interacts with its external entities

Document Flow Diagram

- acts as a bridge between the Context Diagram and Level 1 DFD
- illustrates how documents (papers, conversations, data passed among computers) passed in the system

Level 1 DFD

- provides a higher level overview of the system's data processing
- shows data movements among the major components of the system
- must be consistent with the Context Diagram

Lower level DFDs

- provides a way to go into more details successively
- enables top down approach
- must be consistent with the higher level DFD

Elementary Process Descriptions (EPD)

- contains enough details for program specification\
- written in plain text or pseudo code

Logical Data Modeling (LDM)

LDM models the systems data processed by the processes identified in DFM. It consists of a diagram called Logical Data Structure (LDS) and associated textual descriptions. LDS illustrates how data interrelates to each other and shows how business rules apply on system's data.

Components of a LDS

- Entities
  - ❖ a collection of logically associated and uniquely identifiable objects or concepts
  - ❖ must not get confused with the External Entities in DFM
  - ❖ property of an entity is called an attribute
  - ❖ name should reflect the type of the entity, not an instance of that entity
- Relationships
  - ❖ how entities relate to each other
  - ❖ physical relationships (physical links in a data structure)
  - ❖ logical relationships (business associations or rules)
- degree of a relationship
  - ❖ also known as Cardinality of relationship
  - ❖ number of occurrences of each entity participating in a given relationship
  - ❖ three types (one to one, one to many, many to many)
- optionality of a relationship
  - ❖ shows whether the relationship exists for all occurrences of participating entities

Entity Matrix

- helps to identify the relationships among entities
- provides all possible pairings of entities to identify relationships among them in the interested system
- associations between each pair of entities are checked for once
- does not provide the full description of a relationship

Business System Options (BSO)

BSO describes what the system will do. Each BSO must satisfy the minimum system requirements and consists of a functional description, a high-level technical description, major benefits to the business, approximate cost estimate, development time scale and impact on organization and other existing systems.

Competency 7: Explores the systems concept and uses systems analysis and design methodology in developing information systems

Competency Level 7.7: Designs the proposed system

Time: 12 periods

Learning Outcomes:

- Describes the logical design
- Describes the activities involved in the logical design stage
- Reconstructs logical design of the proposed system starting from elementary processes to context diagram
- Writes elementary process description in pseudo code
- Specifies table and record specifications

Contents:

Logical design tools

- Logical data flow modeling
  - ❖ Logical Data flow diagrams for proposed system
  - ❖ Elementary processes and elementary process description
  - ❖ User Interface design
- Logical data modeling
  - ❖ Logical data structure for the proposed system
- Physical design of database
  - ❖ Table and record specifications
  - ❖ Data dictionary
  - ❖ Database design

Reading Material:

Logical Data Flow Modeling (Logical DFM)

Physical DFM shows

- How data is actually processed and
- Where data is actually stored in the current system

Logical DFM shows

- How data should be processed and
- Where the data should be stored in the proposed system

Logical DFM consist of a set of DFDs and associated textual descriptions

LDM of the proposed system

- adds new entities required to support any new functionalities of the proposed system to the LDS
- provides logical data stores (entities) identified in the LDM for logical DFM
- removes any temporary data store that simply halts data temporarily

Logical DFM of the proposed system

- starts from elementary processes
- as location of a process only indicates a physical constraint, removes it from all processes

- as the person who actually did a process in physical DFM now feeds inputs to the corresponding process in the logical DFM, transforms the location into an external entity
- removes any purely human activity and replaces it with an external entity
- adds new processes required to support any new functionalities of the proposed system
- reconstructs the hierarchy by regrouping logical processes based on their functionality
- describes the functionality of elementary processes in pseudo code and write EPD

Physical Design of Database

Maps logical schema to relational schema

Logical Schema	**Relational Schema**
Entity	Table
Attribute	Field
Instance of an entity	Record of a table
Unique attribute	Primary key

- normalizes all the relations in relational schema to 3NF
- tabulates a Table Specification and a Record Specification for each relation in the normalized relational schema
- provides physical design for the construction of the database

Data Dictionary

- is an integral part of database
- holds information about the database and the data that it stores (data about data - metadata)
- contains the actual database descriptions used by the Database Management System (DBMS)

Competency 7.8: Develops and test the proposed system
Number of periods: 06
Learning outcome:

- Lists the testing method for newly designed system
- Describe the testing method for newly designed system

Contents:

- Program development
- Database development
- Testing
  - ❖ Test cases
  - ❖ White box testing
  - ❖ Black box testing
  - ❖ Unit Testing
  - ❖ Integrated testing
  - ❖ System testing
  - ❖ Acceptance testing

Testing

Test Cases

A test case is a set of actions executed to verify a particular feature or functionality of a software application. Test cases are documented by the Quality Assurance team while the software development is going on.

Software testing techniques

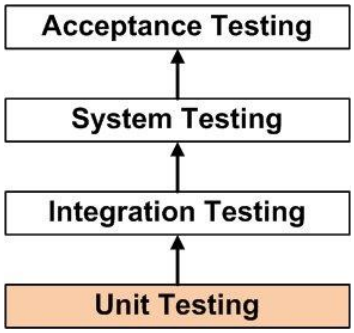
White box testing

- takes internal implementation of a software to derive test cases to test the software
- performed in the early stages of the testing process
- usually applied for testing relatively small program units
- analysis of the program code determines how many test cases are required to exercise all the internal components of the software (statements, branches, paths) adequately

Black box Testing

- software to be tested is treated as a black box and its behavior is examined by studying the inputs and outputs
- knowing the intended functionalities of a software, tests are conducted to see whether the software can deliver them
- test cases are derived from the requirement specification of the software to be tested

Software testing types



In software development,

- software systems are built with sub-systems
- sub-systems are built with individual program units such as functions or classes

Therefore, software testing,

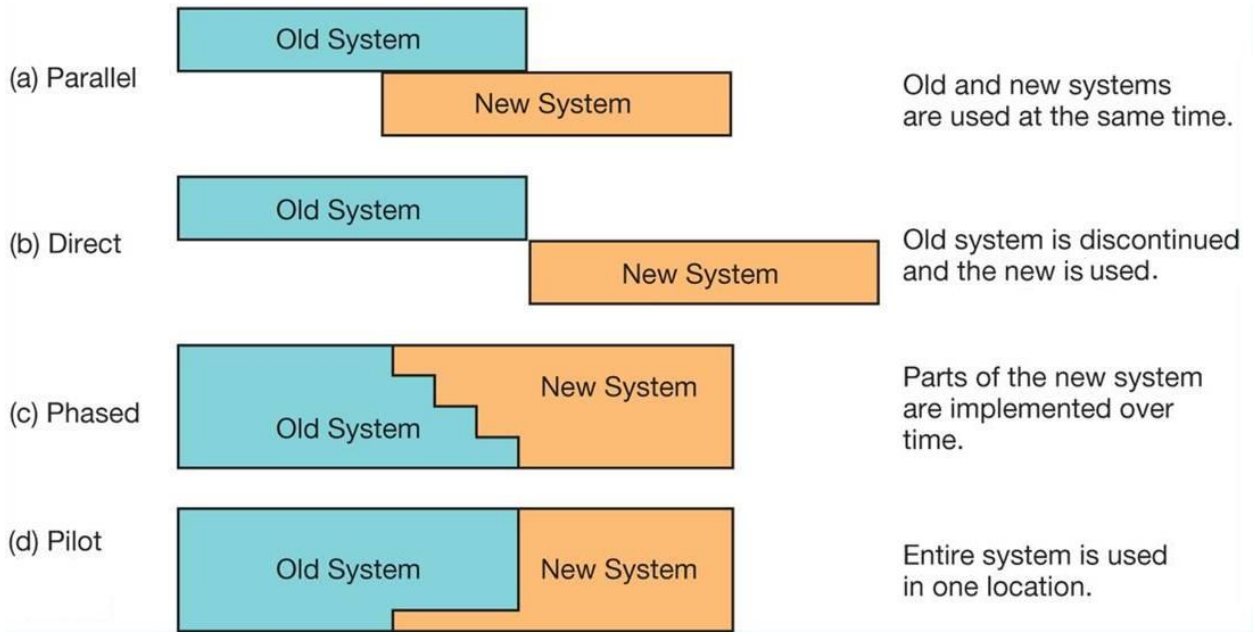
- starts with testing of these individual program units (Unit Testing, usually carried out by programmers, white box techniques are used)
- continues with the testing of the integration of these units (Integration Testing, usually carried out by integration testers or test teams, can either be white box or black box)
- and the testing of the system's functionality as a whole (System Testing, usually carried out by test teams independent of the programmers who developed the system, black box techniques are used)
- finally ends with testing to see whether the system is acceptable to the users (Acceptance Testing, usually carried out by test teams independent of the programmers and/or users who developed the system, black box techniques are used)

Competency Level 7.9: Deploys the developed system
Number of periods: 04
Contents:

- Deployment methods
  - ❖ Parallel
  - ❖ Direct
  - ❖ Pilot
  - ❖ Phased
- Hardware/ software installation, data migration and user training
- Review, support and maintenance

Software deployment

Software deployment includes all the activities that make a software system available for use. The general deployment process consists of several interrelated activities with possible transitions between them. These activities can occur at the developer's side or at the user's side or both.



(Source: https://www.studyblue.com/notes/note/n/exam-3-ppt-slides/deck/721189)

Parallel Deployment

Parallel deployment is a method of hardware or software migration that involves using the existing and new systems simultaneously until the implementation is judged to be completed and satisfactory.

During the transition, users work with both systems as they gradually learn the new software. There is generally some duplication of effort as, for example, data must be entered in both systems. That duplication may lead to data quality issues. Parallel adoption is the most foolproof method. However, it can also be the most time-consuming option and is usually the most expensive.

Direct Deployment

This is the simplest methods of deployment. Direct deployment is a hardware or software migration method that involves getting rid of the existing system and transferring all users to the new system simultaneously.

Implementation is faster with direct deployment than other deployment methods. As the old system is no longer available, users cannot put off learning the new system. Furthermore, the complete and simultaneous implementation also avoids issues that can arise when users are working with different software or hardware. This is the least expensive migration method, assuming there are no major problems.

On the negative side, however, it can be hard on users to have to learn the new system immediately. The method also involves a lot of problems that arise during implementation can be unpredictable, plentiful and serious, and fallback systems may be inadequate to deal with them. However, if the two systems are incompatible, direct deployment may be the only viable method.

Pilot Deployment

A pilot deployment is a hardware or software migration method that involves rolling out the new system to a small group of users for testing and evaluation.

During the pilot implementation, the users of the test group can provide valuable feedback on the system to make the eventual rollout to all users go more smoothly. Once the test group has approved the system, it can be rolled out across the organization. The testers can then help train other users for the new system. On the other hand, the test group could also determine whether the system is a viable option for the organization.

Phased Deployment

Phased deployment is a hardware or software migration method that involves incremental implementation of a new system.

A phased migration might be conducted either by implementing the entire new system in some locations or business units or by implementing separate modules of the system independently until the implementation is complete.

Because everything is not rolled out at once, the organization doesn’t have to deal with all the potential implementation issues at the same time. Furthermore, information learned from early implementation stages can be applied to guide the rest of the process, so that there are fewer issues as the implementation continues. A phased rollout also allows users to adjust to the new system gradually.

On the other hand, it can be confusing to have groups of users working with different systems or to have users working with elements of different systems. That confusion can also lead to data quality issues.

Maintenance

The maintenance phase of the SDLC occurs after the software is in full operation. The maintenance phase involves making changes to hardware, software, and documentation to support its operational effectiveness. It includes making changes to improve a system's performance, correct errors, deal with security issues, or address new user requirements. To ensure that the modifications do not disrupt operations or degrade a system's performance or security, organizations use change management standards and procedures.

Competency level 7.10: Describes system implementation with commercial-off-the-shelf packaged systems

Time: 04 periods

Learning outcome

- Describes the costs and benefits of off-the-shelf packages in terms of investment, operational and maintenance cost
- Describes the features and capabilities of packaged solutions related to standard business applications
- Identifies and describes differences between a given business process and features of commercial-off-the-shelf packages
- Maps business process activities onto work flow of the commercial-off-the-shelf packaged solution
- Identifies changes required in the current business process
- Identifies customization requirements of commercial-off-the-shelf packaged solutions

Contents:

- Advantages and disadvantages of using commercial-off- the-shelf packages
- Identification of package capabilities, work flows etc.
- Business process gap analysis
- Business process mapping
- Business process reengineering

Concepts and terms to be highlighted:

- Comparison of commercial-off-the-self-packages in terms of cost
- The advantages and disadvantages of commercial-off-the-self-packages
- Features of commercial-off-the-self-packages with compared to custom developed applications
- Analyze the gap of business processes that required to be mapped in commercial-off-the-self-packages
- Reengineering the business processes to suit the off-the-self-packages

Guidance for lesson plans:

Guidance for assessments and evaluations:

Quality inputs:

Reading Material:

Advantages of using Commercial Off-The-Shelf (COTS) Packages

COTS software systems are designed for both horizontal and vertical markets. In order to cater for the needs of many, vendors spend an enormous amount of time and effort to incorporate world-class functionality into their systems. Duplicating such expense to develop similar functionality in custom developed software systems, in many cases, is prohibitively expensive.

COTS software systems tend to be far more configurable than custom developed software systems. In other words, they can accommodate change by adjusting parameters to a far greater degree than is usual for custom developed software systems. Moreover, package environments often come with capabilities that users do not to use immediately but are there for future exploitation as and when required.

A COTS software system can be implemented in significantly less time than a custom software system development and often at substantially less cost.

Disadvantages of using COTS Packages

COTS software systems can be highly complex and usually include many features that will be never used. Given the software tends to be large and complicated, it may take a long time to learn how to use the system properly. They may also require to alter the way that the work is done in order to fit in with the way that the system has been designed.

If the organization's business processes are unique, then the COTS software systems may need to be customized or the business processes may need to be changed to accommodate them.

As the competitors can also buy and use the same COTS software system, it is very difficult to gain any competitive advantage from using it.

Advantages of using custom developed software systems

Custom developed software systems are designed specifically to the requirements and built to operate exactly as needed. Moreover, they can be modified as the business changes or altered to further improve their performance. Custom developed software systems can also be integrated with the existing systems and any future systems as required.

The custom developed software systems can provide functions that are needed and none that that are not needed. They also operate in the way that users are used to work which means that they will be easier to use.

Being able to perform tasks that the competitors cannot do means that organizations can gain real competitive advantage with custom developed software solutions. Given that custom developed software can be listed as an asset of an organization, it can add value to the business.

Disadvantages of using custom developed software systems

Custom developed software systems require a large initial investment and the development process can take a long time

Business Process

A set of activities, responsibilities, resources and data flows that interact to accomplish a business function.

Business process modeling

Business process modeling involves an in-depth analysis and then an optimization of the business process by removing inefficiencies and bottlenecks.

Business process gap analysis

As no COTS software solution has been specifically designed to meet any organization's unique requirements, there will be a gap between the business processes supported by the existing systems and those supported by the COTS software system. It is imperative that to understand this gap well before the implementation begins and ensure that the organization can accept this gap without degrading its business performance.

Business process mapping

Business process mapping is a group activity performed by teams of subject matter experts that gather to draw step-by-step diagrams to document how business is carried out. This invaluable tool is mostly used by consultants and business professionals to capture the current state of business operations in preparation for business improvement initiatives.

Business process mapping can also be very beneficial in helping to increase productivity among staff, implementing or decommissioning systems, streamlining processes, and protecting knowledge capital.

In most COTS software systems, there will be gaps between what the organization needs and what the system delivers. For each such gap, organizations have to decide whether to ignore it (remove the requirement and just live with the tool), change how they do something outside the solution (modify the business process) or build something to bridge the gap (extend the solution).

If the COTS software system is extended, it is required to fully specify the requirements for those new capabilities just as done for any new product development effort.

13.0 School Policies and Programs

It needs to be noted at the onset, that the success of the classroom learning-teaching process has an immense bearing on the effective actualization of the expected aims of the subject Information and Communication Technology. Therefore, it is important that the school policy and programs are organized in keeping with these expectations. It is important, in the achievement of the aims of this subject that the novelty of the subject and the consequent paucity of knowledge regarding this subject in student, should be taken into consideration.

The number of periods available for this subject is 300 per year. However, the number of periods in this revised syllabus is 442 for both academic years and this includes practical sessions for the appropriate competency levels. Apart from the above, 30 periods are set apart, spread throughout the year, for the Project in Grade 13.

Practical sessions are so important, as student should know how to apply what they have learnt and experienced throughout this learning activities. In order to acquire a main competency as included in the syllabus, students are required to practice some graded exercises followed by one or more real world applications.

Students have to maintain an activity logbook to record their activities done during this practical session and should be presented to the teacher in charge to maintain its correctness and consistency.

The individual project to be assigned in Grade 13 should be implemented outside normal classroom sessions. Thirty periods, however, will be devoted for teacher led discussions plus practical at different stages of the project. For the success of this activity, which comprises only individual practical works, arrangement will have to be made for the students to use the computer laboratory even outside the timetabled sessions.

14.0 Assessment and Evaluation

It is intended to implement this syllabus in schools with the School Based Assessment (SBA) process. Teachers will prepare creative teaching-learning instruments on the basis of school terms.

The details together with the format and the nature of questions will be introduced by the Department of Examination