

ESE 2023

UPSC ENGINEERING SERVICES EXAMINATION

Preliminary Examination

General Studies and Engineering Aptitude

Information and Communication Technologies (ICT)

Comprehensive Theory *with* Practice Questions
and ESE Solved Questions



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**ESE 2023 Preliminary Examination :
Information and Communication Technologies (ICT)**

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1st Edition : 2016

2nd Edition : 2017

3rd Edition: 2018

4th Edition: 2019

5th Edition: 2020

6th Edition: 2021

7th Edition: 2022

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Preface

The compilation of this book **Information and Communication Technologies** was motivated by the desire to provide a concise book which can benefit students to understand the concepts of this specific topic of General Studies and Engineering Aptitude section.



B. Singh (Ex. IES)

This textbook provides all the requirements of the students, i.e. comprehensive coverage of theory, fundamental concepts and objective type questions articulated in a lucid language. The concise presentation will help the readers grasp the theory of this subject with clarity and apply them with ease to solve objective questions quickly. This book not only covers the syllabus of ESE in a holistic manner but is also useful for many other competitive examinations. All the topics are given the emphasis they deserve so that mere reading of the book clarifies all the concepts.

We have put in our sincere efforts to present detailed theory and MCQs without compromising the accuracy of answers. For the interest of the readers, some notes, do you know and interesting facts are given in the comprehensive manner. At the end of each chapter, sets of practice question are given with their keys, that will allow the readers to evaluate their understanding of the topics and sharpen their question solving skills.

Our team has made their best efforts to remove all possible errors of any kind. Nonetheless, we would highly appreciate and acknowledge if you find and share with us any printing and conceptual errors.

It is impossible to thank all the individuals who helped us, but we would like to sincerely thank all the authors, editors and reviewers for putting in their efforts to publish this book.

With Best Wishes

B. Singh

CMD, MADE EASY

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Information and Communication Technologies (ICT) tools are the various goods, products and services used in the form of digital infrastructures such as computers, tablets, projectors, interactive white boards, digital signage, printer, networking switches, wi-fi, cables, servers and so on. The basis function of ICT tools are primarily intended to fulfil or enable the function of information processing and communication by electronic and digital means, including transmission and display.

As per OECD (Organisation for Economic Co-operation and Development) guide to measuring the information society 2011, the ICT products classifications are as:

Computer and peripheral equipment/tools	<ul style="list-style-type: none"> • Point of sale terminals, ATM's • Laptop, notebook • Input peripherals (keyboard, mouse) • Scanners • Printers (Inkjet, Laser and others) • Media storage units (Fixed/Removable) • Parts and accessories of computing machines • Monitors and projectors • Solid-state non-volatile storage devices
Communication equipment	<ul style="list-style-type: none"> • Transmission apparatus • Television cameras • Line telephone sets with cordless handsets • Telephones for cellular network • Various parts for above mentioned subclasses
Consumer electronic equipment	<ul style="list-style-type: none"> • Video game consoles • Video camera recorders • Digital cameras • Radio broadcast receivers • Television receivers, monitors and projectors • Sound/Video recording • Microphone, loudspeakers, headphones etc.
Miscellaneous ICT components and goods	<ul style="list-style-type: none"> • Printed circuits, CRT's, diodes etc. • Magnetic and optical media • Card with a magnetic strip • Smart cards • LCD, lasers and other optical appliances
Manufacturing services for ICT equipments	<ul style="list-style-type: none"> • Electronic component and board • Computer and peripheral equipment • Communication equipment • Consumer electronic • Magnetic and optical media
Business and productivity software and licensing services	<ul style="list-style-type: none"> • Operating system, system software, application software, network software • Database management software • Development tools and programming language software • Licensing services, online software

Information technology consultancy services	<ul style="list-style-type: none"> • Business process management services • IT consulting and support services • IT design and development services for applications networks and systems • Web hosting services • Network services • Computer system management services
Telecommunication services	<ul style="list-style-type: none"> • Mobile telecommunication services • Carrier services • Private network services • Data transmission services • Internet services (Narrowband/Broadband)
Leasing or rental services for ICT equipments	<ul style="list-style-type: none"> • Leasing or rental services concerning computers without operator telecommunication equipment without operator, television, radio etc.
Other ICT services	<ul style="list-style-type: none"> • Engineering services for telecommunication and broadcasting projects. • Maintenance and repair services of computer and peripheral equipment, telecommunication equipment. • Installation service of computers, radio, television and communication equipment.

2.1 Computer

Computer is a programmable machine that can execute a programmed list of instructions and simultaneously work upon new instructions given to it. It is a electronic device that has the capacity of storing and retrieving information from its memory and can generate the required output as per the processing instructions given to it by the users with high speed, accuracy and reliability.

In a simpler sense, a computer can:

- (i) Take data as input
- (ii) Store data in its memory
- (iii) Retrieve data when necessary
- (iv) Generate the output



Advantages	Disadvantages
<ul style="list-style-type: none"> • Speed: Can perform very large calculations in fractions of second. • Accuracy: Can run a program and give output without any error. • Storage: It can store large amount of data which can be retrieved later. 	<ul style="list-style-type: none"> • Dependency: In a digital world almost all works are dependent on computers. • No self-awareness: It has no intelligence on its own and user has to manipulate it.

2.2 Computer Generations

In the era of digitalization, there have been upgrades in the advancement of technology leading to updates in computer technology both in hardware components as well as software. As of present day, there have been five generations of computers.

All the five generations of computers have been discussed in details as follows:

Generation	Period	Technology based on
First	1945-1955	Vacuum tubes
Second	1955-1965	Transistors
Third	1965-1975	Integrated Circuits (IC's)
Fourth	1975-1989	Very Large Scale Integration (VLSI) microprocessor
Fifth	1989-till date	Ultra Large Scale Integration (ULSI) microprocessor

2.2.1 First Generation of Computers (1945-1955)

The first generation computers used vacuum tubes as the basic components of memory and circuitry for CPU. These vacuum tubes were invented by Lee De Forest. The first operational electronic general purpose computer, namely ENIAC (Electronic Numerical Integrator and Computer) was built using about 18000 vacuum tubes.

Some **basic features** of first generation computers are:

- Vacuum tube technology based.
- Mainly batch processing operating system.
- Punch cards, paper tape and magnetic tape as input and output devices.
- Machine language as programming language:

Disadvantages:

- Bulky and costly.
- Generates high heat and consumes lot of electricity.
- Performance very slow and unreliable.
- AC required.

Examples:

- ENIAC, EDVAC, UNIVAC, IBM-701, IBM-650, EDSAC.

2.2.2 Second Generation of Computers (1955-1965)

The second generation computers used transistors in place of vacuum tubes, that were cheaper, less power consumption, more compact in size, more fast and reliable than first generation machines.

Best features:

- Transistor technology based.
- Batch processing and multiprogramming operating system.
- Magnetic cores used as primary memory and magnetic tape and magnetic disks as secondary memory.
- Assembly language and high-level language like FORTRAN, COBOL as programming language.

Disadvantages:

- Still very costly.
- Still large amount of heat generated.
- AC required.

Examples:

- IBM 7030, IBM 1620, CDC 3600, CDC 1604, UNIVAC 1108, Honey well 400

2.2.3 Third Generation of Computers (1965-1975)

Third generation computers came with the invention on Integrated Circuit (IC) in place of transistors. An IC is a combination of many transistors, capacitors and resistors along with the associated circuitry. Due to this improvement, sizes were substantially reduced with increased reliability and efficiency.

Basic Features:

- IC technology based.
- Remote processing, time-sharing multi-programming, micro-programming operating system.
- Small scale integration and medium scale integration were implemented in CPU, I/O processors.
- Faster processors with magnetic core memories. (Later on replaced by RAM and ROM)
- High level language as FORTRAN-II to IV, PASCAL, BASIC, ALGOL-68 etc. as programming language.

Disadvantages:

- Costly and required AC.

Examples:

- IBM-360 series, PDP-8 Mini Computer, Honey well 6000 series, TDC-316

2.2.4 Fourth Generation of Computers (1975-1989)

The fourth generation computers were based on the microprocessors which employed Large Scale Integration (LSI) and Very Large Scale Integration (VLSI) techniques to pack thousands or millions of transistors on a single chip. Fourth generation computers became more reliable, compact in size powerful and less costly which gave rise to personal computer revolution.

Basic features:

- VLSI technology based.
- Time-sharing, real time networks, distributed operating system.
- CRT screen, laser and ink jet printers, scanners etc. along with LAN and WANS were developed.
- High level language as C, C++, UNIX, DBASE etc. as programming language.

Examples:

- Intel's 8008, 80286, 80386 etc, Motorola's 68000, 68030 etc, Apple II, CRAY 1/2/X/MP, DEC 10, STAR 1000, PDP 11

2.2.5 Fifth Generation of Computers (1989-till date)

In the fifth generation computers, VLSI technology became updated to ULSI (Ultra Large Scale Integration), resulting in the production of microprocessor chips having ten million electronic components.

Basic features:

- ULSI technology based.
- Extensive parallel processing, multiple processing, super conductor technology.
- Advancement of AI (Artificial Intelligence which included Robotics, Virtual Reality, Neural Networks).
- High level language like C, C++, Java, .Net etc. as programming language.

Examples:

- IBM notebooks, Pentium PCs-Pentium 1/2/3/4/Dual core/Quad core, SUN work stations, PARAM 10000, IBM SP/2.

2.3 Types of Computers

Computers are categorized into various types based on their speed and performance level as:

Type	Description	
Personal Computer (PC)	Single user, moderately powerful microprocessor.	Least powerful ↓ Most powerful
Workstation	Single user, more powerful microprocessor than PC.	
Mini Computer	Multi-user, capable of supporting hundreds of users simultaneously.	
Main Computer	Multi-user, capable of supporting hundreds of users simultaneously. Software technology is different from mini computer.	
Super Computer	Extremely fast, capable of executing hundreds of millions of instructions per second.	

2.3.1 Personal Computers

- PC's are small, relatively inexpensive computer designed for an individual user.
- All PC's are based on the microprocessor technology that enables manufacturers to put an entire CPU on one chip.
- PC's are used popularly at home for playing games, surfing the internet etc.
- PC's are used in business purposes for accounting, word processing, desktop publishing, running spread sheet and database management applications.
- Based upon size and portability criteria, PC's are further sub-classified as - Desktop, Notebook, Laptop, Subnotebook, Hand-held, Palmtop and PDA (Personal Digital Assistant).



Fig. Personal Computer

2.3.2 Workstation

- Workstation is a type of computer used for engineering application (CAD/CAM), desktop publishing, software development etc.

- Workstation is preferably used where a moderate amount of computing power and relatively high quality graphics are required.



Fig. Workstation

- Workstation generally comes with a large, high-resolution graphics screen, large amount of RAM, built-in network support and a graphical user interface.
- Most workstations also have a mass storage device, but disk less workstation is a special type of workstation, which comes without a disk drive.
- Workstation are usually a single user computers but can be linked together to form a network of computer, although they can be used as stand alone systems.
- UNIX and Window NT are the common operating systems for workstations.

2.3.3 Mini Computer

- A mini computer is a type of mid-range computer that possesses most of the features and capabilities of a large computer but is smaller in physical size.
- Mini computers emerged in the mid-1960's and were first developed by IBM corporation.
- Mini computers can contain single or multiple processors, support multi-tasking, have resilience to high work load and support multiple user simultaneously.
- Some common examples of mini computers are: IBM mid-range computers, HP 3000/2100 series, DEC PDP, Varian 620 100 series, CDC 160A/1700 etc.



Fig. Minicomputer

2.3.4 Mainframe

- Mainframes are the type of computers that are generally known for their large size, amount of storage, processing power and high level of reliability.
- Mainframe is a large and expensive computer capable of supporting hundreds or thousands of users simultaneously.

- Mainframe are different from super computer from the fact that a mainframe uses it power to execute a reliable volume of computations concurrently whereas super computer uses it power into executing a few programs as fast as possible.
- Mainframe computer play a vast role in the foundation of modern business such as banking, insurance, finance, health care, public utility, government and private enterprises.
- Some common examples of mainframe computers are: IBM Z-series, Unisys's Clear Path Libra and Clear Path Dorado, Fujitsu-ICL VME etc.



Fig. Mainframe

2.3.5 Super Computer

- Super computer are the fastest and most expensive computers that are used for specialized applications which require very large amount of mathematical calculations.
- Super computers are very high performance computing machine designed to have extremely fast processing speeds.
- Super computers are applied to perform complex scientific calculations, modelling simulations and rendering large amount of 3D graphics. They may also be built to simply show case the leading edge of computing technology.



Fig. Super Computer

- Some common applications of super computers are in the field of scientific simulations, weather forecasting, (animations) graphics, fluid dynamics calculations, nuclear energy research, electronic design, analysis of geological data etc.
- Some of the fastest super computers in the world are as:

Rank	Name	Country	Peak Performance
1	Summit	USA	200,794.9 Teraflops/s
2	Sierra	USA	125,712.0 Teraflops/s
3	Sunway TaihuLight	China	125,435.9 Teraflops/s
4	Tianhe-2A (Milky Way 2A)	China	100,678.7 Teraflops/s
5	Frontera	USA	38,745.9 Teraflops/s

- Some of the fastest super computers in India are:

Name	Site	Rmax (Tflops)
Pratyush [Cray XC40*]	Indian Institute of Tropical Meteorology	3763.9 TFolp/s
Mihir [Cray XC40*]	National Centre for Medium Range Weather Forecasting	2570.4 TFolp/s
SERC [Cray XC40*]	Indian Institute of Science	901.506 TFolp/s
HP Appolo 6000	Indian Institute of Technology, Delhi	524.40 TFolp/s
Param Yuva 2	Center for Development of Advanced Computing (C-DAC), Pune	388.44 TFolp/s

NOTE

- Performance of a normal computers is measured in terms of its CPU speed. The speed of CPU is measured in either Megahertz (MHz) or Gigahertz (GHz). 1 MHz CPU can carry out 1 Million Instruction Per Second (MIPS) and a 1 GHz CPU can carry out 1 Billion Instruction Per Second (BIPS).
- Performance of super computer is measured in terms of its processing speed. Its processing speed is measured in Floating Point Operations Per Second (FLOPS) or the number of calculations a super computer can perform in 1 second. These units of super computer are measured as Tera Flops/TFLOPS (10^{12} Floating Point Operations Per Second), Peta Flops/PFLOPS (10^{15} Floating Point Operations Per Second) and Exa Flops/EFLOPS (10^{18} Floating Point Operations Per second).

2.4 Structure of Computer

The primary function of the computer is to take data from input devices, process the data in the CPU and display the processed data on the output devices. The mains parts of computer include:

- Input Unit
- Central Processing Unit (CPU)
- Output Unit

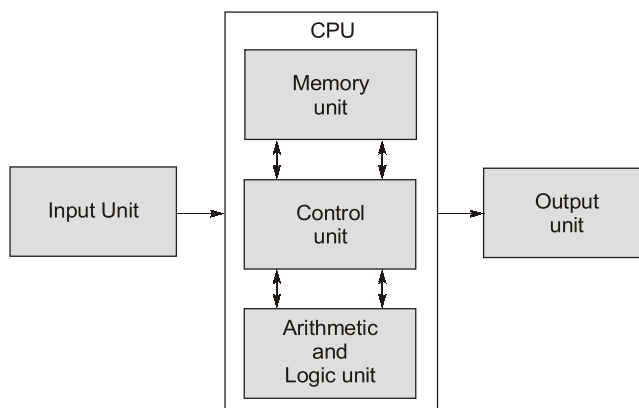


Fig. Basic Structure of a Computer

2.4.1 Input Unit

Input unit plays a significant role in creating a link between the user and the computer. Before a computer can process the data, some method are required to input the data into the machine. This method is accomplished with the help of input devices which will further depend on what form the data takes (like text, sound, artwork etc.)

The various peripheral devices used for computer input unit are discussed below:

- | | | |
|------------------|------------|-------------------|
| • Mouse | • Keyboard | • Touchpad |
| • Trackball | • Joystick | • Light Pen |
| • Graphic Tablet | • Scanner | • Microphone |
| • MICR | • OCR | • Bar Code Reader |
| • QR code | • OMR | • MIDI Devices |
| • Touch Screen | • Webcam | • Digital Camera |

Mouse

- Mouse is the most popular pointing device with two buttons on the left and right and a wheel in between the two buttons.
- Moving the mouse allows to reposition the pointer or cursor, an indicator on the screen that shows where the next interaction with the computer can take place.
- A mouse can be optical, which uses a light and small optical sensor to detect the motion of the mouse or it can be cordless or wireless which communicates with the computer via radio waves (like Bluetooth).



Fig. Mouse

Keyboard

- The computer keyboard is used to enter text information into the computer. The keyboard can also be used to type commands directing the computer to perform certain actions.
- Most of the windows keyboard has total number of 104 keys as the de facto standards. However certain keyboards can have 84 keys or 101/102 keys.
- The keys in the keyboard are as:
 - (i) **Typing keys:** Letters (A - Z) and numbers (0 - 9).

- (ii) **Numeric keypad:** Contains a set of 17 keys, used independently in ATM's, Electronic Point of Sale (EPOS).
- (iii) **Function keys:** 12 function keys with unique purposes.
- (iv) **Control keys:** Provide cursor and screen control. Arrow Keys, Home, End, Insert, Delete, Page Up, Page Down, Ctrl, Alt, Esc are Control keys.
- (v) **Special purpose keys:** Enter, Shift, Caps Lock, Num Lock, Space Bar, Tab, Print Screen.



Fig. Keyboard

NOTE: A modifier key modifies the action of another key when the keys are pressed at the same time. Individually these keys hold no purpose. Shift, Function, Control and Alt are the common modifier keys.

Touchpad

- Touchpad have been most commonly used in laptop computer. The on-screen cursor is moved by sliding finger along the surface of the touchpad.
- The buttons are located below the pad, but most touch pad allows one to perform “mouse clicks” by tapping on the pad itself.
- Touch pad are advantageous over mouse as they require less space to use.



Fig. Touchpad

Trackball

- Trackball is sort of like an upside-down mouse, with the ball located on top. Fingers are used to roll the trackball and internal rollers sense the motion which is transmitted to the computer.
- The body of the trackball remains stationary on the desk and much space is not needed to use the trackball. Hence it is advantageous over mouse.
- Trackball is mostly used in notebook or laptop computer.



Fig. Trackball

Joystick

- Joystick is a pointing device, used to move the cursor position on a monitor screen. It is a stick having a spherical ball at its both lower and upper ends.
- The lower spherical ball moves in a socket. The joystick can be moved in all four directions.
- Joystick is mainly used for playing computer games and in Computer Aided Designing (CAD).



Fig. Joystick

C and C++ : C and C++ (pronounced “c plus plus”) are powerful, general-purpose languages developed at Bell Laboratories. The C language was created in 1972 and the C++ language was created in 1983.

C# : Pronounced “c sharp.” This language was created by Microsoft around the year 2000 for developing applications based on the Microsoft .NET platform.

LaTeX : It is a high-quality typesetting system; it includes features designed for the production of technical and scientific documentation. LaTeX is the de facto standard for the communication and publication of scientific documents. LaTeX is available as free software.

Java : It was created by Sun Microsystems in the early 1990s. It can be used to develop programs that run on a single computer or over the Internet from a web server.

JavaScript : It was, created in the 1990s, can be used in web pages. Despite its name, JavaScript is not related to Java.

Python : It is a general-purpose language created in the early 1990s. It has become popular in business and academic applications.

MATLAB : Matrix laboratory is a multi-paradigm numerical computing environment and proprietary programming language developed by MathWorks. MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, C#, Java, Fortran and Python.

Ruby : Ruby is a general-purpose language that was created in the 1990s. It is increasingly becoming a popular language for programs that run on web servers.

Visual Basic : Visual Basic which is commonly known as VB is a Microsoft programming language and software development environment that allows programmers to create Windows based applications quickly. VB was originally created in the early 1990s.

ALGOL: ALGOL, stands for Algorithmic Language was designed by an international committee of the Association of Computing Machinery (ACM) for publishing algorithms as well as for doing computations. It was the most influential of the four high level language mentioned earlier.

Previous ESE Prelims Questions

Q.1 Which type of output device creates coloured images which look and feel like photographs?

- (a) Electrostatic plotter
- (b) Laser printer
- (c) Dye sublimation printer
- (d) Inkjet plotter

[ESE-2018]

Ans. (c)

Q.2 **Statement (I) :** An emulator is not a mixture of hardware and software and it cannot be used to test and debug the hardware and software of an external system.

Statement (II) : Part of the hardware of an emulator is a multiwire cable which connects the host system to the system being developed.

- (a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I)
- (b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I)
- (c) Statement (I) is true but Statement (II) is false
- (d) Statement (I) is false but Statement (II) is true

[ESE-2019]

Ans. (d)

Q.3 The core elements of high-level programming languages are:

- (a) Keywords, Expressions and Punctuation (b) Functions, Keywords and Operators
(c) Keywords, Operators and Punctuation (d) Functions, Expressions and Operators

[ESE-2019]

Ans. (c)

Individual statements that are used in a program in a High-Level Language (HLL) are called statements, and a programming statement nearly in all high-level programming languages (say Application Programming Interfaces or APIs) includes keywords, operators and punctuation. While Machine Level Languages (MLLs) are binary based say Operating System (OS), High Level Languages (HLLs) say multiple Application Programs are based on Alpha-Numerals.

Q.4 Which one of the following systems is used when there are rigid time requirements on the operation of a processor or the flow of data, and thus is often used as a control device in a dedicated application?

- (a) A real-time system (b) A distributed system
(c) A parallel system (d) A serial system

[ESE : 2022]

Ans. (a)

A real time system is used when there are rigid time requirements on the operation of a processor or the flow of data, and thus is often used as a control device in a dedicated application.



Objective Brain Teasers

Q.1 Which of the following technology was introduced in the development of third generation computers?

- (a) Transistors (b) Vacuum tubes
(c) Integrated circuits (d) VLSI

Q.2 Under which one of the following category, does the programming language 'C' fall into?

- (a) Assembly language
(b) Machine language
(c) High level language
(d) None of the above

Q.3 BASIC is abbreviated for

- (a) Beginner's All-purpose Symbolic Instruction Code
(b) Beginner's All-purpose System Information Code
(c) Basic Algorithm Syntax Information Code
(d) Basic Algorithm System Instruction Code

Q.4 Which of the following function is performed by MIDI device?

- (a) It is a method of machine reading characters made of magnetized particles.

- (b) It converts graphical data into binary inputs.
(c) It is used for debugging.
(d) It is designed to transmit information between electronic musical instrument.

Q.5 Consider the following statements:

1. The control unit of the CPU is used to process and store data.
2. ALU of the CPU can perform both arithmetic as well as logic operations.

Which of the following statements is/are correct?

- (a) 1 only (b) 2 only
(c) Both 1 and 2 (d) None of these

Q.6 Consider the following statements:

1. A mainframe computer uses its power to execute a reliable volume of computations concurrently.
2. Super computer uses its power in executing a few programs as fast as possible.

Which of the following statements is/are correct?

- (a) 1 only (b) 2 only
(c) Both 1 and 2 (d) None of these

Answers

1. (c) 2. (c) 3. (a) 4. (d) 5. (b)
6. (c) 7. (a) 8. (d) 9. (d) 10. (a)
11. (a) 12. (d) 13. (b) 14. (c) 15. (c)
16. (b) 17. (a) 18. (d) 19. (c) 20. (c)
21. (c) 22. (b) 23. (c) 24. (a) 25. (b)
26. (a) 27. (c) 28. (b) 29. (d) 30. (b)
31. (d) 32. (c) 33. (b) 34. (a) 35. (b)
36. (c)

Explanations

1. Vacuum tubes: 1st gen; Transistors: 2nd gen; IC: 3rd gen; VLSI: 4th gen
5. The control unit communicates between ALU and memory. It does not process or store data.

12. Dot-matrix and Daisy-wheel are impact printers laser and inkjet are non-impact printers.
13. A non-impact printer places an image on a page without physically touching the screen.
21. Blu laser has shorter wavelength than red laser that is used for CD's. A single Blu-ray can hold upto 25 GB of data.
24. Semiconductory memory are used in primary storage.
30. Windows NT in a system software developed by microsoft.
33. Graphics tablet is an input device which screen is made of CRT.

