

ESE 2025

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 2025 Preliminary Examination :
Information and Communication Technologies (ICT)**

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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

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1.1 Overview of ICT

- ICT or Information and Communication Technology are the various infrastructure and components that used to transmit, process, store, create, display, share or exchange the information by the means of computing.
- Different views on ICT as given by different people and organisation are:
 - (i) **OECD's View:** The term 'Information and Communication Technology' is "used to cover technologies used in the collection, processing and transmission of information. It includes micro-electronic and info-electronic based technologies incorporated in many product and production process and increasingly affecting the service sector.
 - (ii) **UNESCO's View:** "Information and Communication Technology (ICT) is scientific, technological and engineering disciplines and management techniques used in information handling and processing, their application, computer and their interaction with man and machines and associated social, economic and cultural matters".
 - (iii) **Smith and Cambell's View:** "A mosaic of technologies, products and technologies have combined to provide new electronic dimensions to information management. The mosaic is known by the name of information and communication technology".
 - (iv) **Darnton and Gigcoletto's View:** "It is the systematic study of artifacts that can be used to give form or descriptions to facts in order to provide meaning or support for decision making and artificial that can be used for the organization and application of information."
- Information and Communication Technology can be considered to be built on the 4C's: computing, communication, content and capacity. When considering the use of ICT for development, computing and other hardware continue to be less and less expensive, whereas communications, softwares and training make ICT more expensive.
- Information and Communication Technology is much more than computers and the internet or telephony. The Internation Telecommunications Union (ITU) has segmented the world wide ICT market into three categories as Telecom services, software and services and hardware. The issue of "Digital Divide" and "Internet Governance" are of more focus in ICT world today.
- Applications of Information and Communication Technology are divided into two broad categories:
 - (i) The first are those largely dependent on traditional telecommunication networks (including the internet) that enables on-demand communications to provide information tailored to the user's convenience and needs. Distance education programs, e-commerce or e-governance fall into this category.
 - (ii) The second group of Information and Communication Technology applications are human independent, where information is processed and decisions are arrived on the basis of preset criteria without human intervention at the time of decision making. These can nearly be passive systems, or part of a larger system (embedded ICT). Eg-Sensor based networks.

A major challenge is how to design Information and Communication Technology or other complex engineering or societal system such that two applications can be integrated.

1.2 Measuring ICT

- Various organisations have set up different indices for measuring ICT. Data and statistics on ICT are abundant but some of these lack transparency and standardization. Most popular metrics are based on weighted sub-metrics spanning various facts of ICT.
- The Global Information Technology Report (GITR) ranks 82 economies according to Networked Readiness Index (NRI) which measures the “degree of preparation of a nation or community to participate in and benefit from ICT developments”.
- The UNCTAD ICT Development Index (2003) uses a Gini coefficient equivalent to measure ICT distribution inequality.
- The ITU (International Telecommunication Union) published the World Telecommunication Development Report 2003, to provide updated and standardized data on ICT. This report proposes a new Digital Access Index (DAI), a transparent metric encompassing numerous factors including infrastructure, affordability, knowledge, use and quality. It establishes explicit benchmarks such as literacy rates, total international uplinking bandwidth etc to measure DAI for a country.

1.3 ICT and Development

- ICT is viewed as both a means and an end for development. With roughly two-third of the world economy based on services, and rise of many nations as global IT players, many developing nations have accepted ICT as national mission. Even with manufacturing and industry, ICT has an increasingly important role to play.
- The ITU has published a report on how ICT can help in achieving the goals and target in its World Telecommunication Development Report (2003) which can be tabulated as below:

	Goal/Target	Role of ICTs
1.	<p>Eradicate extreme poverty and hunger.</p> <p>Halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day.</p> <p>Halve, between 1990 and 2015, the proportion of people who suffer from hunger.</p>	<p>Increase access to market information and reduce transaction costs for poor farmers and traders.</p> <p>Increase efficiency, competitiveness and market access of developing country firms.</p> <p>Enhance ability of developing countries to participate in global economy and to exploit comparative advantage in factor costs (particularly skilled labor)</p>
2.	<p>Achieve universal primary education Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling.</p>	<p>Increase supply of trained teachers through ICT-enhanced and distance training of teachers and networks that link teachers to their colleagues.</p> <p>Improve the efficiency and effectiveness of education ministries and related bodies through strategic application of technologies and ICT-enabled skill development.</p> <p>Broaden availability of quality educational materials/resources through ICTs.</p>
3.	<p>Promote gender equality and empower women</p>	<p>Deliver educational and literacy programs specifically targeted to poor girls and women using appropriate technologies.</p> <p>Influence public opinion on gender equality through information or communication programs using a range of ICTs.</p>

4.	Reduce Child mortality	Enhance delivery of basic and in-service training for health workers.
5.	Improve material health	
6.	<p>Combat HIV/AIDS, malaria and other diseases</p> <p>Reduce infant and child mortality rates by two-thirds between 1990 and 2015.</p> <p>Reduce material mortality rates by three-quarters between 1990 and 2015.</p> <p>Provide access to all who need reproductive health services by 2015.</p>	<p>Increase monitoring and information sharing on disease and famine.</p> <p>Increase access of rural caregivers to specialist support and remote diagnosis.</p> <p>Increase access to reproductive health information, including information on AIDS prevention, through locally appropriate content in local language.</p>
7.	<p>Ensure environmental sustainability.</p> <p>Implement national strategies for sustainable development by 2005 so as to reverse the loss of environmental resources by 2015.</p> <p>Halve, by 2015, the proportion of people without sustainable access to safe drinking water.</p> <p>Halve achieved, by 2020, a significant improvement in the lives of at least 100 million slum dwellers.</p>	<p>Remote sensing technologies and communications networks permit more effective monitoring, resource management, mitigation of environmental risks.</p> <p>Increase access to/awareness of sustainable development strategies, in areas such as agriculture, sanitation and water management, mining, etc.</p> <p>Greater transparency and monitoring of environmental abuses/enforcement of environmental regulations.</p> <p>Facilitate knowledge exchange and networking among policymakers, practitioners and advocacy groups.</p>

Table: Role of ICT in Achieving Goals

- The table above has been set to achieve the Millennium Development Goals (MDG) through ICT. The role of ICT should be best seen as an enabler, primarily spanning in several dimensions:
 - (a) Efficiency and competitiveness
 - (b) New business models and opportunities
 - (c) Transparency and empowerment
- The value of ICT lies in the gathering, storing and analysing information with greater accuracy and granularity. This enables tailoring development efforts to suit specific social, economic, gender, age and geographic conditions and requirements.

1.4 ICT Targets

- The International Telecommunication Union (ITU) in conjunction with United Nations organized a summit with emphasis on the growing relevance of ICT in the global domain. The summit also called 'The world summit on the information society' brought to the fore front the role of ICT for development. A set of developmental targets were set up in the summit to be achieved on the field of Information and Communication Technology.
- A summary of the targets emerging out of the World Summit on The Information Society (WSIS) are:
 - (i) To connect villages with ICTs and establish community access points.
 - (ii) To connect universities, colleges, secondary schools and primary schools with ICTs.
 - (iii) To connect scientific and research centres with ICTs.
 - (iv) To connect public libraries, cultural centres, museums, post offices and archives with ICTs.
 - (v) To connect health centres and hospitals with ICTs.

- (vi) To connect all local and central government departments and establish websites and e-mail addresses.
- (vii) To adapt all primary and secondary school curricular to meet the channels of the Information Society, taking into account natural circumstances.
- (viii) To ensure that all the world's population have access to television and radio services.
- (ix) To encourage the development of content and to put in place technical conditions in order to facilitate the presence and use of all world languages on the internet.
- (x) To ensure that more than half of the world's population have access to ICT within their reach.
- A set of ICT targets have been seen to accelerate actions on the Sustainable development Goals (SDG) which is expected to be achieved by 2030. To achieve SDGs, ICT needs to be combined with innovative policies, services and solutions to deliver transformation at unprecedented speed and scale. It can be a powerful means of implementation of ICT into five major ways:
 - (i) Accelerated upscaling of critical services in health, education, financial services, smart agriculture and low-carbon energy systems.
 - (ii) Reduced deployment costs addressing urban and rural realities.
 - (iii) Enhanced public awareness and engagement.
 - (iv) Innovation, connectivity, productivity and efficiency across many sectors.
 - (v) Faster upgrading in the quality of services and jobs.

1.5 Technology Mapping with ICT

- Many hypothesis have developed over years to integrate technology with development. In one such hypothesis, in a keynote address, Richard Newton stated that the most ICT for development is simply "trickle down" instead of purposely development regions.
- Any viable solutions for developing countries will involve sizeable investment in R and D, ranging from enabling technologies to applications as shown in figure below:

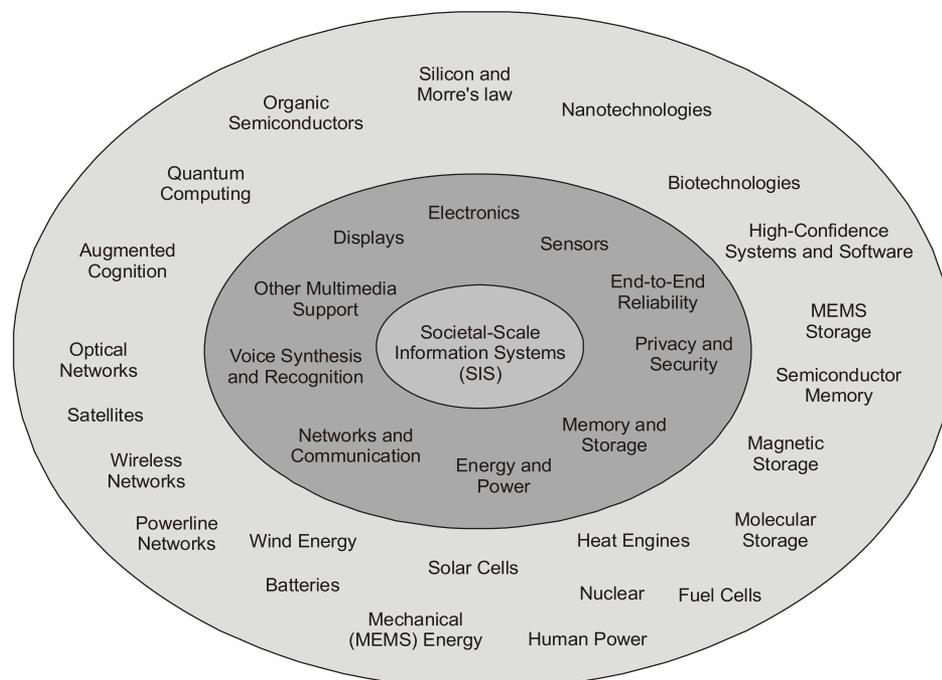


Fig. Components of Societal-Scale Information System

- A generalised model for ICT and R and D is needed to make ICT relevant for development which is entirely within the technology domain.

The generalised model for ICT in technology domain can be presented as:

Sensors (S)	Acquire and convert observations into information in digital formats.
Communication (C)	Reach and richness of networks.
Database/Information Systems (DB/IS)	Global databases of information spanning all media. Availability of information in appropriate formats, language and specifications. Creating knowledge and contextual bases and algorithms for processes and decision-making.
Controllers/Actuators /Effectorss (CTRL)	Effecting change (feedback) in nature and the operating domain.
Human-Computer Interaction (HCI)	Managing and Interfacing with ICT (Includes new devices for ICT-handhelds, all-in-one devices, etc.)

Table: Generalised ICT Model

1.6 Impact of ICT

- The primary ICT components as per the generalised model, where ICT could make major impact on various areas of human and economic development can be illustrated by the following factors:
 1. **Infrastructure Development:** Advanced urban transport, electricity and efficiency and loss/theft reduction, electricity load management etc.
 2. **Basic Human needs Development:** Disaster/weather forecasting and warning, health monitoring and epidemiology, remote medical detection/diagnosis, water management etc.
 3. **Economic Development:** Agricultural/commodity price discovery, expanding markets for rural/traditional goods, drip and advanced irrigation methods etc.
 4. **Empowerment:** Distance and e-learning, e-governance, national and global inclusiveness, digital libraries etc.

1.7 Advantages and Disadvantages of ICT

Advantages of ICT:

1. **Globalization:** It has not only brought the world closer together, but has allowed the world's economy to become a single independent system. This means that not only information can be shared quickly and efficiently, but also bring down barriers of linguistic and geographic boundaries.
2. **Communication:** With the help of IT, communication has become cheaper, quicker and more efficient. Various modes of communication such as mobile phone or internet have generated instantaneous response by simply text messaging or sending an e-mail. The interest has also opened up face-to-face direct communication from different parts of the world.
3. **Cost Effectiveness:** Information technology has helped to computerise the business process, thus streamlining business, to make them extremely cost effective, money-making machines. This in turn increases productivity, which ultimately give rise to profit, resulting in better pay and less strenuous working conditions.
4. **Bridging the Cultural Gap:** Information technology has helped to bridge the cultural gap by helping people from different structures to communicate with one another, allow exchange or views and idea, thus increasing awareness and reducing prejudices.

5. **Round the Clock Service:** Information technology has made it possible for business to be open all the time all over the globe, making purchases from different countries easier and more convenient. It also means one can have goods delivered right into another's doorstep without having to move a single muscle.
6. **Creation of New Jobs:** Probably the best advantages of information technology is the creation of new and interesting jobs like computer programmers, systems analyst, hardware and software developers and web designers are just some of the many new employment opportunities created with the help of IT.

Disadvantages of ICT:

1. **Unemployment:** While information technology may have streamlined the business process, it has also created job redundancies, down sizing and out sourcing. This means that a log of lower and middle level jobs have down away with, causing more people to become unemployed.
2. **Lack of Job Security:** Technology keeps on changing constantly, therefore one has to be in a continuous learning mode.
3. **Domination of Language:** Language like English is dominating over other languages as most of the content on the internet is in English language.
4. **Privacy:** Though information technology may have made communication quicker, easier and more convenient, it has also brought along privacy issues. From cell phone signal interceptions to e-mail hacking, people are now worried about their once private information become public knowledge.
5. **Dominant Culture:** Culture of rich countries are dominating the lives of people of developing or poor nations.
6. **Moral and Ethical Issue:** Information technology has also created problem of morality; younger generation is getting corrupted because of the content of internet.

1.8 ICT Challenges

Several issues that determine the viability of ICT for sustainable development, primarily focused on traditional computing and connectivity are listed below:

1. Digital Divides

- The digital divides is actually a manifestation of other underlying divides, spanning economic, social, geographic, gender and other divides. Attempting to address the digital divide as a cause instead of a symptom of other divides has led to many failure of ICT driven development projects.
- The digital divide is more than differences in availability of hardware and connectivity. The four interrelated feature determine the value of ICT for a user which are as:
 - (i) **Awareness:** People must know what can be done with ICT; they must also be open to using ICT.
 - (ii) **Availability:** ICT must be offered within reasonable proximity, with appropriate hardware/software.
 - (iii) **Accessibility:** Related to the ability to use the ICT (spanning literacy, e-literacy, language, interfaces etc.)
 - (iv) **Affordability:** All ICT usage together should be only a few percent of one's income, this covers life-cycle costs, spanning hardware, software, connectivity, education etc.
- As per Markle Foundation's report on National Strategies of "ICT for development" states, "Digital divides are not just the result of economic differences in access to technologies, but also in cultural capacity and political will to apply these technology for development impact".

2. Hardware and Software Cost

- Until hardware and software cost decreases, ICT may remain beyond the reach of many users. Most of the developing nations may face higher hardware cost due to important duties or other artificial constraints or a lack of local production capabilities.
- While hardware speeds may scale with increase in number of transistors and components on a chip, software scales only with skilled humans. Open-source software has the potential for bringing down software costs, but the interface and use have often been difficult for semi-skilled and un-skilled users.
- So until there is a possibility for developing economies to produce their own software, including building upon existing source code for new programs and applications, this may remain a change to ICT.

3. Connectivity Cost

- As per ITU data report, using dial-up to access the internet can cost more than the average annual Gross National Income (GNI) in many countries. This implies that a shared access model becomes costlier for ICT to be affordable.
- While many worry about basic access (i.e. dial-up) connection, the target should actually be broadband because of higher bandwidth that rich applications and interfaces require. Broadband represents even bigger disparity in prices which creates a major challenge to ICT.

4. Robustness

- Telecommunications equipment is designed to have much higher reliability with about 99.99% uptime or just 5 minutes of downtime per year. However, in developing countries, the reliability of ICT is much lower which is mostly due to failure in electricity, software or other complementary systems, including limited availability of spares.
- From the above and other reasons, manufacture's reliability figures do not translate in to real-world uptimes. Given the complete absence of ICT and other infrastructure in many parts of the world, it would not be unreasonable to consider technology solutions that are slightly less robust or have low functionality by design for dramatically lower costs.

5. Content

- Not only issues such as literacy and multitude of language are yet to be addressed, there are also concerns over control of data, accuracy and transaction costs. In addition, most content is not locally relevant or actionable.
- Today's ICT systems are largely geared towards passive consumption of information, instead of active production of information and content. Non-ICT knowledge networks in rural areas are often peer-to-peer and it is therefore necessary to develop tools to enable people to share information better, combining local knowledge with experts and ICT-enhancements.
- Restrictions on access to content and information are another policy challenge, in addition to the view by many policy-makers that much of the online content is societally inappropriate. This impacts the willingness to use public funds for ICT infrastructure development.

6. Usability and Interface

- The prime means of interfacing with data has been the computer, which assumes a certain level of literacy, both lingual and technical. Until local language and graphical interfaces are improved, users will only be from upper socio-economic strata or developed nations.
- Greater attention needs to be paid to making hardware and software easier to use for even the most sophisticated user. Similar innovation is needed in computer-communication system.

7. Security

- From end user perspectives, issues of privacy, trust and verifiability are key concerns. With the evolution of internet, security is a concern even for uninformed or unaware end-users-it places an implicit cost on all transactions.
- Information security and its aspects encompassing integrity, confidentiality, privacy and assurance is a major concern for all countries, including the developed ones. Due to lack of institutions to tackle cyber security, a few developing nations become victims and also launching pads for a number of attacks.
- An added concern is the physical security of equipment and systems in the field. Even copper cables are often dug out and resold on the market. However with replacement of such wires with wireless technology, such challenges can be mitigated.

8. Internet control, Architecture and Addressing

- One of the major debates ongoing in the ICT and development community is over internet governance. The structure of internet governance largely does not include issues relating accountability and various stakeholders are struggling to define roles and responsibilities.
- From a practical perspective, developing countries face a lack of physical (IP) address space, in addition to issues of internet name space. The current version of Internet Protocol, IPv4 has been unevenly distributed between nations.

1.9 ICT in Daily Life

ICT includes all technical component that are used for handling information and achieving communication. It includes network hardware, communication lines and all necessary software.

We can say, ICT is comprised of information technology, telephony, electronic media and all types of process and transfer of audio and video and all control and managing functions based on network technologies.

The ICT used in various parts of daily services are:

1. Internet services: It includes e-commerce, e-banking and e-governance.

- 'e-commerce' is a form of trade that allow customers to see and purchase products online.
- 'e-banking' allows users to have control over their accounts (view balance and transaction), transactions from one account to another, credit payment, vouchers for mobile phone etc. The benefits are time saving, lower service fee and access from anywhere, anytime.
- 'e-governance' means use of technology to provide better public access to government information, therefore providing citizens their human right of information.

2. e-learning

- It consists of all form of learning or transfer of knowledge based on electronic technologies. It is mostly used to describe a learning technique, in which there is no direct teacher-student contact while using ICT technology.
- Advantages of e-learning is that books come only in text and graphical form on paper, while e-learning materials has multimedia features and the ability to remotely monitor lectures in real-time. One of the best example is students attending the class, which is taking place at some other place with the help of VSAT technology.
- e-learning is advantageous to student as:
 - (i) Adaptive time, place and pace of learning
 - (ii) Access and availability of education

Previous ESE Prelims Question

1. **Statement (I):** Information and Communication Technologies (ICTs) can facilitate improved service delivery and more efficient internal operations.

Statement (II): ICTs can create new opportunities for the marginalized and the vulnerable of society but do not represent a panacea for all development problems.

- (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

Ans. (b)

Statement (I) brings out a broad general utility or positive outcome of Information and Communication Technology (ICT), while Statement (II) puts-forth a real limitation of ICT despite some important utility. So, both statements are only individually true.

[ESE-2020]

- Q.2** Which one of the following involves for the examination of Internet records to track down the identity of someone who posted in a discussion forum on one Website might search for clues to the poster's identity on Facebook, Twitter, and other online sources?

- (a) Pornography (b) Internet filter
 (c) Doxing (d) Internet censorship

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Ans. (c)

Doxing is a way of tracing someone or getting information about an individual using sources on the internet and social engineering techniques.



Objective Brain Teasers

- Q.1** ICT is:
- (a) A processing information for the use of hardware and software.
 (b) Use of hardware and software for distributing useful information.
 (c) Various components that are used to transmit, process, store, create, display or exchange information by means of computing.
 (d) A principle of physical and social sciences for processing of information of many kinds.

- Q.2** Which of the following issues are of important concern in the field of ICT?

1. Digital divide 2. Internet governance
 3. Security 4. Cost of content
 5. Connectivity
 (a) 1, 2 and 4 only (b) 2, 3 and 4 only
 (c) 1, 3 and 4 only (d) All of the above

- Q.3** The scientific methods to store information and arranges it for communication is called:

- (a) Information technology
 (b) Electromagnetic communication
 (c) Telecommunication
 (d) Codes

- Q.4** Which of the following is/are a challenge to the viability of ICT?
1. Robustness
 2. Hardware and software cost
 3. Digital divide
- (a) 3 only (b) 1 and 2 only
(c) 1 and 3 only (d) 1, 2, and 3
- Q.5** Consider the following statements:
1. Information and Communication Technology (ICT) is considered a subset of Information Technology (IT).
 2. The 'right to use' a piece of software is termed as copyright.
- Which of the following statements are correct?
- (a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2
- Q.6** Blog is defined as
- (a) Online music application
 - (b) Internet
 - (c) A personal or corporate website in the form of an online journal
 - (d) A personal or corporate google search
- Q.7** Which of the following facilities are included in information and communication technology:
1. Online learning
 2. Instant messaging
 3. Job security
 4. Distant education
- (a) 1, 2 and 3 only (b) 1, 2 and 4 only
(c) 2, 3 and 4 only (d) 1, 2, 3 and 4
- Q.8** Which of the following is a principle of effective communication?
1. Persuasive and convincing dialogue.
 2. Participation of the audiences.
 3. One-way transfer of information.
 4. Strategic use of informal communication.
- (a) 1, 2 and 3 only (b) 1, 2 and 4 only
(c) 2, 3 and 4 only (d) 1, 2, 3 and 4
- Q.9** The combination of computing, telecommunication and media in a digital atmosphere is referred to as:
- (a) Convergence
 - (b) Integrated media
 - (c) Digital combination
 - (d) Online communication
- Q.10** Which of the following are the benefits of e-learning in ICT?
1. Reduced cost of education
 2. Unlimited repetition of lectures
 3. Adaptive time and place of learning
- (a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3
- Q.11** Which of the following components had a major impact of ICT in its development?
1. Expansion of rural market
 2. Health monitoring and diagnosis
 3. Digital libraries
 4. Transparency
- (a) 1, 2 and 3 only (b) 1, 3 and 4 only
(c) 2, 3 and 4 only (d) 1, 2, 3 and 4

Answers				
1. (c)	2. (d)	3. (a)	4. (d)	5. (d)
6. (c)	7. (b)	8. (c)	9. (a)	10. (d)
11. (d)				

