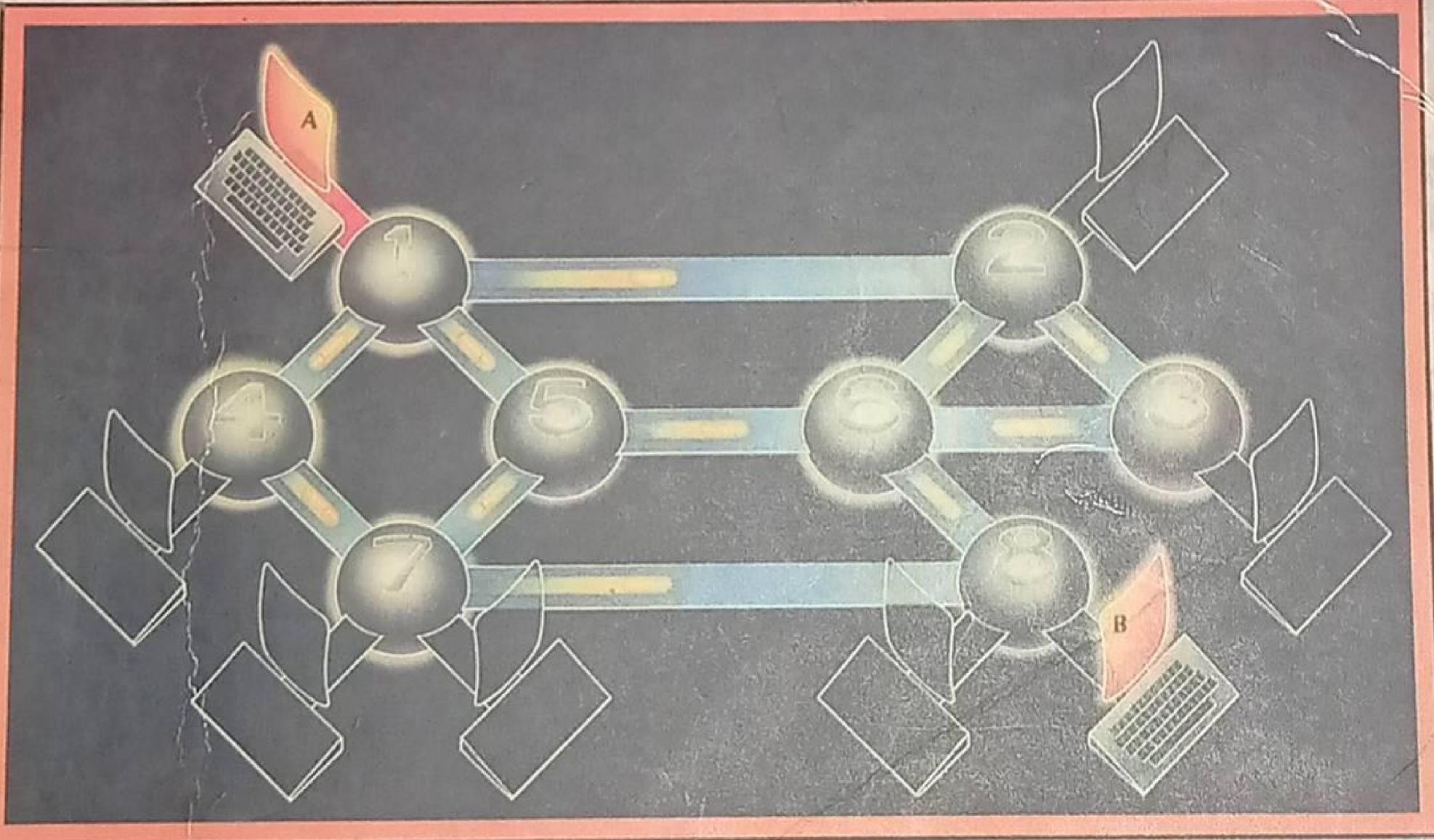


As Per the Syllabus effective from January 2000 Examination for A9 Paper

# DATA COMMUNICATION AND NETWORKING

(According to DOEACC Syllabus for 'A' Level Examination)



Dr. M. Jain  
Satish Jain

# CONTENTS

Preface	vii
Revised Syllabus	ix
Useful Tips for the Examinee	xi

## Part-I Data Communication and Networking Essentials

<b>Chapter 1. Data Communication</b>	<b>3</b>
1.1 INTRODUCTION .....	3
1.2 ANCIENT METHODS OF COMMUNICATIONS AND THEIR DEMERITS .....	4
1.3 ELECTRONIC METHODS OF COMMUNICATIONS .....	4
1.4 COMPUTERISED COMMUNICATIONS .....	4
✓ 1.5 DIGITAL AND ANALOG DATA .....	5
1.5.1 Digital Data .....	5
1.5.2 Analog .....	6
1.5.3 Different Characteristics of Analog and Digital Data Communication .....	6
✓ 1.6 ELECTROMAGNETIC WAVES AND SOUND WAVES .....	6
✓ 1.7 COMMUNICATION SYSTEM .....	7
1.7.1 Advantages of Digital Transmission over Analog Transmission .....	8
✓ 1.8 COMMUNICATION CHANNEL .....	8
1.8.1 Characteristics of an Ideal Communication Channel .....	9
1.8.2 Types of Communication Channels .....	9
1.8.3 Digital Channel Capacity .....	9
✓ 1.8.4 Baud and Bit Rate .....	10
✓ 1.8.5 Maximum Data Rate of a Channel .....	10
✓ 1.9 MULTIPLEXER .....	10
1.9.1 Time division multiplexing (TDM) .....	11
1.9.2 Frequency Division Multiplexing (FDM) .....	12
1.9.3 Space-division Multiplexing .....	13
1.9.4 How to Decide for Multiplexing? .....	13
✓ 1.10 ASYNCHRONOUS AND SYNCHRONOUS DATA .....	13
1.10.1 Asynchronous .....	13
1.10.2 Asynchronous Communications .....	13

1.10.3	Comparison between Asynchronous and Synchronous Transmission .....	14
1.10.4	Efficiency of Data Transmission in Synchronous and Asynchronous Modes .....	16
1.10.5	Cyclic Redundancy Check (CRC) .....	17
1.11	DATA TRANSMISSION MODES .....	18
1.11.1	Simplex .....	18
1.11.2	Half-duplex .....	19
1.11.3	Full-duplex .....	19
	REVIEW QUESTIONS WITH ANSWERS .....	19
	TEST PAPER 1 .....	21
<b>Chapter 2.</b>	<b>Transmission Media</b> .....	<b>26</b>
2.1	INTRODUCTION .....	26
2.2	TWISTED-PAIR WIRE .....	26
2.2.1	Advantages .....	27
2.2.2	Disadvantages .....	27
2.3	COAXIAL CABLE .....	28
2.3.1	Installation .....	30
2.3.2	Advantages of Coaxial Cable .....	31
2.3.3	Trade-off between Coaxial Cable and Twisted-pair Wiring .....	32
	<i>Cost, 32</i>	
	<i>Data Rate, 32</i>	
	<i>Security, 32</i>	
	<i>Electromagnetic compatibility, 32</i>	
2.4	RADIO, VHF, MICROWAVE AND SATELLITE LINK .....	32
2.4.1	Radio Transmission .....	33
	<i>Multiplexing by the Common Carrier, 34</i>	
	<i>Concentrators, 34</i>	
2.4.2	Microwave Transmission .....	35
	<i>Characteristics of Microwave Communications, 36</i>	
	<i>Types of Microwave Communication Systems, 36</i>	
	<i>Terrestrial Microwave, 37</i>	
	<i>Satellite Microwave, 37</i>	
	<i>Advantages and Limitations of EMI, 39</i>	
	<i>VSATs (Very Small Aperture Terminals), 39</i>	
	<i>Iridium System (Low-Orbit Satellites), 40</i>	
2.5	INFRARED AND MILLIMETER WAVES .....	41
2.5.1	Light Wave Transmission .....	42

2.6 OPTICAL FIBER .....	43
2.6.1 Characteristics of Fiber-optic Cable .....	45
Cost, 45	
Installation, 45	
Bandwidth capacity, 45	
Node Capacity, 45	
Attenuation, 45	
Electro Magnetic Interference, 45	
Mode of Transmission, 46	
2.6.2 Uses of Optical Fiber .....	46
2.6.3 Comparison of Fiber Optics and Copper Wire .....	47
Advantages, 47	
Disadvantages, 47	
REVIEW QUESTIONS WITH ANSWERS .....	47
TEST PAPER 2 .....	50
<b>Chapter 3. Data Modems</b> .....	<b>60</b>
3.1 INTRODUCTION .....	60
3.2 CONCEPT OF MODULATION .....	61
3.2.1 Amplitude Modulation .....	62
Advantages, 63	
Disadvantages, 63	
3.2.2 Frequency Modulation .....	63
Advantage, 64	
Disadvantages, 64	
Uses of FM, 64	
3.2.3 Phase Modulation .....	64
Advantages, 64	
Disadvantages, 65	
Uses, 65	
3.2.4 Combining Phase-amplitude Modulation .....	66
Advantages, 66	
3.2.5 Digital Signal Modulation Vs. Analog Signal Modulation .....	67
3.3 AMPLITUDE SHIFT KEYING .....	68
3.4 FREQUENCY SHIFT KEYING (FSK) .....	70
3.4.1 Uses of Modems operating on FSK Principle .....	73
3.4.2 Disadvantage of Low Speed modems .....	74
3.5 PHASE SHIFT KEYING .....	74
3.5.1 Generation of Binary Phase Shift Keying (BPSK) .....	74
3.5.2 BPSK Phase Detector .....	75

3.5.3	Differential Phase-shift Keying .....	76
3.5.4	Binary (Dibit) Coding by Phase Shift .....	77
3.5.5	DPSK Modulator .....	78
3.5.6	Medium Speed Modems .....	79
	<i>V.22 bis Modem, 80</i>	
3.5.7	High-Speed Modems .....	81
	<i>Two Dimensional Eye Pattern and Impairments, 82</i>	
3.6	BASEBAND AND BROADBAND TRANSMISSION .....	82
3.6.1	Baseband .....	84
3.6.2	Broadband .....	84
	REVIEW QUESTIONS WITH ANSWERS .....	84
	TEST PAPER 3 .....	86
	<b>Chapter 4. Multichannel Data Communication</b> .....	95
4.1	INTRODUCTION .....	95
4.2	CIRCUITS, CHANNELS AND CONCEPT OF MULTICHANNELLING .....	97
4.2.1	Frequency Division Multiplexing (FDM) .....	98
4.2.2	FDM GROUPS .....	101
4.2.3	Frequency Division Multiplex Subgroups .....	103
4.3	TIME DIVISION MULTIPLEXING .....	103
4.3.1	Synchronous Time Division Multiplexing (STDM) .....	105
4.3.2	Statistical Time Division Multiplexing (STATDM) .....	105
	<i>Data Compression, 105</i>	
4.3.3	Multichannel TDM .....	107
4.3.4	Sampling using TDM .....	107
4.3.5	Quantization .....	107
4.4	PULSE CODE MODULATION (PCM) .....	108
4.4.1	Converting Voice to Ones and Zeros .....	109
	<i>Stage 1, 109</i>	
	<i>Stage 2, 109</i>	
	<i>Stage 3, 111</i>	
	<i>PCM Transmitter (Block Diagram), 111</i>	
	<i>PCM Decoder, 111</i>	
4.4.2	Sampling Rate .....	112
4.4.3	Natural Sampling .....	113
4.4.4	Sample and Hold .....	113
4.4.5	Coding a Quantized Signal .....	115
4.4.6	Companding .....	116
4.5	CODECS .....	116
	REVIEW QUESTIONS WITH ANSWERS .....	119

TEST PAPER 4 .....	121
<b>Chapter 5. Data Networks</b> .....	<b>128</b>
5.1 INTRODUCTION .....	128
5.2 CIRCUIT SWITCHING .....	128
5.2.1 Difficulties in Circuit Switching .....	129
5.2.2 Message Switching .....	130
5.3 PACKET SWITCHING .....	130
5.3.1 Packet-switching Communication Network .....	131
<i>Data Packets, 132</i>	
<i>Control Packets, 132</i>	
5.3.2 Difference between Packet and Circuit Switching .....	132
5.3.3 Critical Job of a Network Node .....	134
5.3.4 Static Routing of Packets .....	135
<i>Fixed Routing, 136</i>	
<i>Flooding, 137</i>	
<i>Transmission Delay, 137</i>	
<i>Access Delay, 138</i>	
5.3.5 Virtual Circuit versus Circuit Switching .....	138
5.4 PRIVATE BRANCH EXCHANGE (PBX) .....	139
5.4.1 PBX Control Mechanism .....	139
5.4.2 Private Branch Exchange (PBX) Bridges .....	140
5.4.3 Working of a PBX Network .....	141
<i>Communication Session on a PBX System, 142</i>	
5.5 TOPOLOGY .....	143
5.6 DIFFERENT TYPES OF TOPOLOGY .....	143
5.6.1 Linear Bus Topology .....	143
<i>Advantages of the Bus Topology, 144</i>	
<i>Disadvantages of the Bus Topology, 145</i>	
5.6.2 Circular .....	145
<i>Advantages of Ring Topology, 146</i>	
<i>Disadvantages of Ring Topology, 146</i>	
5.6.3 Star .....	146
<i>Advantages of Star Topology, 147</i>	
<i>Disadvantages of Star Topology, 147</i>	
5.6.4 Tree .....	149
5.6.5 Graph .....	151
5.6.6 Star Bus and Star Ring Topology .....	151
<i>Star Bus Network, 151</i>	
<i>Star Ring Network, 151</i>	

5.7 LOGICAL TYPES OF TOPOLOGY .....	151
5.7.1 Ethernet .....	152
CSMA/CD, 152	
Members of Ethernet's Nuclear Family, 152	
5.7.2 Token Ring and FDDI .....	153
5.7.3 Asynchronous Transfer Mode (ATM) .....	155
How ATM Works?, 156	
Role of ATM in Internetworks, 156	
REVIEW QUESTIONS WITH ANSWERS .....	157
TEST PAPER 5 .....	160
<b>Chapter 6. Network Protocols</b>	
6.1 INTRODUCTION .....	172
6.2 PROTOCOL .....	172
6.2.1 OSI Model (Open System Interconnecting) .....	173
Protocol Stacks, 173	
Layer 1 — Physical Layer, 177	
Layer 2 — Data Link Layer, 178	
Layer 3 — Network Layer, 178	
Layer 4 — Transport Layer, 179	
Layer 5 — Session Layer, 180	
Layer 6 — Presentation Layer, 180	
Layer 7 — Application Layer, 181	
Overview of Network Protocols, 181	
Comparison of OSI with Postal Model, 182	
6.2.2 Internetworking .....	184
6.2.3 Host .....	184
6.2.4 Backbone Network .....	184
6.2.5 Repeater .....	185
6.2.6 Bridge .....	186
6.2.7 Router and Brouters .....	188
Difference between Router and Bridge, 189	
Brouter, 189	
6.2.8 Gateway .....	189
Comparison between Routers and Gateways, 190	
6.2.9 Wireless Information Society .....	191
6.3 DATA LINK PROTOCOLS .....	192
6.3.1 Data Link Control Protocol .....	192
6.3.2 Data Link Layer Design Issues .....	192
Services Provided to the Network Layer, 193	

	<i>Services Provided by the Physical Layer to Data Link Layer, 194</i>	
	<i>Flow Control, 196</i>	
6.4	ERROR DETECTION AND ERROR CORRECTION .....	197
6.4.1	Asynchronous Data Error Detection .....	197
6.4.2	Data Correction using Parity .....	197
6.4.3	Error Detection for Synchronous Transmission .....	198
6.4.4	Checksum Error Detection .....	202
6.4.5	Hamming Coding Technique for Error Correction .....	204
6.4.6	XMODEM Protocol .....	206
6.5	LOCAL AREA NETWORKS: ETHERNET AND TOKEN RING .....	207
6.5.1	Ethernet Local Area Networks (CSMA/CD) .....	207
	<i>Physical Layer, 208</i>	
	<i>Physical Layer Interface, 210</i>	
	<i>Data Link Layer, 211</i>	
	<i>System Configurations, 212</i>	
	<i>10BASE-5, 215</i>	
	<i>10BASE-2, 216</i>	
	<i>10BASE-T, 216</i>	
6.5.2	Token-Passing Networks .....	217
6.5.3	Token Ring .....	218
	<i>Hubs (MAUs, MSAUs, and SMAUs), 219</i>	
	<i>How Token Ring Works?, 219</i>	
	<i>Active Monitors and Standby Monitors, 220</i>	
	<i>Beaconing, 220</i>	
6.5.4	FDDI (Fiber Distributed Data Interface) .....	221
	<i>How FDDI Works?, 222</i>	
	<i>FDDI Protocol, 223</i>	
6.6	X.25 PROTOCOL .....	227
6.7	SATELLITE NETWORKS .....	229
6.7.1	Polling .....	229
6.7.2	ALOHA .....	229
6.7.3	FDM .....	231
	<i>Drawbacks of FDM, 232</i>	
	<i>SPADE System, 232</i>	
6.7.4	TDM (Time Division Multiplexing) .....	233
	<i>Earth Station Antennas, 234</i>	
	<i>Drawbacks of TDM System, 235</i>	
6.7.5	CDMA (Code Division Multiple Access) .....	236
6.8	SATELLITE POLARIZED TRANSMISSIONS .....	236

6.9	ISDN (INTEGRATED SERVICES DIGITAL NETWORKS) .....	237
6.9.1	Integrated Service Digital Network (ISDN) Architecture .....	239
6.9.2	Primary Access .....	240
6.9.3	Use of ISDN for Video Conferencing .....	241
6.9.4	Use of ISDN in Graphic Based World Wide Web .....	241
6.10	ARCNET .....	242
6.11	TCP/IP (TRANSMISSION CONTROL PROTOCOL/INTERNET PROTOCOL) .....	242
6.12	SONET (SYNCHRONOUS OPTICAL NETWORK) .....	242
6.13	SWITCHING .....	244
6.13.1	Circuit Switching .....	244
	<i>Difference between Circuit Switching and Packet Switching, 246</i>	
	REVIEW QUESTIONS WITH ANSWERS .....	247
	TEST PAPER 6 .....	249
	<b>Chapter 7. Fibre Optic Communications</b> .....	266
7.1	INTRODUCTION .....	266
7.2	OPTICAL SOURCE .....	266
7.3	PROPAGATION IN FIBER .....	267
7.3.1	Single Mode Optical Fiber .....	267
7.3.2	Multimode Step Index Fiber .....	268
7.3.3	Graded Index Multimode Fiber .....	269
7.4	LIGHT DETECTOR .....	269
7.5	FIBER DISTRIBUTED DATA INTERFACE .....	271
7.6	ADVANTAGES OF FIBER OPTICS CABLES .....	272
7.7	FIBER OPTIC NETWORKS .....	272
7.7.1	Passive Interface .....	272
7.7.2	Active Repeater .....	273
	<i>Comparison of Fiber Optics and Copper Wire, 273</i>	
	<i>Disadvantages of Fiber Cable over Copper Wires, 274</i>	
	REVIEW QUESTIONS WITH ANSWERS .....	274
	TEST PAPER 7 .....	277
	<b>Chapter 8. Data Communication Systems</b> .....	281
8.1	INTRODUCTION .....	281
8.2	FASCIMILE (FAX) .....	281
8.2.1	Optical Scanning Methods .....	281
8.3	SATELLITE COMMUNICATION .....	283
8.3.1	Components of Satellite Communication .....	285
	<i>Ground segment equipment, 285</i>	
	<i>Free space, 285</i>	

<i>Space segment, 285</i>	
8.4 MULTIPLE ACCESS TECHNIQUES .....	285
8.4.1 Frequency Division Multiple Access (FDMA) .....	286
8.4.2 Time Division Multiple Access (TDMA) .....	286
<i>TDMA System, 287</i>	
8.4.3 Code Division Multiple Access .....	288
8.4.4 Earth Stations .....	288
8.5 HUB AND VSAT EQUIPMENT .....	289
8.6 DIGITAL EXCHANGE .....	289
REVIEW QUESTIONS WITH ANSWERS .....	292
TEST PAPER 8 .....	294
<i>Glossary, 299</i>	
<i>Index, 349</i>	

## Part-II DOEACC EXAMINATION QUESTION PAPERS

PAPER 1 DOEACC Examination July, 1997 Question Paper.	3
PAPER 2 DOEACC Examination January, 1998 Question Paper.	8
PAPER 3 DOEACC Examination July, 1998 Question Paper.	13
PAPER 4 DOEACC Examination January, 1999 Question Paper.	18
PAPER 5 DOEACC Examination July, 1999 Question Paper.	23

*Specimen answer sheet for writing answers to Part-One of  
'A' Level Question Papers, 20*