

Contents

Preface

v

1. Useful Tables **1–17**

Weights and Measures 1
 Linear Measure 1
 Cubic or Solid Measure 1
 Square or Land Measure 1
 Avoirdupois Weight 2
 Fluid Memoranda 2
Greek Symbols 2
Physical Constants 3
Prime Numbers 4
Thermometer and Hydrometer Scales 16

2. Algebra **18–24**

Fundamental Properties (Real Numbers) 18
Exponents 19
Fractional Exponents 19
Irrational Exponents 19
Logarithms 19
Factorials 20
Factors and Expansion 20
Progression 21
Complex Numbers 21
Polar Form 22
Permutation 22
Binomial Theorem 23
Combination 23
Algebraic Equations 23

3. Plane Surfaces and Solids **25–28**

Area and Volume 25

| | |
|--|--------------|
| 4. Trigonometry | 29–34 |
| <hr/> | |
| Trigonometric Ratios | 29 |
| Trigonometric Identities | 29 |
| Trigonometric Ratios of Compound Angles | 30 |
| Multiple Angles | 30 |
| Sum and Product Formulae | 30 |
| Submultiple Angles | 31 |
| Inverse Trigonometric Functions | 32 |
| Relation between the Sides and Angles of a Triangle | 33 |
| Trigonometric Functions | 33 |
| 5. Table of Derivatives | 35–38 |
| <hr/> | |
| Derivatives | 35 |
| Additional Relations with Derivatives | 38 |
| Chain Rule | 38 |
| 6. Table of Indefinite and Definite Integrals | 39–42 |
| <hr/> | |
| Standard Integrals | 39 |
| Integrals of the Form $ax + b$ and Trigonometric Forms | 40 |
| Logarithmic and Exponential Forms | 41 |
| Definite Integrals | 42 |
| 7. Vector Analysis | 43–46 |
| <hr/> | |
| Vectors | 43 |
| Vector Differentiation | 44 |
| Divergence Theorem (Gauss) | 45 |
| Stoke's Theorem | 45 |
| Planer Motion in Polar Coordinates | 45 |
| 8. Special Functions | 47–59 |
| <hr/> | |
| Hyperbolic Functions | 47 |
| Gamma Function (Generalized Factorial Function) | 48 |
| Laplace Transforms | 48 |
| z-Transform | 51 |
| z-Transform and the Laplace Transform | 51 |
| Fourier Series | 53 |
| Functions with Period Other than 2π | 54 |
| Bessel Functions | 55 |
| Legendre Polynomials | 56 |
| Laguerre Polynomials | 58 |

| | |
|---------------------|----|
| Hermite Polynomials | 58 |
| Orthogonality | 59 |

9. Statistics 60–65

| | |
|---|----|
| Arithmetic Mean | 60 |
| Median | 60 |
| Mode | 60 |
| Geometric Mean | 60 |
| Harmonic Mean | 60 |
| Variance | 61 |
| Standard Deviation | 61 |
| Coefficient of Variation | 61 |
| Moments | 61 |
| Skewness | 61 |
| Kurtosis | 62 |
| Probability | 62 |
| Conditional Probability and Bayes' Rule | 62 |
| Binomial Distribution | 62 |
| Mean of Binomially Distributed Variable | 63 |
| Poisson Distribution | 64 |
| Probable Error (λ) | 64 |
| Standard Error | 64 |
| Summary of Probability Distributions | 64 |
| Continuous Distributions | 64 |
| <i>F</i> -distribution | 64 |
| Chi-square Test | 65 |
| Students <i>t</i> -Test | 65 |
| Discrete Distribution | 65 |
| Poisson Distribution | 65 |

10. Coordinate Geometry 66–75

| | |
|-------------------------------------|----|
| Rectangular Coordinates | 66 |
| Distance between Two Points (Slope) | 66 |
| Equations of Straight Lines | 67 |
| Distance from a Point to a Line | 69 |
| Circle | 69 |
| Parabola | 69 |
| Orthogonal Spheres | 70 |
| Ellipse | 71 |
| Hyperbola ($e > 1$) | 72 |

Change of Axes 72
Translation 73
Rotation 73
General Equation of Degree Two 74
Polar Coordinates 74

11. Determinants and Matrices **76–81**

Determinants 76
Calculation of Cofactors 77
Properties of Determinants 77
Matrices 78
Operations 78
Transpose 79
Unit Matrix 79
Null Matrix 80
Triangular Matrices 80
Submatrix 80
Symmetric Matrices 80
Skew Symmetric Matrix 80
Complex Conjugate of a Matrix 80
Adjoint Matrix 80
Inverse Matrix 80
Matrix Solution 81

12. Electromagnetics **82–99**

Unit Vectors and Coordinate Systems 82
Electric Field Intensity 83
Coulomb's Laws 83
Electric Field of Many Charges 83
Gauss Law of Electricity 84
Gauss Law in Differential Form 84
Electric Potential 85
Potential Due to Group of Charges 85
Electric Potential Energy 85
Poisson's Equation 86
Current Density 86
Biot-Savart's Law 86
Maxwell's Equations for Static Fields 86
Stoke's Theorem 86
Magnetic Flux Density 87

| | |
|--|--|
| Maxwell's Equations for Static Fields 87 | |
| Maxwell's Equations for Time-varying Fields 87 | |
| Magnetic Deflecting Force 87 | |
| Lorentz Relation 88 | |
| Magnetic Flux Density 88 | |
| Force on a Conductor 88 | |
| Force on a Current Carrying Conductor 89 | |
| Biot-Savart Law (Integral form) 89 | |
| Magnetic Field Due to a Current Carrying Wire 90 | |
| Force between Two Parallel Conductors 90 | |
| Ampere's Law 90 | |
| Ampere's Law in Differential Form 91 | |
| Capacitance of Various Systems 91 | |
| Energy Stored in a Capacitor 92 | |
| Faraday's Laws of Electromagnetic Induction 92 | |
| Lenz's Law 92 | |
| Faraday's Law in Integral Form 92 | |
| Inductance of a Coil 92 | |
| Inductance in Series 93 | |
| Inductance in Parallel 93 | |
| Magnetic Energy Stored in an Inductance 94 | |
| AC Circuits 94 | |
| Periodic Time and Frequency 94 | |
| Form Factor K_f 94 | |
| Peak Factor K_p 94 | |
| Average Value of Sinusoidal Current 94 | |
| RMS Value of Alternating Current 95 | |
| Power Definitions and Relations 95 | |
| Purely Inductive Circuit 95 | |
| Purely Capacitive Circuit 95 | |
| Mesh or Delta Connection 96 | |
| Star Connections 96 | |
| Phase Sequence 96 | |
| Composite Magnetic Circuits 97 | |

13. Circuit Theory and Network**100–113**

| | |
|-------------------------------------|--|
| Electric Current and Voltage 100 | |
| Current Flow in Circuit Element 101 | |
| Resistance and Ohm's Law 101 | |
| Kirchhoff's Laws 101 | |

| | |
|--|-----|
| Equivalent Resistance and Equivalent Conductance | 102 |
| Voltage and Current Divider Circuits | 102 |
| Node Voltages | 102 |
| Mesh Current Analysis | 103 |
| Voltage and Current Source Transformations | 104 |
| The Superposition Principle | 105 |
| Thevenin Theorem | 105 |
| Norton Theorem | 106 |
| Tellegan Theorem | 106 |
| Compensation Theorem | 106 |
| Maximum Power Transfer Theorem | 107 |
| Parallel Generator Theorem | 107 |
| Efficiency of Power Transfer | 108 |
| Star to Delta Transformation | 108 |
| Delta to Star Transformation | 108 |
| Circuits with Energy Storage Elements | 109 |
| Initial Conditions | 113 |
| Final Conditions in Elements Behaviour | 113 |

| | |
|--------------------------------|----------------|
| 14. Electrical Machines | 114–124 |
|--------------------------------|----------------|

| | |
|--|-----|
| DC Generator | 114 |
| Types of DC Generators | 115 |
| Series Wound | 115 |
| Shunt Wound | 115 |
| Compound Wound | 116 |
| DC Motor | 116 |
| Types of DC Motors | 117 |
| Heating and Cooling Equations | 118 |
| Transformers | 119 |
| Induction Motor | 120 |
| Methods of Starting of Induction Motor | 121 |
| Alternator | 122 |
| Converters and Rectifiers | 124 |

| | |
|----------------------------|----------------|
| 15. Instrumentation | 125–129 |
|----------------------------|----------------|

| | |
|--|-----|
| Current and Potential Transformers (CT and PT) | 125 |
|--|-----|

| | |
|--------------------------------|----------------|
| 16. Control Engineering | 130–148 |
|--------------------------------|----------------|

| | |
|--|-----|
| Terminology of the Closed-loop Block Diagram | 130 |
| Automatic Control | 131 |

| | |
|--|--|
| Transfer Function 132 | |
| Vector Locus or Nyquist Diagram 133 | |
| Transient Response 134 | |
| Mason's Gain Formula for Singal Flow Graph 135 | |
| Analogous Quantities 135 | |
| Sensors and Encoders in Control System 136 | |
| Block Reduction 136 | |
| Time Response and Control Systems 138 | |
| Test Functions 139 | |
| Order of Control 139 | |
| Second Order System 140 | |
| Complex Plane: Pole-Zero Maps 141 | |
| Stability 141 | |
| Routh Stability Criterion 142 | |
| The Nyquist Stability Criterion 142 | |
| Bode's Plot 143 | |
| Root Locus 144 | |
| State Space Analysis of Control Systems 145 | |
| Improvement of Response by Cascade Elements 146 | |
| Improvement of Response by Feedback Elements 148 | |

17. Generation, Transmission and Distribution 149–165

| | |
|---|--|
| Characteristics of Turbines 149 | |
| Calculation of HP (Metric) and kW Power 149 | |
| Units of Energy and Relationships 150 | |
| Terms Commonly Used in System Operation 150 | |
| Kelvin's Law: Economic Choice of Conductor Size 152 | |
| The Empirical Formula for Economic Voltage for | |
| Transmission Line 152 | |
| Parameters 153 | |
| Inductance of Two-wire, Single-phase Line 153 | |
| Inductance of Three-wire, Three-phase Line 154 | |
| Inductance of Composite Conductors 154 | |
| Capacitance 154 | |
| Short Transmission Line 155 | |
| Long Transmission Line 156 | |
| Transmission Line As a Two-port Network 156 | |
| ABCD Constants for Transmission Lines 157 | |
| Power Flow on Transmission Lines 157 | |
| Traveling Waves on Transmission Lines 157 | |

| | |
|---|-----|
| Reflection Coefficients | 158 |
| Ferranti Effect | 158 |
| Grading of Cables | 158 |
| Cable Inductance | 160 |
| Cable Capacitance | 160 |
| Important Corona Terms | 161 |
| Visual Critical Voltage | 162 |
| Power Loss Due to Corona | 162 |
| Calculation of Sag | 162 |
| Effect of Wind and Ice Loading | 163 |
| Potential Distribution of Overhead Suspension | |
| Insulator String | 164 |
| String Efficiency | 165 |

| | |
|-----------------------|----------------|
| 18. Protection | 166–172 |
|-----------------------|----------------|

| | |
|--|-----|
| Terms Related to Fault Calculations Per Unit | 166 |
| Unsymmetrical Currents | 167 |
| Restriking Voltage | 167 |
| Current Chopping | 168 |
| Resistance Switching | 168 |
| Active Recovery Voltage | 169 |
| Circuit Breaker Ratings | 169 |
| Inertia Constant and Swing Equation | 170 |
| Constant on a Common MVA Base | 171 |
| Equal Area Criterion | 171 |
| Critical Clearing Angle | 172 |
| A Two Machine System | 172 |

| | |
|---|----------------|
| 19. Induction and Dielectric Heating | 173–177 |
|---|----------------|

| | |
|---------------------------------------|-----|
| Classification of Heating Methods | 173 |
| Resistance Heating | 173 |
| Different Types of Heating Materials | 174 |
| Design of Resistance Heating Elements | 174 |
| Induction Heating | 174 |
| Dielectric Heating | 175 |
| Thermal Losses in Dielectric Heating | 176 |

| | |
|------------------------------|----------------|
| 20. Power Electronics | 178–185 |
|------------------------------|----------------|

| | |
|--|-----|
| Single Phase Separately Excited DC Motor Drive | 178 |
| Basic Equations | 178 |

| | |
|--|-----|
| Continuous Armature Current | 179 |
| Torque Speed Characteristics | 180 |
| Single Phase DC Series Motor Drives | 181 |
| Continuous Motor Current | 182 |
| Three Phase Drives | 183 |
| Basic Equations for Full Converter | 184 |
| Variable Current and Frequency Control | 184 |
| Induction Motor Control by Choppers | 185 |

21. Braking **186–188**

| | |
|----------------------------------|-----|
| Electric Braking | 186 |
| Fundamental Formulae in Dynamics | 187 |
| Time Calculations | 187 |
| Standard Ratings for Motors | 187 |
| Choice of Motor | 188 |

22. Electronics **189–198**

| | |
|--|-----|
| Electron Emission | 189 |
| Commonly Used Thermionic Emitters | 189 |
| Child's Law | 190 |
| Comparison of Valve Constants | 190 |
| Semiconductors | 190 |
| Current in Semiconductor | 190 |
| Semiconductor Diodes | 191 |
| Transistors | 191 |
| Common Base configuration (CB) | 191 |
| Common Emitter Configuration (CE) | 192 |
| Common Collector Configuration (CC) | 192 |
| Comparison of Transistor Configurations | 193 |
| Field Effect Transistors | 193 |
| Bipolar Junction Transistor (BJT) | 193 |
| Ebers–Moll Equations | 194 |
| Hybrid Model | 194 |
| Performance of Linear Circuit in h -Parameters and for Common Emitter Configuration | 195 |
| Integrating Circuit | 195 |
| Differentiator | 196 |
| Half-wave Rectifier | 196 |
| Centre-tap Type Full Wave Rectifier | 196 |
| Three Phase Half-wave Rectifier | 196 |

The m-Phase Rectifier 197
Comparison of Rectifiers 197
SCR With Resistive Load 198
Speed Control of DC Motors 198

23. Digital Logic **199–202**

Digital Logic: Postulates 199
 DeMorgan's Theorem (Inverse of Boolean Function) 200
AND Gate 200
OR Gate 200
NOT Gate 201
NAND Gate 201
Exclusive OR Gate 201
Exclusive NOR Gate 202

24. Communication Systems **203–209**

Half-Power Bandwidth 203
 Amplitude Modulation 203
 Phase and Frequency Modulation 203
Measure of Information 204
 Entropy 204
 The Sampling Theory 204
 Field Mapping 206
 Graphical Solution 207
 Full Vector Notation 208

Appendices **211–229**