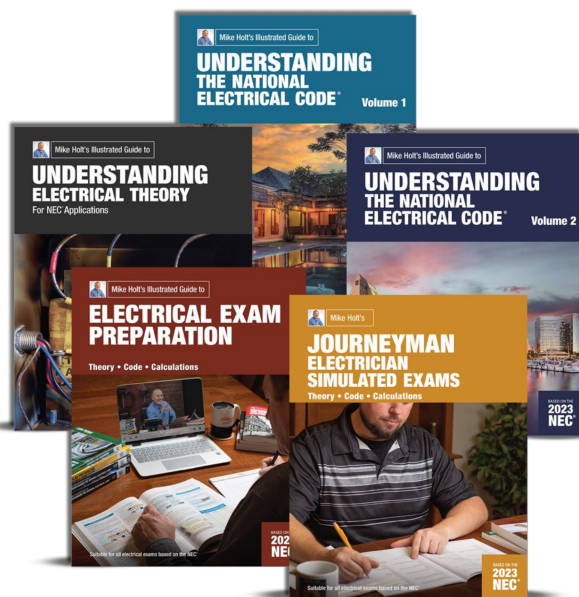


Mike Holt's Journeyman Exam Prep Book Package

Table of Contents

This document includes the Table of Contents from each book that is included in your library. Click on the title to view details of the contents of that book.



Title	page #
Understanding Electrical Theory	2
Understanding the NEC Volume 1 (Art. 90-480).....	6
Understanding the NEC Volume 2 (Art. 500—810).....	16
Electrical Exam Preparation	23
Journeyman Electrician Simulated Exams	27

2023
NEC®



Mike Holt's Understanding Electrical Theory—for NEC Applications

TABLE OF CONTENTS

About This Textbook	ix	4.7	Secondary Distribution Voltage.....	23
Additional Products to Help You Learn	xii	4.8	Service Drop and Service Lateral.....	23
CHAPTER 1—ELECTRICAL FUNDAMENTALS	1	Chapter 1—Practice Questions		25
Unit 1—Atomic Structure	3	CHAPTER 2—USES AND DANGERS OF ELECTRICITY		33
1.1 Introduction.....	3	Unit 5—Uses of Electricity		35
1.2 Atomic Theory.....	3	5.1 Introduction.....		35
1.3 Electrostatic Field.....	4	5.2 Uses of Electricity.....		35
1.4 Atomic Charge of an Atom.....	5	5.3 Electrochemical Processes.....		35
1.5 Electrostatic Charge and Discharge.....	6	5.4 Electromagnetism.....		35
1.6 Lightning.....	7	5.5 Photoelectricity.....		36
1.7 Lightning Protection System.....	8	5.6 Electric Heating.....		37
Unit 2—Electron Theory and Chemical Bonding	9	5.7 Lighting.....		39
2.1 Introduction.....	9	Unit 6—Dangers of Electricity		41
2.2 Electron Orbitals.....	9	6.1 Introduction.....		41
2.3 Valence Electrons.....	9	6.2 <i>National Electrical Code (NEC)</i>		41
2.4 Freeing Valence Electron(s) from an Atom.....	10	6.3 Electrical Fire.....		41
2.5 Conductance.....	10	6.4 Electric Shock.....		42
2.6 Insulators.....	12	6.5 Electric Arc Flash and Arc Blast.....		43
2.7 Semiconductors.....	12	6.6 Arc Flash Incident Energy.....		44
2.8 Chemical Bonding.....	13	6.7 Electrically Safe Work Condition.....		45
Unit 3—Electrical Circuits and Power Sources	15	6.8 Personal Protective Equipment.....		46
3.1 Introduction.....	15	Chapter 2—Practice Questions		49
3.2 The Electrical Circuit.....	15	CHAPTER 3—MAGNETISM AND ELECTROMAGNETISM		55
3.3 Electric Current Flow (Electricity).....	15	Unit 7—Basics of Magnetism		57
3.4 Electrical Power Sources.....	16	7.1 Introduction.....		57
Unit 4—The Electrical System	21	7.2 The Natural Magnet.....		57
4.1 Introduction.....	21	7.3 Magnetic Polarities.....		57
4.2 Source of Electrical Generation.....	21	7.4 Theory of Magnetism.....		58
4.3 Step-Up Transmission Voltage.....	21	7.5 Permanent and Temporary Magnets.....		58
4.4 High-Voltage Transmission Lines.....	22	7.6 Magnetizing and Demagnetizing Magnets.....		58
4.5 Primary Distribution Voltage.....	22			
4.6 Primary Distribution Wires.....	22			

7.7	Magnetic Lines of Force.....	59
7.8	Law of Attraction and Repulsion of Magnets.....	59

Unit 8—Electromagnetism.....61

8.1	Introduction	61
8.2	Electromagnetism in a Wire.....	61
8.3	Electromagnet Field Interaction	62
8.4	Electromagnetic Field Interaction of Wire Loops.....	62
8.5	Electromagnetic Core	63

Unit 9—Uses of Electromagnetism.....65

9.1	Introduction	65
9.2	Motors	65
9.3	Generators.....	66
9.4	Relays.....	66
9.5	Transformers.....	66

Chapter 3—Practice Questions.....67

CHAPTER 4—MATHEMATICS.....71

Unit 10—Basic Math.....73

10.1	Introduction	73
10.2	Whole Numbers.....	73
10.3	Fractional Numbers	73
10.4	Decimal Numbers.....	73
10.5	Percentages.....	74
10.6	Parentheses.....	75
10.7	Squaring a Number	75
10.8	Square Root.....	75
10.9	Kilo.....	76
10.10	Rounding	76
10.11	Surface Area of a Rectangle or Square.....	76
10.12	Surface Area of a Circle.....	77
10.13	Volume	79
10.14	Reciprocal.....	79
10.15	Testing Your Answer.....	79

Unit 11—Trigonometry.....81

11.1	Introduction	81
11.2	Triangles.....	81
11.3	Right Triangle	81
11.4	Pythagorean Theorem.....	82
11.5	Practical Use of Trigonometry	83

Chapter 4—Practice Questions.....85

CHAPTER 5—OHM’S LAW AND WATT’S LAW.....91

Unit 12—Ohm’s Law.....93

12.1	Introduction	93
12.2	The Electrical Circuit.....	93
12.3	Electromotive Force (Pressure).....	93
12.4	Circuit Resistance	94
12.5	Circuit Intensity	95
12.6	Ohm’s Law	95
12.7	Ohm’s Law Formula Circle	96

Unit 13—Watt’s Law.....99

13.1	Introduction	99
13.2	Watt’s Law	99
13.3	Power Formula Circle.....	100
13.4	Power Changes with the Square of the Voltage.....	101

Chapter 5—Practice Questions.....103

CHAPTER 6—ELECTRICAL CIRCUIT TYPES.....107

Unit 14—Series Circuits.....109

14.1	Introduction	109
14.2	Series Circuits.....	109
14.3	Understanding Series Circuits.....	109
14.4	Series Circuit Summary.....	113
14.5	Series-Connected Power Supplies	113
14.6	Applications of Series Circuits.....	114

Unit 15—Parallel Circuits.....117

15.1	Introduction	117
15.2	Understanding Parallel Circuits.....	117
15.3	Parallel Circuit Resistance Calculations	119
15.4	Parallel Circuit Summary.....	122
15.5	Parallel-Connected Power Supplies	122
15.6	Practical Uses of Parallel Circuits.....	123

Unit 16—Series-Parallel Circuits.....125

16.1	Introduction	125
16.2	Understanding Series-Parallel Circuits	125
16.3	Calculating Resistance in Series-Parallel Circuits	126

Chapter 6—Practice Questions.....129

CHAPTER 7—ALTERNATING CURRENT 137

Unit 17—Alternating Current Fundamentals 139

17.1	Introduction	139
17.2	How Alternating Current is Produced	139
17.3	Waveforms	140
17.4	Frequency	143
17.5	In-Phase Waveforms	143
17.6	Out-of-Phase Waveforms	143
17.7	Alternating-Current Waveform Values	144

Unit 18—Inductance 147

18.1	Introduction	147
18.2	How Inductance Works	147
18.3	Self-Inductance	147
18.4	Mutual Inductance	148
18.5	Inductive Reactance	149
18.6	Uses of Induction	150

Unit 19—Capacitance 151

19.1	Introduction	151
19.2	Capacitance in Capacitors	151
19.3	Capacitor Charge and Discharge	152
19.4	Capacitive Reactance	152
19.5	Uses of Capacitors	153

Unit 20—True Power, Power Factor, and Apparent Power 155

20.1	Introduction	155
20.2	True Power	155
20.3	Power Losses of Wires	156
20.4	Power Losses at Terminals	156
20.5	Equipment Efficiency	157
20.6	Cost of Power	158
20.7	Power Factor	159
20.8	Apparent Power	160
20.9	Apparent Power versus True Power	161
20.10	Effects of Power Factor on Circuits	162

Chapter 7—Practice Questions 165

CHAPTER 8—MOTORS, GENERATORS, RELAYS, AND TRANSFORMERS 177

Unit 21—Motors 179

21.1	Introduction	179
21.2	Alternating-Current Motor Principles	179
21.3	Motor Horsepower Rating	180
21.4	Motor Amperes	181
21.5	Motor Nameplate Amperes	182
21.6	Dual-Voltage Motors	184
21.7	Reversing the Rotation of Alternating-Current Motors	185
21.8	Alternating-Current Motor Types	186

Unit 22—Generators 187

22.1	Introduction	187
22.2	Generator Prime Mover	187
22.3	Alternating-Current Generators	187
22.4	Generator Output Current	188
22.5	Single-Phase and Three-Phase Generator Voltages	189
22.6	Electrical Industry Voltages	189

Unit 23—Relays 191

23.1	Introduction	191
23.2	How Relays Operate	191
23.3	Relay Contacts	192

Unit 24—Transformers 193

24.1	Introduction	193
24.2	Types of Transformers	193
24.3	Primary versus Secondary	193
24.4	Transformer Mutual Induction	194
24.5	Secondary Induced Voltage	194
24.6	Transformer Turns Ratios	194
24.7	Isolation Transformer (1:1)	196
24.8	Autotransformer	197
24.9	Transformer kVA Rating	197
24.10	Transformer Current Flow	197
24.11	Transformer Current Rating	197
24.12	Transformer Configurations	200
24.13	Delta/Wye Transformers	201
24.14	Delta/Delta (High-Leg) Transformer	203

Chapter 8—Practice Questions 205

CHAPTER 9—PROTECTIVE DEVICES	215	Unit 28—Multiwire Circuits	249
Unit 25—Overcurrent Protection	217	28.1 Introduction	249
25.1 Introduction	217	28.2 Neutral Wire.....	249
25.2 Overcurrent Protection	217	28.3 Grounded Wire	250
25.3 Fuses	219	28.4 Current Flow on the Neutral Wire.....	250
25.4 Circuit Breakers.....	221	28.5 Multiwire Branch Circuits.....	251
25.5 Overcurrent Protective Devices, Time-Current Curves	222	28.6 Dangers of Multiwire Circuits	253
25.6 Available Short-Circuit Current	223	28.7 NEC Requirements.....	254
25.7 Overcurrent Protective Devices, Interrupting Rating.....	225	Unit 29—The Formula Wheel	255
25.8 Equipment Short-Circuit Current Rating (SCCR).....	225	29.1 Introduction	255
25.9 Coordination of Overcurrent Protective Devices.....	226	29.2 Formula Wheel Quadrants	255
UNIT 26—GFCIs, GFPEs, AFCIs, AND SPDs	229	29.3 Using the Formula Wheel	256
26.1 Introduction	229	Chapter 10—Practice Questions	259
26.2 Ground-Fault Circuit Interrupters (GFCIs).....	229	FINAL EXAM	267
26.3 Special Purpose Ground-Fault Circuit Interrupters (SPGFCIs).....	231	INDEX	279
26.4 Ground-Fault Protection of Equipment (GFPEs)	231	About the Author	283
26.5 Arc-Fault Circuit Interrupters (AFCIs).....	232	About the Illustrator	284
26.6 Clearing Arcing Faults	232	About the Mike Holt Team	285
26.7 Surge Protective Devices (SPDs)	233		
26.8 How Surge Protective Device Functions.....	234		
Chapter 9—Practice Questions	235		
CHAPTER 10—GENERAL KNOWLEDGE	241		
Unit 27—Wire Resistance and Voltage Drop	243		
27.1 Introduction	243		
27.2 Wire Sizes	243		
27.3 Direct-Current Wire Resistance.....	243		
27.4 NEC Wire Direct-Current Resistance.....	244		
27.5 Alternating-Current Wire Resistance	245		
27.6 Alternating-Current Resistance versus Direct-Current Resistance	246		
27.7 Wire Voltage Drop—Ohm's Law Method	246		

Mike Holt's Understanding the 2023 NEC - Volume 1

TABLE OF CONTENTS

About This Textbook	xv	110.17	Servicing and Maintenance of Equipment	81
Additional Products to Help You Learn	xviii	110.20	Reconditioned Equipment.....	82
How to Use the <i>National Electrical Code</i>	1	110.21	Hazard Markings.....	82
Article 90—Introduction to the <i>National Electrical Code</i>	7	110.22	Identification of Disconnecting Means	83
90.1 Scope.....	7	110.24	Available Fault Current Marking	83
90.2 Use and Application of the <i>NEC</i>	7	110.25	Lockable Disconnecting Means	84
90.3 Code Arrangement.....	11	Part II. 1000V, Nominal, or Less		84
90.4 <i>NEC</i> Enforcement	12	110.26	Spaces Around Electrical Equipment	84
90.5 Mandatory Requirements and Explanatory Material	13	110.27	Protection Against Physical Damage.....	95
90.7 Examination of Equipment for Safety	14	110.28	NEMA Enclosure Types.....	95
Article 90—Review Questions	15	Chapter 1—Review Questions		97
CHAPTER 1—GENERAL RULES	17	CHAPTER 2—WIRING AND PROTECTION		101
Article 100—Definitions	19	Article 200—Use and Identification of Grounded Conductors		103
Article 110—General Requirements for Electrical Installations	63	200.1 Scope		104
Part I. General Requirements	63	200.2 General.....		104
110.1 Scope	63	200.4 Neutral Conductor.....		104
110.2 Approval of Conductors and Equipment.....	64	200.6 Identification of Neutral and Grounded Conductors.....		105
110.3 Use of Equipment.....	64	200.7 Use of White or Gray Color		107
110.5 Conductor Material	66	200.10 Receptacle and Screw Shell Terminal		108
110.6 Conductor Sizes	66	Article 210—Branch Circuits		109
110.7 Wiring Integrity.....	66	Part I. General Provisions		109
110.8 Suitable Wiring Methods	66	210.1 Scope		109
110.9 Interrupting Rating of Overcurrent Protective Devices	67	210.3 Other Articles.....		109
110.10 Equipment Short-Circuit Current Rating	68	210.4 Multiwire Branch Circuits.....		109
Available Fault Current	69	210.5 Conductor Identification.....		113
110.11 Deteriorating Agents.....	70	210.6 Branch-Circuit Voltage.....		114
110.12 Mechanical Execution of Work	70	210.7 Multiple Branch Circuits		114
110.13 Mounting and Cooling of Equipment.....	72	210.8 GFCI Protection.....		114
110.14 Conductor Termination and Splicing.....	72	210.11 Branch Circuits Required		125
110.15 High-Leg Conductor Identification.....	79	210.12 Arc-Fault Circuit-Interrupter Protection		128
110.16 Arc-Flash Hazard Warning Label, Other Than Dwelling Units.....	79	210.17 Guest Rooms and Guest Suites.....		131
		Part II. Branch-Circuit Ratings		131
		210.19 Conductor Sizing.....		131
		210.20 Overcurrent Protection		135

210.21	Receptacle Rating.....	136	220.55	Cooking Appliances in Dwelling Units	175
210.23	Multiple-Outlet Branch Circuits.....	137	220.56	Kitchen Equipment Load, Commercial	178
Part III. Required Outlets.....		137	220.57	Electric Vehicle Supply Equipment Load	179
210.50	Receptacle Outlets.....	137	220.60	Noncoincident Loads	179
210.52	Dwelling Unit Receptacle Outlet Requirements.....	138	220.61	Neutral Calculated Load.....	180
210.60	Receptacles in Guest Rooms, Guest Suites, Dormitory Units, and Similar Occupancies.....	145	220.70	Energy Management Systems.....	181
210.62	Show-Window Receptacles	146	Part IV. Optional Method—Feeder/Service Load Calculations	182	
210.63	Equipment Requiring Servicing.....	146	220.82	Optional Load Calculations, Dwellings.....	182
210.65	Meeting Rooms	147	220.84	Optional Load Calculations, Multifamily	183
210.70	Lighting Outlet Requirements.....	148	220.85	Optional Load Calculations, Two-Family Dwelling Units.....	184
			220.87	Determining Existing Loads	184
Article 215—Feeders.....		153	Part VII. Marinas, Boatyards, and Docking Facilities.....	185	
215.1	Scope	153	220.120	Shore Power Receptacle Loads	185
215.2	Conductor Sizing	154	Article 225—Outside Branch Circuits and Feeders.....	187	
215.3	Overcurrent Protection Sizing.....	158	Part I. General	187	
215.6	Feeder Equipment Grounding Conductor.....	159	225.1	Scope	187
215.10	Ground-Fault Protection of Equipment	159	225.6	Minimum Conductor Size and Support.....	187
215.12	Conductor Identification.....	159	225.17	Masts as Supports.....	189
215.15	Barriers	161	225.18	Clearance for Overhead Conductors.....	189
215.18	Surge Protection	161	225.19	Clearances from Buildings	190
			225.22	Raceways on Exterior Surfaces of Buildings	191
Article 220—Branch-Circuit, Feeder, and Service Load Calculations.....		163	225.26	Trees for Conductor Support	191
Part I. General		164	225.27	Raceway Seals	192
220.1	Scope	164	Part II. Buildings or Other Structures Supplied by a Feeder.....	192	
220.3	Application of Other Articles.....	164	225.30	Number of Supplies	192
220.5	Calculations	164	225.31	Disconnecting Means	193
Part II. Branch-Circuit Load Calculations		165	225.33	Maximum Number of Disconnects.....	194
220.11	Maximum Load	165	225.34	Grouping of Disconnects	194
220.14	Other Loads—Occupancies	166	225.37	Identification of Multiple Supplies	194
Part III. Standard Method—Feeder/Service Load Calculations.....		168	225.39	Rating of Disconnecting Means.....	194
220.40	General.....	168	225.41	Emergency (Shutoff) Disconnects	194
220.41	Dwelling Unit(s), Load Calculation	168	225.42	Surge Protection	195
220.42	Lighting Load for Non-Dwelling Occupancies	169	Article 230—Services	197	
220.43	Office Buildings	171	230.1	Scope	198
220.44	Hotel and Motel Occupancies	171	Part I. General	199	
220.45	General Lighting Demand Factors	171	230.2	Number of Services	199
220.46	Show-Window and Track Lighting Loads, Commercial	172	230.3	Not to Pass Through a Building.....	200
220.47	Receptacle Demand Load, Commercial	172	230.6	Conductors Considered Outside a Building or Structure.....	200
220.50	Motor and Air-Conditioning Loads.....	173	230.7	Service Conductors Separate from Other Conductors	201
220.51	Fixed Electric Space-Heating Load	173	230.8	Raceway Seals	201
220.52	Small-Appliance and Laundry Loads, Dwelling	173	230.9	Clearances on Buildings.....	202
220.53	Appliance Demand Load, Dwelling	173	230.10	Vegetation as Support.....	202
220.54	Clothes Dryer Demand Load, Dwelling	174			

Part II. Overhead Service Conductors	202	240.13	Ground-Fault Protection of Equipment	232
230.23	Overhead Service Conductor Size and Rating	203	240.15	Overcurrent Protective Device, Handle Ties
230.24	Vertical Clearance for Overhead Service Conductors	204	Part II. Location of Overcurrent Protective Device	233
230.26	Point of Attachment	204	240.21	Location of Overcurrent Protective Device in Circuit
230.27	Means of Attachment	205	240.22	Grounded-Phase Conductor on Overcurrent Device
230.28	Service Masts as Support	205	240.24	Location of Overcurrent Protective Devices
Part III. Underground Service Conductors	205	Part III. Enclosures Containing Overcurrent Protective Devices	241	
230.30	Installation	206	240.33	Vertical Position, Enclosures
230.31	Underground Service Conductor Ampacity	206	Part V. Plug Fuses, Fuseholders, and Adapters	242
230.32	Protection Against Damage	207	240.51	Edison-Base Fuses
Part IV. Service-Entrance Conductors	207	Part VI. Cartridge Fuses and Fuseholders	242	
230.40	Number of Service-Entrance Conductor Sets	207	240.67	Arc-Energy Reduction—Fuses
230.42	Conductor Sizing	208	Part VII. Circuit Breakers	242
230.43	Wiring Methods	210	240.81	Indicating
230.46	Spliced and Tapped Connections	210	240.83	Markings
230.50	Protection Against Physical Damage	210	240.85	Applications
230.51	Cable Supports	211	240.86	Series Ratings
230.53	Raceways to Drain	211	240.87	Arc-Energy Reduction—Circuit Breakers
230.54	Overhead Service Locations	211		
230.56	High-Leg Conductor Identification	212	Article 242—Overvoltage Protection	247
Part V. Service Disconnect—General	213	Part I. General	248	
230.62	Service Equipment—Barriers	213	242.1	Scope
230.66	Marking for Service Equipment	213	Part II. Surge-Protective Devices (SPDs), 1000V or Less	248
230.67	Surge Protection	214	242.6	Listing
Part VI. Service Disconnect—Disconnecting Means	215	242.8	Short-Circuit Current Rating	248
230.70	Service Disconnect Requirements	215	242.9	Indicating
230.71	Number of Service Disconnects	216	242.12	Uses Not Permitted
230.72	Grouping of Service Disconnects	217	242.13	Type 1 SPDs—Supply Side of Service Equipment
230.79	Rating of Disconnect	218	242.14	Type 2 SPDs—Feeder Circuits
230.82	Connected on Supply Side of the Service Disconnect	218	242.20	Number Required
230.85	Emergency (Shutoff) Disconnect	219	242.24	Routing of Surge-Protective Device Conductors
Part VII. Service Conductor Overcurrent Protection	221	Article 250—Grounding and Bonding	253	
230.90	Overload Protection—Where Required	221	Part I. General	254
230.91	Location	222	250.1	Scope
230.95	Ground-Fault Protection of Equipment	222	250.4	Performance Requirements for Grounding and Bonding
Article 240—Overcurrent Protection	223	Earth Shells	259	
Part I. General	224	250.6	Objectionable Current	260
240.1	Scope	224	Objectionable Current	260
240.3	Other Articles (Overcurrent Protection of Equipment)	225	Dangers of Objectionable Current	262
240.4	Overcurrent Protection of Conductors	225	250.8	Connection of Grounding and Bonding Conductors
240.5	Overcurrent Protection of Flexible Cords, Flexible Cables, and Fixture Wires	230	250.10	Protection of Ground Clamps and Fittings
240.6	Standard Ampere Ratings	230	250.12	Clean Surfaces
240.10	Supplementary Conductor Overcurrent Protection	231		

Part II. System Grounding and Bonding	264	Part VII. Equipment Grounding Conductor Connections	322
250.20 Systems Required to be Grounded	264	250.134 Equipment Connected by Permanent Wiring Methods	322
250.21 Ungrounded Systems	264	250.138 Cord-and-Plug-Connected	323
250.24 Service Grounding	265	250.140 Frames of Ranges, Ovens, and Clothes Dryers.....	323
250.28 Main Bonding Jumper and System Bonding Jumper.....	269	250.146 Connecting Receptacle Grounding Terminal to an Equipment Grounding Conductor.....	323
250.30 Transformer Separately Derived Systems.....	271	250.148 Continuity and Attachment of Equipment Grounding Conductors in Boxes.....	326
250.30 Generator Separately Derived Systems	277	Chapter 2—Review Questions	329
250.32 Buildings Supplied by a Feeder	278		
250.36 Impedance Grounded Systems—480V to 1000V.....	279		
Part III. Grounding Electrode System and Grounding Electrode Conductor	281		
250.50 Grounding Electrode System	281		
250.52 Grounding Electrode Types	281		
250.53 Grounding Electrode Installation	285		
Soil Resistivity	288		
250.54 Auxiliary Grounding Electrodes	288		
250.60 Lightning Protection Electrode	290		
250.62 Grounding Electrode Conductor	290		
250.64 Grounding Electrode Conductor Installation	290		
250.66 Sizing Grounding Electrode Conductors.....	295		
250.68 Grounding Electrode Conductor Connection to Grounding Electrodes	296		
250.70 Grounding Electrode Conductor Termination Fittings.....	298		
Part IV. Enclosure and Raceway	299		
250.80 Service Raceways and Enclosures	299		
250.86 Other than Service Enclosures and Raceways	300		
Part V. Bonding	300		
250.92 Bonding Metal Service Raceways and Enclosures	300		
250.94 Bonding for Communications Systems	303		
250.97 Bonding Metal Raceways and Metal Cables Containing 277V and 480V Circuits.....	304		
250.98 Bonding Loosely Jointed Metal Raceways.....	305		
250.100 Bonding in Hazardous (Classified) Locations	305		
250.102 Bonding Jumper Sizing.....	305		
250.104 Bonding of Piping Systems and Exposed Structural Metal.....	308		
250.106 Lightning Protection Systems.....	312		
Part VI. Equipment Grounding Conductors	312		
250.109 Metal Enclosures, Effective Ground-Fault Current Path.....	312		
250.114 Equipment Connected by Cord and Plug	313		
250.118 Types of Equipment Grounding Conductors.....	313		
250.119 Identification of Wire-Type Equipment Grounding Conductors	318		
250.120 Equipment Grounding Conductor Installation.....	319		
250.122 Sizing Wire-Type Equipment Grounding Conductors.....	319		
		Article 300—General Requirements for Wiring Methods and Materials	339
		Part I. General Requirements	339
		300.1 Scope	339
		300.3 Conductors	340
		300.4 Protection Against Physical Damage.....	342
		300.5 Underground Installations.....	345
		300.6 Protection Against Corrosion.....	348
		300.7 Raceways Exposed to Different Temperatures.....	349
		300.9 Raceways in Wet Locations Above Grade	350
		300.10 Electrical Continuity.....	351
		300.11 Securing and Supporting	351
		300.12 Mechanical Continuity.....	353
		300.13 Mechanical and Electrical Continuity of Conductors— Splices and Pigtails.....	353
		300.14 Conductor Length at Boxes	355
		300.15 Boxes or Fittings, Splices and Terminations	355
		300.17 Number and Size of Conductors in a Raceway.....	357
		300.18 Raceway Installations.....	358
		300.19 Supporting Conductors in Vertical Raceways.....	359
		300.20 Reducing Inductive Heating.....	359
		300.21 Spread of Fire or Products of Combustion	361
		300.22 Wiring in Ducts and Plenum Spaces.....	362
		300.23 Panels Designed to Allow Access	365
		300.25 Exit Stair Towers	365
		Article 310—Conductors for General Wiring	367
		Part I. General	367
		310.1 Scope	367
		310.3 Conductors, Minimum Size and Material.....	367
		Part II. Construction Specifications	369
		310.4 Conductor Construction and Application	369
		310.6 Conductor Identification.....	371

Part III. Installation	372	Part II. Installation	417
310.10 Uses Permitted	372	320.10 Uses Permitted	417
310.12 Dwelling Services and Feeders	374	320.12 Uses Not Permitted	418
310.14 Ampacities for Conductors Rated 0V to 2000V	377	320.15 Exposed Work	418
310.15 Ampacity Tables	378	320.17 Through or Parallel to Framing Members	418
310.16 Ampacities of Insulated Conductors	385	320.23 In Roof Spaces	419
Article 312—Cabinets, Cutout Boxes, and Meter Socket Enclosures	387	320.24 Bending Radius	419
Part I. General	387	320.30 Securing and Supporting	419
312.1 Scope	387	320.40 Boxes and Fittings	420
312.2 Damp or Wet Locations	388	320.80 Conductor Ampacity	421
312.3 Position in Walls	389	Part III. Construction Specifications	422
312.4 Repairing Gaps in Noncombustible Surfaces	389	320.100 Construction	422
312.5 Cable Termination to Enclosures	389	320.108 Equipment Grounding Conductor	422
312.6 Deflection of Conductors	390	Article 330—Metal-Clad Cable (Type MC)	423
312.8 Overcurrent Device Enclosures	391	Part I. General	424
312.10 Screws or Other Fasteners	392	330.1 Scope	424
Part II. Construction Specifications	393	330.6 Listing Requirements	424
312.100 Enclosure Material	393	Part II. Installation	424
Article 314—Boxes, Conduit Bodies, and Handhole Enclosures	395	330.10 Uses Permitted	424
Part I. General	396	330.12 Uses Not Permitted	425
314.1 Scope	396	330.15 Exposed Work	425
314.3 Nonmetallic Boxes	396	330.17 Through or Parallel to Framing Members	425
314.4 Metal Boxes	396	330.23 In Roof Spaces	426
314.5 Screws or Other Fasteners	396	330.24 Bending Radius	426
Part II. Installation	397	330.30 Securing and Supporting	426
314.15 Wet Locations	397	330.80 Conductor Ampacities	427
314.16 Outlet Box Sizing	397	Part III. Construction Specifications	428
314.17 Cables That Enter Boxes	404	330.108 Equipment Grounding Conductor	428
314.20 Flush-Mounted Boxes	405	Article 334—Nonmetallic-Sheathed Cable (Type NM)	431
314.21 Repairing Noncombustible Surfaces	405	Part I. General	432
314.22 Surface Extensions	406	334.1 Scope	432
314.23 Securing Boxes	406	334.6 Listing Requirements	432
314.27 Box Requirements	409	Part II. Installation	432
314.28 Pull Boxes, Junction Boxes, and Conduit Bodies	411	334.10 Type NM Cable, Uses Permitted	432
314.29 Wiring to be Accessible	414	334.12 Uses Not Permitted	433
314.30 Handhole Enclosures	414	334.15 Exposed Work	434
Article 320—Armored Cable (Type AC)	417	334.17 Through or Parallel to Framing Members	435
Part I. General	417	334.19 Cables Entering Enclosures	436
320.1 Scope	417	334.23 Accessible Roof Spaces	436
320.6 Listing Requirements	417	334.24 Bending Radius	436
		334.30 Securing and Supporting	436
		334.40 Boxes and Fittings	437
		334.80 Conductor Ampacity	437

Part III. Construction Specifications	439	342.24	Bends	455
334.108 Equipment Grounding Conductor.....	439	342.28	Reaming	455
Article 336—Power and Control Tray Cable (Type TC) ...	441	342.30	Securing and Supporting	456
Part I. General	441	342.42	Couplings and Connectors	457
336.1 Scope	441	342.46	Bushings	458
336.6 Listing Requirements	442	342.60	Equipment Grounding Conductor.....	459
Part II. Installation	442	Article 344—Rigid Metal Conduit (RMC)	461	
336.10 Uses Permitted.....	442	Part I. General	462	
336.12 Uses Not Permitted.....	443	344.1 Scope	462	
336.24 Bending Radius	443	344.6 Listing Requirements	462	
Article 338—Service-Entrance Cable (Types SE and USE)	445	Part II. Installation	462	
Part I. General	445	344.10 Uses Permitted.....	462	
338.1 Scope	445	344.14 Dissimilar Metals.....	463	
338.6 Listing Requirements	446	344.20 Trade Size	463	
Part II. Installation	446	344.22 Number of Conductors	463	
338.10 Uses Permitted.....	446	344.24 Bends	463	
338.12 Uses Not Permitted.....	447	344.28 Reaming and Threading.....	463	
338.24 Bending Radius	447	344.30 Securing and Supporting	464	
Article 340—Underground Feeder and Branch-Circuit Cable (Type UF)	449	344.42 Couplings and Connectors.....	465	
Part I. General	449	344.46 Bushings	465	
340.1 Scope	449	344.60 Equipment Grounding Conductor.....	466	
340.6 Listing Requirements	450	Article 348—Flexible Metal Conduit (FMC)	467	
Part II. Installation	450	Part I. General	467	
340.10 Uses Permitted.....	450	348.1 Scope	467	
340.12 Uses Not Permitted.....	450	348.6 Listing Requirements	468	
340.24 Bends	450	Part II. Installation	468	
340.80 Ampacity.....	450	348.10 Uses Permitted.....	468	
Part III. Construction Specifications	451	348.12 Uses Not Permitted.....	468	
340.108 Equipment Grounding Conductor.....	451	348.20 Trade Size	468	
340.112 Insulation	451	348.22 Number of Conductors	469	
Article 342—Intermediate Metal Conduit (IMC)	453	348.24 Bends	469	
Part I. General	454	348.28 Trimming.....	469	
342.1 Scope	454	348.30 Securing and Supporting	470	
342.6 Listing Requirements	454	348.42 Couplings and Connectors.....	471	
Part II. Installation	454	348.60 Equipment Grounding and Bonding Conductors.....	471	
342.10 Uses Permitted.....	454	Article 350—Liquidtight Flexible Metal Conduit (LFMC) ... 473		
342.14 Dissimilar Metals.....	455	Part I. General	474	
342.20 Trade Size	455	350.1 Scope	474	
342.22 Number of Conductors	455	350.6 Listing Requirements	474	
		Part II. Installation	474	
		350.10 Uses Permitted.....	474	
		350.12 Uses Not Permitted.....	474	
		350.20 Trade Size	475	

350.22	Number of Conductors	475
350.24	Bends	476
350.28	Trimming	476
350.30	Securing and Supporting	476
350.60	Equipment Grounding and Bonding Conductors	477

Article 352—Rigid Polyvinyl Chloride Conduit (PVC).....479

Part I. General	480
352.1 Scope	480
352.6 Listing.....	480
Part II. Installation	480
352.10 Uses Permitted.....	480
352.12 Uses Not Permitted.....	481
352.20 Trade Size	482
352.22 Number of Conductors	482
352.24 Bends	482
352.28 Trimming	483
352.30 Securing and Supporting	483
352.44 Expansion Fittings.....	484
352.46 Bushings	485
352.48 Joints.....	485
352.60 Equipment Grounding Conductor.....	485

Article 356—Liquidtight Flexible Nonmetallic Conduit (LFNC).....487

Part I. General	488
356.1 Scope	488
356.6 Listing Requirements	488
Part II. Installation	488
356.10 Uses Permitted.....	488
356.12 Uses Not Permitted.....	489
356.20 Trade Size	489
356.22 Number of Conductors	489
356.24 Bends	489
356.30 Securing and Supporting	489
356.42 Fittings	490
356.60 Equipment Grounding Conductor.....	490

Article 358—Electrical Metallic Tubing (EMT).....493

Part I. General	494
358.1 Scope	494
358.6 Listing Requirements	494
Part II. Installation	494
358.10 Uses Permitted.....	494
358.12 Uses Not Permitted.....	495

358.20 Trade Size	495
358.22 Number of Conductors	495
358.24 Bends	496
358.28 Reaming	496
358.30 Securing and Supporting	497
358.42 Couplings and Connectors	497
358.60 Equipment Grounding Conductor.....	498

Article 362—Electrical Nonmetallic Tubing (ENT).....499

Part I. General	500
362.1 Scope	500
362.6 Listing.....	500
Part II. Installation	500
362.10 Uses Permitted.....	500
362.12 Uses Not Permitted.....	502
362.20 Trade Sizes.....	502
362.22 Number of Conductors	502
362.24 Bends	503
362.28 Trimming	503
362.30 Securing and Supporting	503
362.46 Bushings	504
362.48 Joints.....	504
362.60 Equipment Grounding Conductor.....	504

Article 376—Metal Wireways.....505

Part I. General	506
376.1 Scope	506
Part II. Installation	506
376.10 Uses Permitted.....	506
376.12 Uses Not Permitted.....	506
376.20 Conductors Connected in Parallel.....	506
376.21 Size of Conductors.....	507
376.22 Number of Conductors and Ampacity	507
376.23 Wireway Sizing	509
376.30 Supports	509
376.56 Splices, Taps, and Power Distribution Blocks.....	510
376.60 Equipment Grounding Conductor.....	511

Article 380—Multioutlet Assemblies.....513

Part I. General	514
380.1 Scope	514
Part II. Installation	514
380.10 Uses Permitted.....	514
380.12 Uses Not Permitted.....	514
380.76 Through Partitions	514

Article 386—Surface Metal Raceways	515	402.5	Ampacity of Fixture Wires.....	539
Part I. General	515	402.6	Minimum Size.....	540
386.1 Scope.....	515	402.7	Raceway Size.....	540
386.6 Listing Requirements.....	516	402.8	Neutral Conductor.....	540
Part II. Installation	516	402.10	Uses Permitted.....	540
386.10 Uses Permitted.....	516	402.12	Uses Not Permitted.....	540
386.12 Uses Not Permitted.....	516	Article 404—Switches	543	
386.21 Size of Conductors.....	516	Part I. Installation	543	
386.22 Number of Conductors.....	516	404.1 Scope.....	543	
386.30 Securing and Supporting.....	517	404.2 Switch Connections.....	544	
386.56 Splices and Taps.....	517	404.3 Circuit Breaker Enclosures.....	546	
386.60 Equipment Grounding Conductor.....	517	404.4 Damp or Wet Locations.....	546	
Article 392—Cable Trays	519	404.7 Indicating.....	547	
Part I. General	520	404.8 Accessibility and Grouping.....	547	
392.1 Scope.....	520	404.9 General-Use Snap Switches, Dimmers, and Control Switches.....	549	
Part II. Installation	520	404.10 Mounting of Snap Switches, Dimmers, and Control Switches.....	550	
392.10 Uses Permitted.....	520	404.12 Bonding of Enclosures.....	551	
392.12 Uses Not Permitted.....	521	404.14 Rating and Use of Snap Switches.....	551	
392.18 Cable Tray Installations.....	522	Part II. Construction Specifications	552	
392.20 Cable and Conductor Installation.....	522	404.20 Switch Marking.....	552	
392.30 Securing and Supporting.....	523	Article 406—Receptacles, Attachment Plugs, and Flanged Inlets	553	
392.44 Expansion Splice Plates.....	523	406.1 Scope.....	554	
392.46 Bushed Conduit and Tubing.....	523	406.3 Receptacle Rating and Type.....	554	
392.56 Cable Splices.....	523	406.4 General Installation Requirements.....	555	
392.60 Equipment Grounding Conductor.....	524	406.5 Receptacle Mounting.....	557	
Chapter 3—Review Questions	525	406.6 Receptacle Faceplates.....	560	
CHAPTER 4—EQUIPMENT FOR GENERAL USE	531	406.7 Attachment Plugs and Flanged Surface Inlets.....	560	
Article 400—Flexible Cords	533	406.9 Receptacles in Damp or Wet Locations.....	561	
400.1 Scope.....	534	406.11 Connecting Receptacle Grounding Terminal to Equipment Grounding Conductor.....	563	
400.3 Suitability.....	534	406.12 Tamper-Resistant Receptacles.....	563	
400.4 Types of Flexible Cords.....	534	Article 408—Switchboards and Panelboards	565	
400.5 Ampacity of Flexible Cords.....	534	Part I. General	566	
400.10 Uses Permitted.....	534	408.1 Scope.....	566	
400.12 Uses Not Permitted.....	536	408.3 Arrangement of Busbars and Conductors.....	566	
400.13 Splices.....	537	408.4 Circuit Directory and Description.....	567	
400.14 Pull at Joints and Terminals.....	537	408.5 Clearance for Conductors Entering Bus Enclosures.....	569	
400.17 Protection from Damage.....	537	408.6 Short-Circuit Current Rating.....	569	
Article 402—Fixture Wires	539	408.7 Unused Openings.....	569	
402.1 Scope.....	539	408.9 Replacement Panelboards.....	569	
402.2 Other Articles.....	539			
402.3 Types.....	539			

Part II. Switchboards	569	Article 411—Low-Voltage Lighting	585
408.18 Clearances.....	569	411.1 Scope.....	585
Part III. Panelboards	570	411.2 Listing Required.....	585
408.30 Panelboard Rating.....	570	411.3 Voltage Limitations.....	586
408.36 Overcurrent Protection.....	570	411.4 Low-Voltage Lighting Systems.....	586
408.37 Panelboards in Damp or Wet Locations.....	571	411.6 Specific Location Requirements.....	586
408.38 Enclosure.....	571	411.8 Branch Circuit.....	587
408.40 Equipment Grounding Conductor.....	571	Article 422—Appliances	589
408.41 Neutral Conductor Terminations.....	572	Part I. General	589
408.43 Panelboard Orientation.....	572	422.1 Scope.....	589
Article 410—Luminaires	573	422.6 Listing Required.....	589
Part I. General	574	Part II. Branch-Circuit Requirements	590
410.1 Scope.....	574	422.10 Branch Circuits.....	590
410.6 Listing Required.....	574	422.11 Overcurrent Protection.....	590
Part II. Luminaire Locations	574	422.12 Central Heating Equipment.....	591
410.10 Luminaires in Specific Locations.....	574	422.13 Storage Water Heaters.....	591
410.16 Luminaires in Clothes Closets.....	576	422.16 Flexible Cords.....	591
Part III. Luminaire Outlet Boxes and Covers	577	422.18 Support of Ceiling-Suspended (Paddle) Fans.....	594
410.22 Outlet Boxes to be Covered.....	577	422.20 Outlet Boxes to be Covered.....	594
410.24 Connection of Electric-Discharge and LED Luminaires.....	578	Part III. Disconnecting Means	594
Part IV. Luminaire Supports	578	422.30 Disconnect—General.....	594
410.30 Supports.....	578	422.31 Permanently Connected Appliance Disconnects.....	594
410.36 Means of Support.....	579	422.33 Cord-and-Plug-Connected Appliances.....	595
Part V. Grounding (Bonding)	580	Article 424—Fixed Electric Space-Heating Equipment	597
410.44 Connection to the Equipment Grounding Conductor.....	580	Part I. General	597
Part VI. Wiring of Luminaires	581	424.1 Scope.....	597
410.62 Cord-Connected Luminaires.....	581	424.3 Other Articles.....	597
410.71 Disconnecting Means for Fluorescent or LED Luminaires that Utilize Double-Ended Lamps.....	581	424.4 Branch Circuits.....	598
Part X. Special Provisions for Flush and Recessed Luminaires	582	Part III. Electric Space-Heating Equipment	599
410.115 Temperature.....	582	424.19 Disconnecting Means.....	599
410.116 Clearance and Installation.....	582	Part VI. Duct Heaters	599
Part XIV. Track Lighting	583	424.65 Location of Disconnecting Means for Electric Duct Heater.....	599
410.150 Installation.....	583	Article 430—Motor Circuits, Controllers, and Adjustable-Speed Drives	601
410.154 Fastening.....	583	Part I. General	602
Part XVI. Special Provisions for Horticultural Lighting Equipment	583	430.1 Scope.....	602
410.170 General.....	583	430.6 Motor Table FLC versus Motor Nameplate Current Rating.....	602
410.172 Listing.....	583	430.14 Location of Motors.....	603
410.174 Installation and Use.....	583	430.17 Highest Rated Motor.....	603
410.176 Locations Not Permitted.....	583	Part II. Conductor Ampacity	604
410.178 Flexible Cord.....	583	430.22 Motor Conductor Ampacity.....	604
410.180 Fittings and Connectors.....	584	430.24 Several Motors—Conductor Ampacity.....	606
410.182 Equipment Grounding Conductor.....	584		
410.184 GFCI and Special Purpose GFCI Protection.....	584		
410.186 Support.....	584		

Part III. Motor and Branch-Circuit Overload Protection.....	607
430.31 Overload Protection	607
430.32 Overload Protection for Continuous-Duty Motors.....	608
Part IV. Branch-Circuit Short-Circuit and Ground-Fault Protection	609
430.51 General.....	609
430.52 Branch-Circuit Short-Circuit and Ground-Fault Protection.....	610
430.55 Combined Overcurrent Protective Device	613
Part V. Feeder Short-Circuit and Ground-Fault Protection.....	613
430.62 Motor Feeder Protection	613
Part VI. Motor Control Circuits	615
430.72 Overcurrent Protection for Control Circuits.....	615
430.75 Disconnect for Control Circuits.....	615
Part VII. Motor Controllers	616
430.83 Motor Controller Horsepower Rating	616
Part IX. Disconnecting Means	616
430.102 Disconnect Location.....	616
430.107 Motor or Controller Disconnect, Readily Accessible.....	617
430.109 Type of Disconnecting Means.....	618
Part X. Adjustable-Speed Drive Systems	619
430.120 General.....	619
430.122 Conductor Ampacity.....	619
430.124 Overload Protection	620
430.128 Disconnecting Means	620
430.130 Branch-Circuit Short-Circuit and Ground-Fault Protection.....	620
Part XIV. Tables	620
Table 430.248 Full-Load Current, Single-Phase Motors.....	620
Table 430.250 Full-Load Current, Three-Phase Motors	621
 Article 440—Air-Conditioning Equipment.....	 623
Part I. General	624
440.1 Scope	624
440.4 Marking on Hermetic Motor-Compressors and Equipment....	624
440.8 Bathtub and Shower Space	625
440.9 Equipment Grounding Conductor.....	625
Part II. Disconnecting Means	626
440.11 General.....	626
440.14 Location	626
Part III. Overcurrent Protection	626
440.22 Short-Circuit and Ground-Fault Protective Device Size	626
Part IV. Conductor Ampacity	627
440.33 Conductor Ampacity.....	627
 Article 445—Generators.....	 629
445.1 Scope	629
445.6 Listing.....	630
445.11 Marking.....	630
445.13 Conductor Ampacity.....	630
445.19 Emergency Shutdown of Prime Mover	631
 Article 450—Transformers	 633
450.1 Scope	633
450.3 Primary Overcurrent Protection.....	634
450.9 Ventilation	636
450.10 Grounding and Bonding.....	636
450.13 Transformer Accessibility.....	636
450.14 Disconnecting Means	637
 Article 480—Stationary Standby Batteries	 639
480.1 Scope	639
480.4 Battery and Cell Terminations	640
480.9 Battery Support Systems.....	640
480.10 Battery Locations.....	640
480.12 Battery Interconnections.....	641
 Chapter 4—Review Questions	 643
 FINAL EXAM A—STRAIGHT ORDER	 649
FINAL EXAM B—RANDOM ORDER.....	659
 INDEX.....	 669
 About the Author	 678
About the Illustrator	679
About the Mike Holt Team	680

MikeHolt's Understanding the 2023 NEC - Volume 2

TABLE OF CONTENTS

About This Textbook	xii	110.17	Servicing and Maintenance of Equipment	89
Additional Products to Help You Learn	xvi	110.20	Reconditioned Equipment.....	90
How to Use the <i>National Electrical Code</i>	1	110.21	Hazard Markings.....	90
Article 90—Introduction to the <i>National Electrical Code</i>	7	110.22	Identification of Disconnecting Means	91
90.1 Scope	7	110.24	Available Fault Current Marking	92
90.2 Use and Application of the <i>NEC</i>	7	110.25	Lockable Disconnecting Means	92
90.3 Code Arrangement.....	11	Part II. 1000V, Nominal, or Less		92
90.4 <i>NEC</i> Enforcement	12	110.26	Spaces Around Electrical Equipment	92
90.5 Mandatory Requirements and Explanatory Material	13	110.27	Protection Against Physical Damage	103
90.7 Examination of Equipment for Safety	14	110.28	NEMA Enclosure Types.....	104
Article 90—Review Questions	15	Chapter 1—Review Questions		105
CHAPTER 1—GENERAL RULES	19	CHAPTER 5—SPECIAL OCCUPANCIES		125
Article 100—Definitions	21	Article 500—Hazardous (Classified) Locations		127
Article 110—General Requirements for Electrical Installations	71	500.1 Scope—Articles 500 Through 503		128
Part I. General Requirements	71	500.4 Documentation.....		128
110.1 Scope	71	500.5 Classifications of Hazardous (Classified) Locations.....		129
110.2 Approval of Conductors and Equipment.....	72	500.6 Material Groups.....		131
110.3 Use of Equipment.....	72	500.7 Protection Techniques.....		132
110.5 Conductor Material	74	500.8 Equipment.....		134
110.6 Conductor Sizes	74	Article 501—Class I Hazardous (Classified) Locations		137
110.7 Wiring Integrity.....	74	Part I. General		137
110.8 Suitable Wiring Methods	74	501.1 Scope		137
110.9 Interrupting Rating of Overcurrent Protective Devices	75	Part II. Wiring		137
110.10 Equipment Short-Circuit Current Rating	76	501.10 Wiring Methods		137
Available Fault Current	77	501.15 Conduit and Cable Seals		140
110.11 Deteriorating Agents.....	78	501.20 Conductor Insulation.....		146
110.12 Mechanical Execution of Work	78	501.30 Grounding and Bonding.....		146
110.13 Mounting and Cooling of Equipment.....	80	Part III. Equipment		148
110.14 Conductor Termination and Splicing.....	80	501.115 Enclosures Containing Make-and-Break Contact Devices		148
110.15 High-Leg Conductor Identification.....	87	501.125 Motors and Generators		148
110.16 Arc-Flash Hazard Warning Label, Other Than Dwelling Units	88	501.130 Luminaires.....		149
		501.135 Utilization Equipment.....		149
		501.140 Flexible Cords, Class I, Divisions 1 and 2.....		150
		501.145 Receptacles		150

Article 502—Class II Hazardous (Classified)

Locations	153
Part I. General	153
502.1 Scope	153
502.5 Explosionproof Equipment	154
Part II. Wiring	154
502.10 Wiring Methods	154
502.15 Sealing.....	155
502.30 Grounding and Bonding.....	156
Part III. Equipment	157
502.115 Enclosures Containing Make-and-Break Contacts	157
502.125 Motors and Generators	158
502.130 Luminaires	158
502.135 Utilization Equipment.....	159
502.140 Flexible Cords	159
502.145 Receptacles and Attachment Plugs.....	160

Article 511—Commercial Repair and Storage

Garages	161
511.1 Scope	161
511.3 Classification of Hazardous Areas.....	161
511.7 Wiring and Equipment Above Hazardous (Classified) Locations	164
511.8 Wiring Below Hazardous (Classified) Locations	165
511.9 Seals.....	165
511.10 Special Equipment.....	165
511.12 GFCI-Protected Receptacles	166

Article 514—Motor Fuel Dispensing Facilities

514.1 Scope	167
514.3 Classification of Locations	167
514.4 Wiring and Equipment Within Hazardous (Classified) Locations	168
514.7 Wiring and Equipment Above Hazardous (Classified) Locations	168
514.8 Underground Wiring.....	169
514.9 Conduit Seal	169
514.11 Circuit Disconnects.....	170
514.16 Bonding Requirements.....	170

Article 517—Health Care Facilities.....

Part I. General	171
517.1 Scope	171
Part II. Wiring and Protection	173
517.10 Applicability	173
517.12 Wiring Methods.....	174

517.13 Equipment Grounding Conductor for Receptacles and Fixed Electrical Equipment in Patient Care Spaces.....	174
517.16 Isolated Ground Receptacles.....	177
517.18 Category 2 Spaces.....	177

Article 518—Assembly Occupancies

518.1 Scope	179
518.2 General Classifications	179
518.3 Temporary Wiring.....	180
518.4 Wiring Methods	180
518.6 Illumination	181

Article 525—Carnivals, Circuses, Fairs, and Similar Events.....

Part I. General	183
525.1 Scope	183
525.5 Overhead Conductor Clearances.....	183
525.6 Protection of Electrical Equipment.....	184
Part III. Wiring Methods	184
525.20 Wiring Methods	184
525.21 Rides, Tents, and Concessions.....	185
525.22 Outdoor Portable Distribution or Termination Boxes	185
525.23 GFCI-Protected Receptacles and Equipment	185
Part IV. Grounding and Bonding	186
525.32 Portable Equipment Grounding Conductor Continuity.....	186

Article 547—Agricultural Buildings.....

Part I. General	187
547.1 Scope	187
Part II. Installations	188
547.20 Wiring Methods	188
547.22 Equipment Enclosures, Boxes, Conduit Bodies, and Fittings....	188
547.23 Damp or Wet Locations.....	188
547.24 Corrosive Atmosphere.....	188
547.25 Flexible Connections.....	188
547.26 Physical Protection	189
547.27 Equipment Grounding Conductor.....	189
547.28 GFCI Protection of Receptacles.....	189
547.31 Luminaires	190
547.44 Equipotential Planes	190

Article 555—Marinas, Boatyards, and Docking Facilities

Part I. General	193
555.1 Scope	193
555.3 Electrical Datum Plane Distances	194

555.4	Location of Service Equipment	194	Article 620—Elevators	241
555.7	Transformers	195	Part I. General	241
555.10	Electric Shock Hazard Sign.....	195	620.1	Scope
555.11	Motor Fuel Dispensing Stations—Hazardous (Classified)		620.6	GFCI Protection for Receptacles.....
	Locations	195	Part III. Wiring	243
555.12	Repair Facilities—Hazardous (Classified) Locations.....	195	620.22	Branch Circuits for Elevator Car(s).....
555.15	Replacement of Equipment.....	196	620.23	Branch Circuits for Machine Room/Machinery Space
Part II. Marinas, Boatyards, and Docking Facilities		196	620.24	Branch Circuit for Hoistway Pit Lighting and Receptacles
555.30	Electrical Equipment and Connections.....	196	Part IV. Installation of Conductors	244
555.33	Receptacles	197	620.37	Wiring in Elevator Hoistways, Control, and Machine
555.34	Wiring Methods and Installation.....	198		Rooms/Spaces.....
555.35	Ground-Fault Protection (GFPE and GFCI)	199	Part VI. Disconnecting Means and Control	244
555.36	Shore Power Receptacle Disconnecting Means.....	200	620.51	Disconnecting Means
555.37	Equipment Grounding Conductor.....	201	Article 625—Electric Vehicle Power Transfer	
555.38	Luminaires	201	System	247
Article 590—Temporary Installations		203	Part I. General	247
590.1	Scope	203	625.1	Scope
590.2	All Wiring Installations.....	203	625.6	Listed.....
590.3	Time Constraints.....	204	Part III. Installation	248
590.4	General.....	204	625.40	Electric Vehicle Branch Circuit.....
590.5	Listing of Decorative Lighting.....	207	625.41	Overcurrent Protection
590.6	GFCI Protection for Personnel.....	207	625.42	Load.....
590.8	Overcurrent Protective Devices.....	208	625.43	Disconnecting Means
Chapter 5—Review Questions		209	625.48	Interactive Equipment
CHAPTER 6—SPECIAL EQUIPMENT		229	625.49	Island Mode
Article 600—Electric Signs		231	625.52	Ventilation
Part I. General		231	625.54	GFCI
600.1	Scope	231	Part IV. Wireless Power Transfer Equipment	252
600.3	Listing.....	232	625.101	Grounding
600.4	Markings.....	232	625.102	Installation
600.5	Branch Circuits.....	232	Article 630—Electric Welders	255
600.6	Disconnecting Means	233	Part I. General	255
600.7	Grounding and Bonding.....	235	630.1	Scope
600.9	Location	237	630.6	Listing.....
600.21	Ballasts, Transformers, Class 2 Power-Limited Power		630.8	Receptacle, GFCI Protection
	Sources, and Electronic Power Supplies.....	237	Part II. Arc Welders	256
600.24	Class 2 Power-Limited Power Sources	238	630.11	Ampacity of Supply Conductors.....
Article 604—Manufactured Wiring Systems		239	630.12	Overcurrent Protection
604.1	Scope	239	630.13	Disconnecting Means
604.6	Listing Requirements	239	630.15	Grounding of Welder Secondary Circuit
604.7	Installation—Securing and Supporting	239	Part III. Resistance Welders	259
604.10	Uses Permitted.....	240	630.31	Ampacity of Supply Conductor
			630.32	Overcurrent Protection
			630.33	Disconnecting Means

**Article 640—Audio Signal Amplification and
Reproduction Equipment**

Part I. General	263
640.1 Scope	263
640.3 Locations and Other Articles	264
640.4 Protection of Electrical Equipment	264
640.5 Access to Electrical Equipment Behind Panels Designed to Allow Access	264
640.6 Mechanical Execution of Work	264
640.9 Wiring Methods	265
640.10 Audio Systems Near Bodies of Water	265
Part II. Permanent Audio System Installations	265
640.21 Use of Flexible Cords and Flexible Cables	265
640.23 Conduit or Tubing	266

**Article 645—Information Technology
Equipment (ITE)**

645.1 Scope	267
645.3 Other Articles	267
645.4 Special Requirements	268
645.5 Supply Circuits and Interconnecting Cables	268
645.10 Disconnecting Means	269
645.15 Equipment Grounding and Bonding	270

**Article 680—Swimming Pools, Hot Tubs, and
Fountains**

Part I. General Requirements for Pools, Spas, Hot Tubs, and Fountains	272
680.1 Scope	272
680.4 Inspections After Installation	273
680.5 GFCI and SPGFCI Protection	273
680.6 Listing Requirements	274
680.7 Grounding and Bonding	274
680.9 Overhead Conductor Clearance	275
680.10 Electric Pool Water Heaters and Heat Pumps	276
680.11 Underground Wiring	276
680.12 Equipment Rooms, Vaults, and Pits	277
680.13 Equipment Disconnecting Means	277
680.14 Corrosive Environment	277
Part II. Permanently Installed Pools	278
680.20 General	278
680.21 Pool Pump Motors	279
680.22 Receptacles, Luminaires, and Switches	279
680.23 Underwater Pool Luminaires	282
680.24 Junction Box, Transformer, or GFCI Enclosure	285
680.26 Equipotential Bonding	286

680.27 Specialized Equipment	291
680.28 Gas-Fired Water Heaters	291
Part III. Storable Pools	292
680.30 General	292
680.31 Pumps	292
680.32 GFCI Protection	292
680.34 Receptacle Locations	293
680.35 Storable Pools	293
Part IV. Hot Tubs	293
680.40 General	293
680.41 Emergency Shutoff Equipment	294
680.42 Outdoor Installations	294
680.43 Indoor Installations	295
680.44 GFCI or SPGFCI Protection	296
680.45 Permanently Installed Immersion Pools	296
Part V. Fountains	296
680.50 General	296
680.51 Luminaires and Submersible Equipment	297
680.54 Connection to an Equipment Grounding Conductor	298
680.55 Methods of Equipment Grounding	298
680.56 Cord-and-Plug-Connected Equipment	299
680.57 Electric Signs in or Adjacent to Fountains	299
680.58 GFCI Protection of Receptacles	299
680.59 GFCI or SPGFCI Protection for Permanently Installed Nonsubmersible Pumps	299
Part VII. Hydromassage Bathtubs	299
680.70 General	299
680.71 GFCI Protection	300
680.73 Accessibility	300
680.74 Equipotential Bonding	300

Article 690—Solar Photovoltaic (PV) Systems

Part I. General	304
690.1 Scope	304
690.4 General Requirements	304
690.6 Alternating-Current Modules	307
Part II. Circuit Requirements	308
690.7 Maximum PV System Direct-Current Circuit Voltage	308
690.8 Circuit Current and Conductor Sizing	313
690.9 Overcurrent Protection	322
690.11 Arc-Fault Circuit Protection	324
690.12 Rapid Shutdown—PV Circuits on Building	324
Part III. Disconnect	329
690.13 PV System Disconnect	329
690.15 PV Equipment Disconnect/Isolating Device	331

Part IV. Wiring Methods	333	700.4	Capacity and Rating.....	389
690.31 Wiring Methods and Materials.....	333	700.5	Transfer Switch	389
690.32 Component Interconnections	338	700.6	Signals.....	390
690.33 Connectors (Mating).....	338	700.7	Signs.....	390
690.34 Access to Boxes	339	700.8	Surge Protection	390
Part V. Grounding and Bonding	339	Part II. Circuit Wiring		391
690.41 PV System DC Circuit Grounding and Protection.....	339	700.10 Wiring to Emergency Loads.....		391
690.43 Equipment Grounding Conductor.....	340	700.11 Wiring, Class 2-Powered Emergency Lighting Systems		393
690.45 Size of Equipment Grounding Conductors	341	Part III. Sources of Power		393
690.47 Grounding Electrode System	342	700.12 General Requirements.....		393
Part VI. Source Connections	343	Part IV. Emergency System Circuits for Lighting and Power		395
690.56 Identification of Power Sources.....	343	700.15 Loads on Emergency Branch Circuits.....		395
690.59 Connection to Other Power Sources.....	343	700.16 Emergency Illumination.....		395
		700.19 Multiwire Branch Circuits.....		396
		700.27 Class 2 Powered Emergency Lighting Systems		396
Article 691—Large-Scale Photovoltaic (PV) Electric Supply Stations	345	Part VI. Overcurrent Protection		396
691.1 Scope	345	700.30 Accessibility.....		396
691.4 Special Requirements for Large-Scale PV Electric Supply Stations.....	345	700.32 Selective Coordination.....		396
691.5 Equipment.....	346			
691.6 Engineered Design.....	346	Article 701—Legally Required Standby Systems		399
691.7 Conformance of Construction to Engineered Design.....	346	Part I. General		400
691.8 Direct-Current Operating Voltage	346	701.1 Scope		400
691.9 Disconnect for Isolating Photovoltaic Equipment.....	346	701.3 Commissioning and Maintenance		400
691.10 Fire Mitigation.....	347	701.4 Capacity and Rating.....		401
691.11 Fence Bonding and Grounding	347	701.5 Transfer Switches		401
		701.6 Signals.....		401
		701.7 Signs.....		401
Article 695—Fire Pumps	349	Part II. Circuit Wiring		401
695.1 Scope	349	701.10 Wiring		401
695.3 Electric Power Source(s).....	350	Part III. Sources of Power		402
695.4 Continuity of Power.....	351	701.12 General Requirements.....		402
695.5 Transformers	352	Part IV. Overcurrent Protection		402
695.6 Power Wiring	352	701.30 Accessibility.....		402
695.7 Fire Pump Controller Voltage Drop.....	354	701.32 Selective Coordination.....		403
695.10 Listed Equipment	355			
695.12 Equipment Location.....	355	Article 702—Optional Standby Systems		405
695.14 Control Wiring.....	355	Part I. General		405
695.15 Surge Protection	355	702.1 Scope		405
Chapter 6—Review Questions	357	702.4 Capacity and Rating.....		406
		702.5 Interconnection Equipment or Transfer Equipment		407
		702.7 Signs.....		408
CHAPTER 7—SPECIAL CONDITIONS	385	Part II. Circuit Wiring		409
Article 700—Emergency Systems	387	702.10 Wiring		409
Part I. General	388	702.12 Outdoor Generators		409
700.1 Scope	388			
700.3 Tests and Maintenance	389			

Article 705—Interconnected Electric Power

Production Sources	411
Part I. General	411
705.1 Scope	411
705.6 Equipment Approval	412
705.8 System Installation	414
705.10 Identification of Parallel Power Production Sources	414
705.11 Service Connection	415
705.12 Load-Side Source Connection	417
705.13 Energy Management Systems	423
705.20 Power Production Source Disconnect	423
705.25 Wiring Methods	424
705.28 Output Current and Circuit Sizing	425
705.30 Overcurrent Protection	426
705.32 Ground-Fault Protection	428
705.40 Loss of Primary Source	429
705.45 Unbalanced Interconnections	429
Part II. Microgrid Systems	430
705.50 Microgrid System Operation	430
705.60 Connections to the Primary Source	431
705.70 Microgrid Interconnect Devices (MID)	432
705.76 Microgrid Control System (MCS)	432

Article 706—Energy Storage Systems

Part I. General	433
706.1 Scope	433
706.3 Qualified Personnel	433
706.4 System Nameplate Requirements	434
706.5 Listing	435
706.6 Multiple Systems	435
706.7 Commissioning and Maintenance	435
Part II. Disconnect	436
706.15 Disconnect	436
706.16 ESS in Parallel with Other Sources of Power	439
Part III. Installation Requirements	439
706.20 General Installation Requirements	439
Part IV. Energy Storage System Circuit Requirements	440
706.30 Circuit Current Rating	440
706.31 Overcurrent Protection	441

Article 710—Stand-Alone Systems

710.1 Scope	443
710.6 Equipment Approval	444
710.10 Identification of Power Sources	444
710.12 Stand-Alone Inverter Input Circuit Current	444
710.15 Wiring	444

Article 722—Cables for Power-Limited Circuits

Part I. General	445
722.1 Scope	445
722.3 Other Articles	446
722.21 Electrical Equipment Behind Access Panels	448
722.24 Mechanical Execution of Work	448
722.25 Abandoned Cable	451
722.135 Installation of Power-Limited Cables	451
Part II. Listing Requirements	454
722.179 Listing and Marking of Power-Limited Cables	454

Article 724—Class 1 Power-Limited Circuits

Part I. General	457
724.1 Scope	457
724.30 Class 1 Circuit Identification	457
724.40 Class 1 Power Source	458
724.43 Class 1 Circuit Overcurrent Protection	458
724.45 Class 1 Circuit Overcurrent Protective Device Location	458
724.46 Class 1 Circuit Wiring Methods	459
724.48 Conductors of Different Circuits in Same Cable, Cable Tray, Enclosure, or Raceway	459
724.49 Class 1 Circuit Conductors	459
724.51 Number of Conductors in a Raceway	459

Article 725—Class 2 Power-Limited Circuits

Part I. General	461
725.1 Scope	461
725.31 Safety-Control Equipment	462
Part II. Class 2 Circuit Requirements	462
725.60 Power Sources for Class 2 Circuits	462
725.127 Wiring Methods on Supply Side of the Class 2 Power Source	463
725.130 Wiring Methods on Load Side of the Class 2 Power Source	463
725.136 Separation from Power Conductors	463
725.139 Conductors of Different Circuits in Same Cable, Enclosure, Cable Tray, and Raceway	465
725.144 Bundling Cables Transmitting Power and Data	466

Article 760—Fire Alarm Systems

Part I. General	469
760.1 Scope	469
760.3 Other Articles	470
760.21 Access to Electrical Equipment Behind Panels Designed to Allow Access	472
760.24 Mechanical Execution of Work	472

760.25	Abandoned Cables.....	473	800.154	Applications of Listed Communications Wires, Coaxial Cables, and Raceways.....	511
760.30	Fire Alarm Circuit Identification.....	473	800.170	Plenum Cable Ties.....	511
760.33	Supply-Side Overvoltage Protection.....	474	Article 810—Antenna Systems.....		513
760.35	Fire Alarm Circuit Requirements.....	474	Part I. General.....		513
Part III. Power-Limited Fire Alarm (PLFA) Circuits.....		474	810.1	Scope.....	513
760.121	Power Sources for Power-Limited Fire Alarm Equipment.....	474	810.3	Other Articles.....	514
760.124	Marking.....	475	Part II. Receiving Equipment—Antenna Systems.....		514
760.127	Wiring Methods on Supply Side of the Power-Limited Fire Alarm Source.....	476	810.13	Avoid Contact with Conductors of Other Systems.....	514
760.130	Load Side of the Power-Limited Fire Alarm Power Source.....	476	810.15	Metal Antenna Supports—Bonding.....	514
760.136	Separation from Power Conductors.....	476	810.18	Clearances.....	515
760.143	Support of PLFA Cables.....	476	810.20	Antenna Discharge Unit.....	515
Article 770—Optical Fiber Cables.....		479	810.21	Bonding Conductors and Grounding Electrode Conductors.....	516
Part I. General.....		479	Part III. Amateur and Citizen Band Transmitting and Receiving Stations—Antenna Systems.....		518
770.1	Scope.....	479	810.51	Other Sections.....	518
770.3	Other Articles.....	480	810.57	Antenna Discharge Units—Transmitting Stations.....	518
770.21	Access to Electrical Equipment Behind Panels Designed to Allow Access.....	480	810.58	Bonding Conductors and Grounding Electrode Conductors—Amateur and Citizen Band Transmitting and Receiving Stations.....	518
770.24	Mechanical Execution of Work.....	480	Chapter 8—Review Questions.....		519
770.25	Abandoned Cable.....	481	FINAL EXAM A STRAIGHT ORDER.....		523
770.26	Spread of Fire or Products of Combustion.....	481	FINAL EXAM B RANDOM ORDER.....		533
Part V. Installation Methods Within Buildings.....		482	INDEX.....		545
770.133	Installation of Optical Fiber Cables and Electrical Conductors.....	482	About the Author.....		552
Chapter 7—Review Questions.....		485	About the Illustrator.....		553
CHAPTER 8—COMMUNICATIONS SYSTEMS.....		503	About the Mike Holt Team.....		554
Article 800—General Requirements for Communications Systems.....		505			
Part I. General.....		506			
800.1	Scope.....	506			
800.3	Other Articles.....	506			
800.21	Access to Electrical Equipment Behind Panels Designed to Allow Access.....	506			
800.24	Mechanical Execution of Work.....	506			
800.25	Abandoned Cable.....	507			
800.26	Spread of Fire or Products of Combustion.....	508			
Part II. Wires and Cables Outside and Entering Buildings.....		509			
800.53	Separation from Lightning Conductors.....	509			
Part IV. Installation Methods Within Buildings.....		509			
800.110	Raceways.....	509			
800.113	Installation of Communications Wires, Cables, and Raceways.....	509			
800.133	Installation of Coaxial Cables and Equipment.....	510			

Mike Holt's 2023 Electrical Exam Preparation

TABLE OF CONTENTS

About This Textbook.....	ix
Passing Your Exam.....	xiii
Additional Products to Help You Learn.....	xix
How to Use the <i>National Electrical Code</i>	1

THEORY

MODULE I—ELECTRICAL FUNDAMENTALS..... 7

Unit 10—Basic Math	9
10.1 Introduction	9
10.2 Whole Numbers.....	9
10.3 Fractional Numbers	9
10.4 Decimal Numbers.....	9
10.5 Percentages.....	10
10.6 Parentheses.....	11
10.7 Squaring a Number	11
10.8 Square Root.....	11
10.9 Kilo.....	11
10.10 Rounding	12
10.11 Surface Area of a Rectangle or Square	12
10.12 Surface Area of a Circle.....	13
10.13 Volume.....	14
10.14 Reciprocal	15
10.15 Testing Your Answer	15
Unit 10—Review Questions	16
Unit 12—Ohm's Law	19
12.1 Introduction	19
12.2 The Electrical Circuit.....	19
12.3 Electromotive Force (Pressure).....	19
12.4 Circuit Resistance	20
12.5 Circuit Intensity.....	21
12.6 Ohm's Law	21
Unit 12—Review Questions	23

Unit 13—Watt's Law	25
13.1 Introduction	25
13.2 Watt's Law	25
13.3 Power Formula Circle.....	26
13.4 Power Changes with the Square of the Voltage.....	27
Unit 13—Review Questions	28
Unit 14—Series Circuits	31
14.1 Introduction	31
14.2 Series Circuits.....	31
14.3 Understanding Series Circuits	31
14.4 Series Circuit Summary.....	34
14.5 Series-Connected Power Supplies	35
14.6 Applications of Series Circuits	36
Unit 14—Review Questions	37
Unit 15—Parallel Circuits	39
15.1 Introduction	39
15.2 Understanding Parallel Circuits	39
15.3 Parallel Circuit Resistance Calculations	41
15.4 Parallel Circuit Summary.....	44
15.5 Parallel-Connected Power Supplies	44
15.6 Practical Uses of Parallel Circuits.....	45
Unit 15—Review Questions	47
Unit 16—Series-Parallel Circuits	51
16.1 Introduction	51
16.2 Understanding Series-Parallel Circuits	51
16.3 Calculating Resistance in Series-Parallel Circuits	51
Unit 16—Review Questions	53
Unit 17—Alternating Current Fundamentals	55
17.1 Introduction	55
17.2 How Alternating Current is Produced	55
17.3 Waveforms	56
17.4 Frequency	58
17.5 In-Phase Waveforms	59
17.6 Out-of-Phase Waveforms	59
17.7 Alternating-Current Waveform Values	60
Unit 17—Review Questions	63

Unit 20—True Power, Power Factor, and Apparent Power	67
20.1 Introduction	67
20.2 True Power	67
20.3 Power Losses of Wires	67
20.4 Power Losses at Terminals	68
20.5 Equipment Efficiency	69
20.6 Cost of Power	69
20.7 Power Factor	70
20.8 Apparent Power	72
20.9 Apparent Power versus True Power	73
Unit 20—Review Questions	74
Unit 21—Motors	77
21.1 Introduction	77
21.3 Motor Horsepower Rating	77
21.5 Motor Nameplate Amperes	78
21.7 Reversing the Rotation of Alternating-Current Motors	79
21.8 Alternating-Current Motor Types	80
Unit 21—Review Questions	81
Unit 22—Generators	83
22.1 Introduction	83
22.4 Generator Output Current	83
22.5 Single-Phase and Three-Phase Generator Voltages	84
Unit 22—Review Questions	85
Unit 23—Relays	87
23.1 Introduction	87
23.2 How Relays Operate	87
23.3 Relay Contacts	88
Unit 23—Review Questions	89
Unit 24—Transformers	91
24.1 Introduction	91
24.6 Transformer Turns Ratios	91
24.8 Autotransformers	93
24.11 Transformer Current Rating	93
Unit 24—Review Questions	97
Unit 25—Overcurrent Protection	101
25.1 Introduction	101
25.6 Available Short-Circuit Current	101
25.7 Overcurrent Protective Devices, Interrupting Rating	103
Unit 25—Review Questions	104

Unit 29—The Formula Wheel	105
29.1 Introduction	105
29.2 Formula Wheel Quadrants	105
29.3 Using the Formula Wheel	106
Unit 29—Review Questions	108
Module I—Electrical Fundamentals—Practice Exam	111
Module I—Electrical Fundamentals Section Reference Index	117

CODE

MODULE II—NEC REVIEW QUESTIONS	119
<i>NEC Article 90—Introduction to the National Electrical Code Review Questions</i>	121
<i>NEC Chapter 1—General Rules Review Questions</i>	123
<i>NEC Chapter 2—Wiring and Protection Review Questions</i>	130
<i>NEC Chapter 3—Wiring Methods and Materials Review Questions</i>	155
<i>NEC Chapter 4—Equipment for General Use Review Questions</i>	172
<i>NEC Chapter 5—Special Occupancies Review Questions</i>	185
<i>NEC Chapter 6—Special Equipment Review Questions</i>	192
<i>NEC Chapter 7—Special Conditions Review Questions</i>	199
<i>NEC Chapter 8—Communications Systems Review Questions</i>	219
Module II—NEC Review Questions—Practice Exam	225
Module II—NEC Review Questions Code Rule Index	235

CALCULATIONS

MODULE III—NEC CALCULATIONS	239
Unit 1—Raceway Calculations	241
1.1 Conductor Cross-Sectional Area—Chapter 9, Tables 5 and 8	241
1.2 Raceway Properties	245
1.3 Sizing Raceways, Conductors all the Same Size—Annex C	247
1.4 Raceways Sizing with Different Size Conductors	251
1.5 Multiconductor and Optical Fiber Cables—Chapter 9, Note (5) and Note (9)	253
1.6 Wireways and Cable Tray Systems	254
1.7 Tips for Raceway Calculations	258
Unit 1—Review Questions	259

Unit 2—Box Calculations	265
Part A—Outlet Box Sizing	265
Introduction.....	265
2.1 Box Sizing—Conductors All the Same Size [Table 314.16(A)].....	266
2.2 Outlet Box Fill Calculations [314.16(B)].....	267
2.3 Outlet Box Sizing, Examples [314.16(B)].....	271
2.4 Tips for Outlet Box Sizing	272
Part B—Pull and Junction Boxes	273
Introduction.....	273
2.5 Pull/Junction Box Sizing Requirements	273
2.6 How to Size Pull/Junction Boxes.....	275
2.7 Pull Box Sizing Examples.....	275
2.8 Tips for Pull Box Sizing	277
Unit 2—Review Questions	279
Unit 3—Conductor Sizing and Protection Calculations	283
Part A—Conductor Insulation, Terminals, and Overcurrent Protection	283
Introduction.....	283
3.1 Conductor Insulation [Table 310.4(1)]	283
3.2 Conductor Sizes	284
3.3 Conductor Size—Equipment Terminal Rating [110.14(C)].....	285
3.4 Overcurrent Protection of Conductors [240.4]	288
Part B—Conductor Ampacity and Protection	290
Introduction.....	290
3.5 Conductor Ampacity Table [310.15(A)].....	290
3.6 Conductor Ampacity Correction [310.15(B)(1)]	290
3.7 Conductor Ampacity Adjustment [310.15(C)(1)].....	292
3.8 Ampacity Correction and Adjustment [310.15].....	294
3.9 Neutral Current-Carrying Conductor [310.15(E)]	295
3.10 Branch Circuit Conductor Sizing [210.19(A)(1)]	297
3.11 Branch Circuit Conductor Sizing—Loads	298
3.12 Branch Circuit Overcurrent Protection Sizing [210.20(A)].....	299
3.13 Feeder Conductor Sizing [215.2(A)(1)].....	300
3.14 Feeder Neutral Conductor Size [215.2(A)(1) Ex 3].....	301
3.15 Feeder Overcurrent Protection Sizing [215.3]	302
3.16 Feeder Tap Rules [240.21(B)]	302
Unit 3—Review Questions	307
Unit 4—Motor, Air-Conditioning, and Transformer Calculations	315
Part A—Motor Calculations	315
Introduction.....	315
4.1 Motor Full-Load Current (FLC)	315
4.2 Motor Full-Load Current and Motor Nameplate Current Rating [430.6(A)].....	317
4.3 Branch-Circuit Conductor Sizing Continuous Duty Application [430.22].....	318
4.4 Branch-Circuit Conductor Sizing for Duty-Cycle Application [430.22(E)].....	321
4.5 Overcurrent Protection	322
4.6 Motor Overload Protection	323
4.7 Branch-Circuit Short-Circuit and Ground-Fault Protection [430.52].....	327
4.8 Branch-Circuit Summary	331
4.9 Motor Circuit Equipment Grounding Conductor Size [250.122(D)(1)].....	332
4.10 Feeder Conductor Sizing [430.24]	332
4.11 Feeder Short-Circuit and Ground-Fault Protection [430.62(A)]	334
Part B—Air-Conditioning Calculations	336
Introduction.....	336
4.12 Air-Conditioning Equipment Nameplate [440.4(B)].....	336
4.13 Air-Conditioning Equipment, Short-Circuit and Ground-Fault Protection [440.22].....	337
4.14 Air-Conditioning Equipment, Conductor Ampacity [440.33]	338
Part C—Transformers	339
Introduction.....	339
4.15 Transformer Primary Only Overcurrent Protection [450.3(B)]	339
4.16 Transformer Secondary Conductor Sizing [240.21(C)]	342
Unit 4—Review Questions	345
Unit 5—Voltage-Drop Calculations	351
Part A—Conductor Resistance Calculations	351
Introduction.....	351
5.1 Conductor Cross-Sectional Area in Circular Mills [Chapter 9, Table 8].....	351
5.2 Conductor Resistance	353
5.3 Conductor Resistance [Chapter 9, Table 8]	354
Part B—Voltage-Drop Calculations	356
Introduction.....	356
5.4 Conductors' Voltage Drop—Ohm's Law Method	356
5.5 Single-Phase Circuit Voltage Drop—Formula Method.....	357
5.6 Three-Phase Circuit Voltage Drop—Formula Method	359
5.7 Sizing Conductor Single-Phase Circuit Voltage Drop—Formula Method	360
5.8 Sizing Conductor Three-Phase Circuit Voltage Drop—Formula Method	362
Unit 5—Review Questions	365

Unit 6—Dwelling Unit Calculations	369
Part A—Optional Method Load Calculations [Article 220, Part IV]	369
Introduction.....	369
6.1 Dwelling Unit Optional Load Calculations [220.82]	369
6.2 Dwelling Unit Optional Load Calculation [220.82], Example	371
Part B—Standard Method Load Calculations [Article 220, Part III]	372
Introduction.....	372
6.3 Dwelling Unit Standard Load Calculation	372
6.4 General Lighting and General-Use Receptacle Demand Load [220.41 and Table 220.45].....	372
6.5 Fixed Appliance Demand Load [220.53]	375
6.6 Dryer Demand Load [220.54].....	376
6.8 Electric Cooking Equipment Demand Load [220.55].....	376
6.10 Electric Vehicle [220.57]	378
6.11 Air-Conditioning Versus Heating [220.50, 220.51, and 220.60].....	379
6.12 Service Conductor Size [Table 310.12(A)]	380
6.13 Standard Method Load Calculations, Example [Article 220, Part III].....	381
6.14 Number of General Lighting and General-Purpose Receptacle Circuits [210.11(A)]	382
Part C—Neutral Load Calculations	383
Introduction.....	383
6.15 Neutral Calculations—Dryers and Ranges [220.61]	383
6.16 Service Neutral Calculation [220.61].....	384
Unit 6—Review Questions	387
Module III—NEC Calculations Practice Exam	393
 MODULE IV—ADVANCED NEC CALCULATIONS	401
Unit 7—Multifamily Dwelling Calculations	403
Part A—Optional Method Load Calculations [Article 220, Part IV]	403
Introduction.....	403
7.1 Multifamily Dwelling Optional Load Calculations [220.84]	403
7.2 Multifamily Dwelling Optional Method, Example [220.84].....	404
Part B—Standard Method Load Calculations [Article 220, Part III]	405
Introduction.....	405
7.3 General Lighting and General-Use Receptacle Demand Load [220.41 and 220.45].....	406
7.4 Appliance Demand Load [220.53]	407
7.5 Dryer Demand Load [220.54]	408
7.6 Single-Phase Dryers on Three-Phase Service [220.54].....	410
7.7 Electric Cooking Equipment [220.55].....	412
7.8 Single-Phase Ranges on Three-Phase Service [220.55]	414
7.9 Air-Conditioning and Heating Demand Load	416
7.10 Service Conductor Sizing [Table 310.16]	417
7.11 Multifamily Dwelling Calculations—Standard Method, Examples.....	418
7.12 Two-Family (Duplex) Dwelling Units Load Calculations [220.85]	420
Part C—Neutral Load Calculations	423
Introduction.....	423
7.13 Neutral Demand Load—Dryers and Ranges [220.61]	423
7.14 Service Neutral Demand Load [220.61(B)].....	424
Unit 7—Review Questions	427
 Unit 8—Commercial Calculations	435
Part A—General Commercial Demand Loads	435
Introduction.....	435
8.1 General Lighting Load [Table 220.42(A)]	435
8.2 General Lighting Load, Examples [Table 220.42(A)].....	436
8.3 General Lighting Load Demand Factors [Table 220.45].....	437
8.4 Number of General Lighting Circuits.....	438
8.5 Sign Circuit [220.14(F)]	439
8.6 Multioutlet Assemblies [220.14(H)].....	439
8.7 Receptacle Demand Load [220.14(I) and 220.47].....	440
8.8 Air-Conditioning versus Heating Demand Load [220.60]	442
Part B—Office, Mobile Home, Kitchen, Restaurants, and School Examples	442
Introduction.....	442
8.9 Office Building, Example.....	443
8.10 Mobile Home Parks [550.31]	444
8.11 Kitchen Equipment and Restaurants	444
8.12 School Optional Method Load Calculations [220.86].....	447
Part C—Welder Calculations	448
Introduction.....	448
8.13 Arc Welders	448
8.14 Resistance Welders	450
Part D—Light Industrial Calculations	452
Introduction.....	452
8.15 Light Industrial Calculations.....	452
Unit 8—Review Questions	455
Module IV—Advanced NEC Calculations—Practice Exam	461
Modules III and IV—NEC Calculations Code and Section Index	465
 About the Author	469
About the Illustrator	470
About the Mike Holt Team	471



Mike Holt's 2023 Journeyman Electrician Simulated Exams

TABLE OF CONTENTS

About This Book vii

CHAPTER 1—STUDY TIPS TO PASS YOUR EXAM 1

CHAPTER 2—HOW TO USE THE *NATIONAL ELECTRICAL CODE* 7

CHAPTER 3—JOURNEYMAN SIMULATED EXAMS 17

 Journeyman Simulated Exam A 19

 Journeyman Simulated Exam B 39

CHAPTER 4—TEST-TAKING TIPS TO PASS YOUR EXAM 59

CHAPTER 5—STUDY OPTIONS 63

About Mike Holt 72