

Mike Holt's Understanding the NEC Volume 1 Video Program

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 the NEC Volume 1 (Art. 90-480).....	2
Understanding the NEC WORKBOOK (Art. 90-480).....	12
Bonding and Grounding	14
Fundamental NEC Calculations.....	19

2023
NEC®

UNDERSTANDING THE 2023 NATIONAL ELECTRICAL CODE, VOLUME 1

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
Article 220—Branch-Circuit, Feeder, and Service Load Calculations		163	225.22	Raceways on Exterior Surfaces of Buildings	191
Part I. General		164	225.26	Trees for Conductor Support	191
220.1	Scope	164	225.27	Raceway Seals	192
220.3	Application of Other Articles.....	164	Part II. Buildings or Other Structures Supplied by a Feeder	192	
220.5	Calculations	164	225.30	Number of Supplies	192
Part II. Branch-Circuit Load Calculations		165	225.31	Disconnecting Means	193
220.11	Maximum Load	165	225.33	Maximum Number of Disconnects.....	194
220.14	Other Loads—Occupancies	166	225.34	Grouping of Disconnects.....	194
Part III. Standard Method—Feeder/Service Load Calculations		168	225.37	Identification of Multiple Supplies.....	194
220.40	General.....	168	225.39	Rating of Disconnecting Means.....	194
220.41	Dwelling Unit(s), Load Calculation	168	225.41	Emergency (Shutoff) Disconnects	194
220.42	Lighting Load for Non-Dwelling Occupancies	169	225.42	Surge Protection	195
220.43	Office Buildings	171	Article 230—Services	197	
220.44	Hotel and Motel Occupancies	171	230.1	Scope	198
220.45	General Lighting Demand Factors	171	Part I. General	199	
220.46	Show-Window and Track Lighting Loads, Commercial	172	230.2	Number of Services	199
220.47	Receptacle Demand Load, Commercial	172	230.3	Not to Pass Through a Building.....	200
220.50	Motor and Air-Conditioning Loads.....	173	230.6	Conductors Considered Outside a Building or Structure.....	200
220.51	Fixed Electric Space-Heating Load	173	230.7	Service Conductors Separate from Other Conductors	201
220.52	Small-Appliance and Laundry Loads, Dwelling	173	230.8	Raceway Seals	201
220.53	Appliance Demand Load, Dwelling	173	230.9	Clearances on Buildings.....	202
220.54	Clothes Dryer Demand Load, Dwelling	174	230.10	Vegetation as Support.....	202

Part II. Overhead Service Conductors	202	240.13	Ground-Fault Protection of Equipment	232
230.23	Overhead Service Conductor Size and Rating	240.15	Overcurrent Protective Device, Handle Ties.....	232
230.24	Vertical Clearance for Overhead Service Conductors.....	Part II. Location of Overcurrent Protective Device		233
230.26	Point of Attachment.....	240.21	Location of Overcurrent Protective Device in Circuit.....	233
230.27	Means of Attachment	240.22	Grounded-Phase Conductor on Overcurrent Device	240
230.28	Service Masts as Support.....	240.24	Location of Overcurrent Protective Devices.....	240
Part III. Underground Service Conductors	205	Part III. Enclosures Containing Overcurrent Protective Devices		241
230.30	Installation	240.33	Vertical Position, Enclosures.....	241
230.31	Underground Service Conductor Ampacity	Part V. Plug Fuses, Fuseholders, and Adapters		242
230.32	Protection Against Damage	240.51	Edison-Base Fuses.....	242
Part IV. Service-Entrance Conductors	207	Part VI. Cartridge Fuses and Fuseholders		242
230.40	Number of Service-Entrance Conductor Sets.....	240.67	Arc-Energy Reduction—Fuses.....	242
230.42	Conductor Sizing.....	Part VII. Circuit Breakers		242
230.43	Wiring Methods	240.81	Indicating	243
230.46	Spliced and Tapped Connections.....	240.83	Markings	243
230.50	Protection Against Physical Damage.....	240.85	Applications	243
230.51	Cable Supports.....	240.86	Series Ratings	244
230.53	Raceways to Drain.....	240.87	Arc-Energy Reduction—Circuit Breakers	244
230.54	Overhead Service Locations.....	Article 242—Overvoltage Protection		247
230.56	High-Leg Conductor Identification.....	Part I. General		248
Part V. Service Disconnect—General	213	242.1	Scope	248
230.62	Service Equipment—Barriers	Part II. Surge-Protective Devices (SPDs), 1000V or Less		248
230.66	Marking for Service Equipment.....	242.6	Listing.....	248
230.67	Surge Protection	242.8	Short-Circuit Current Rating.....	248
Part VI. Service Disconnect—Disconnecting Means	215	242.9	Indicating	248
230.70	Service Disconnect Requirements.....	242.12	Uses Not Permitted.....	249
230.71	Number of Service Disconnects.....	242.13	Type 1 SPDs—Supply Side of Service Equipment.....	249
230.72	Grouping of Service Disconnects.....	242.14	Type 2 SPDs—Feeder Circuits.....	250
230.79	Rating of Disconnect	242.20	Number Required.....	251
230.82	Connected on Supply Side of the Service Disconnect.....	242.24	Routing of Surge-Protective Device Conductors	251
230.85	Emergency (Shutoff) Disconnect	Article 250—Grounding and Bonding		253
Part VII. Service Conductor Overcurrent Protection	221	Part I. General		254
230.90	Overload Protection—Where Required.....	250.1	Scope	254
230.91	Location	250.4	Performance Requirements for Grounding and Bonding	255
230.95	Ground-Fault Protection of Equipment	Earth Shells		259
Article 240—Overcurrent Protection	223	250.6	Objectionable Current.....	260
Part I. General	224	Objectionable Current		260
240.1	Scope	Dangers of Objectionable Current		262
240.3	Other Articles (Overcurrent Protection of Equipment).....	250.8	Connection of Grounding and Bonding Conductors.....	263
240.4	Overcurrent Protection of Conductors.....	250.10	Protection of Ground Clamps and Fittings	263
240.5	Overcurrent Protection of Flexible Cords, Flexible Cables, and Fixture Wires	250.12	Clean Surfaces	263
240.6	Standard Ampere Ratings.....			
240.10	Supplementary Conductor Overcurrent Protection.....			

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	CHAPTER 3—WIRING METHODS AND MATERIALS	335
250.50 Grounding Electrode System	281	Article 300—General Requirements for Wiring Methods and Materials	339
250.52 Grounding Electrode Types	281	Part I. General Requirements	339
250.53 Grounding Electrode Installation	285	300.1 Scope	339
Soil Resistivity	288	300.3 Conductors	340
250.54 Auxiliary Grounding Electrodes	288	300.4 Protection Against Physical Damage.....	342
250.60 Lightning Protection Electrode	290	300.5 Underground Installations.....	345
250.62 Grounding Electrode Conductor	290	300.6 Protection Against Corrosion.....	348
250.64 Grounding Electrode Conductor Installation	290	300.7 Raceways Exposed to Different Temperatures.....	349
250.66 Sizing Grounding Electrode Conductors.....	295	300.9 Raceways in Wet Locations Above Grade	350
250.68 Grounding Electrode Conductor Connection to Grounding Electrodes	296	300.10 Electrical Continuity.....	351
250.70 Grounding Electrode Conductor Termination Fittings.....	298	300.11 Securing and Supporting	351
Part IV. Enclosure and Raceway	299	300.12 Mechanical Continuity.....	353
250.80 Service Raceways and Enclosures	299	300.13 Mechanical and Electrical Continuity of Conductors— Splices and Pigtails.....	353
250.86 Other than Service Enclosures and Raceways	300	300.14 Conductor Length at Boxes	355
Part V. Bonding	300	300.15 Boxes or Fittings, Splices and Terminations	355
250.92 Bonding Metal Service Raceways and Enclosures	300	300.17 Number and Size of Conductors in a Raceway.....	357
250.94 Bonding for Communications Systems	303	300.18 Raceway Installations.....	358
250.97 Bonding Metal Raceways and Metal Cables Containing 277V and 480V Circuits.....	304	300.19 Supporting Conductors in Vertical Raceways.....	359
250.98 Bonding Loosely Jointed Metal Raceways.....	305	300.20 Reducing Inductive Heating.....	359
250.100 Bonding in Hazardous (Classified) Locations	305	300.21 Spread of Fire or Products of Combustion	361
250.102 Bonding Jumper Sizing.....	305	300.22 Wiring in Ducts and Plenum Spaces.....	362
250.104 Bonding of Piping Systems and Exposed Structural Metal.....	309	300.23 Panels Designed to Allow Access	365
250.106 Lightning Protection Systems.....	312	300.25 Exit Stair Towers	365
Part VI. Equipment Grounding Conductors	312	Article 310—Conductors for General Wiring	367
250.109 Metal Enclosures, Effective Ground-Fault Current Path.....	312	Part I. General	367
250.114 Equipment Connected by Cord and Plug.....	313	310.1 Scope	367
250.118 Types of Equipment Grounding Conductors.....	313	310.3 Conductors, Minimum Size and Material.....	367
250.119 Identification of Wire-Type Equipment Grounding Conductors	318	Part II. Construction Specifications	369
250.120 Equipment Grounding Conductor Installation.....	319	310.4 Conductor Construction and Application	369
250.122 Sizing Wire-Type Equipment Grounding Conductors.....	319	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		
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			
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.....
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		
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		
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
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		
342.20	Trade Size	455	350.1	Scope	474
342.22	Number of Conductors	455	350.6	Listing Requirements	474
Article 344—Rigid Metal Conduit (RMC)461		Part II. Installation			
Part I. General		462	350.10	Uses Permitted.....	474
344.1	Scope	462	350.12	Uses Not Permitted.....	474
344.6	Listing Requirements	462	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 Protection607	Article 445—Generators629
430.31 Overload Protection607	445.1 Scope629
430.32 Overload Protection for Continuous-Duty Motors.....608	445.6 Listing.....630
Part IV. Branch-Circuit Short-Circuit and Ground-Fault Protection609	445.11 Marking.....630
430.51 General.....609	445.13 Conductor Ampacity.....630
430.52 Branch-Circuit Short-Circuit and Ground-Fault Protection.....610	445.19 Emergency Shutdown of Prime Mover631
430.55 Combined Overcurrent Protective Device613	
Part V. Feeder Short-Circuit and Ground-Fault Protection613	Article 450—Transformers633
430.62 Motor Feeder Protection613	450.1 Scope633
Part VI. Motor Control Circuits615	450.3 Primary Overcurrent Protection.....634
430.72 Overcurrent Protection for Control Circuits.....615	450.9 Ventilation636
430.75 Disconnect for Control Circuits.....615	450.10 Grounding and Bonding.....636
Part VII. Motor Controllers616	450.13 Transformer Accessibility.....636
430.83 Motor Controller Horsepower Rating.....616	450.14 Disconnecting Means637
Part IX. Disconnecting Means616	
430.102 Disconnect Location.....616	Article 480—Stationary Standby Batteries639
430.107 Motor or Controller Disconnect, Readily Accessible.....617	480.1 Scope639
430.109 Type of Disconnecting Means.....618	480.4 Battery and Cell Terminations640
Part X. Adjustable-Speed Drive Systems619	480.9 Battery Support Systems.....640
430.120 General.....619	480.10 Battery Locations.....640
430.122 Conductor Ampacity.....619	480.12 Battery Interconnections.....641
430.124 Overload Protection620	Chapter 4—Review Questions643
430.128 Disconnecting Means.....620	
430.130 Branch-Circuit Short-Circuit and Ground-Fault Protection.....620	FINAL EXAM A—STRAIGHT ORDER649
Part XIV. Tables620	FINAL EXAM B—RANDOM ORDER659
Table 430.248 Full-Load Current, Single-Phase Motors.....620	
Table 430.250 Full-Load Current, Three-Phase Motors621	INDEX669
Article 440—Air-Conditioning Equipment623	About the Author678
Part I. General624	About the Illustrator679
440.1 Scope624	About the Mike Holt Team680
440.4 Marking on Hermetic Motor-Compressors and Equipment...624	
440.8 Bathtub and Shower Space625	
440.9 Equipment Grounding Conductor.....625	
Part II. Disconnecting Means626	
440.11 General.....626	
440.14 Location626	
Part III. Overcurrent Protection626	
440.22 Short-Circuit and Ground-Fault Protective Device Size.....626	
Part IV. Conductor Ampacity627	
440.33 Conductor Ampacity.....627	

UNDERSTANDING THE 2023 *NATIONAL ELECTRICAL CODE* WORKBOOK, ARTICLES 90-48

About This Textbook.....	vii	CHAPTER 3—WIRING METHODS AND MATERIALS	101
Additional Products to Help You Learn.....	ix	Article 300—General Requirements for Wiring Methods and Materials.....	105
How to Use the <i>National Electrical Code</i>	1	Article 310—Conductors for General Wiring.....	113
Article 90—Introduction to the <i>National Electrical Code</i>	7	Article 312—Cabinets, Cutout Boxes, and Meter Socket Enclosures.....	119
CHAPTER 1—GENERAL RULES	11	Article 314—Boxes, Conduit Bodies, and Handhole Enclosures.....	123
Article 100—Definitions.....	13	Article 320—Armored Cable (Type AC).....	131
Article 110—General Requirements for Electrical Installations.....	27	Article 330—Metal-Clad Cable (Type MC).....	135
CHAPTER 2—WIRING AND PROTECTION	35	Article 334—Nonmetallic-Sheathed Cable (Type NM).....	139
Article 200—Use and Identification of Grounded Conductors.....	37	Article 336—Power and Control Tray Cable (Type TC).....	143
Article 210—Branch Circuits.....	39	Article 338—Service-Entrance Cable (Types SE and USE).....	145
Article 215—Feeders.....	51	Article 340—Underground Feeder and Branch-Circuit Cable (Type UF).....	147
Article 220—Branch-Circuit, Feeder, and Service Load Calculations.....	53	Article 342—Intermediate Metal Conduit (IMC).....	149
Article 225—Outside Branch Circuits and Feeders.....	59	Article 344—Rigid Metal Conduit (RMC).....	153
Article 230—Services.....	65	Article 348—Flexible Metal Conduit (FMC).....	157
Article 240—Overcurrent Protection.....	73	Article 350—Liquidtight Flexible Metal Conduit (LFMC).....	159
Article 242—Overvoltage Protection.....	79	Article 352—Rigid Polyvinyl Chloride Conduit (PVC).....	161
Article 250—Grounding and Bonding.....	81		

Article 356—Liquidtight Flexible Nonmetallic Conduit (LFNC)	165	Article 411—Low-Voltage Lighting	213
Article 358—Electrical Metallic Tubing (EMT)	169	Article 422—Appliances	215
Article 362—Electrical Nonmetallic Tubing (ENT)	171	Article 424—Fixed Electric Space-Heating Equipment	219
Article 376—Metal Wireways	175	Article 430—Motor Circuits, Controllers, and Adjustable-Speed Drives	221
Article 380—Multioutlet Assemblies	179	Article 440—Air-Conditioning Equipment	227
Article 386—Surface Metal Raceways	181	Article 445—Generators	229
Article 392—Cable Trays	183	Article 450—Transformers	231
 		Article 480—Stationary Standby Batteries	233
CHAPTER 4—EQUIPMENT FOR GENERAL USE	187	Final Exam A—Straight Order	235
Article 400—Flexible Cords	189	Final Exam B—Random Order	245
Article 402—Fixture Wires	191	 	
Article 404—Switches	193	About the Author	257
Article 406—Receptacles, Attachment Plugs, and Flanged Inlets	197	About the Illustrator	258
Article 408—Switchboards and Panelboards	203	About the Mike Holt Team	259
Article 410—Luminaires	207		

2023 *NEC* REQUIREMENTS FOR BONDING AND GROUNDING

About This Textbook	x	4.4 High-Voltage Transmission Lines.....	34
Additional Products to Help You Learn	xiii	4.5 Primary Distribution Voltage.....	34
How to Use the <i>National Electrical Code</i>	1	4.6 Primary Distribution Wires.....	34
		4.7 Secondary Distribution Voltage.....	34
		4.8 Service Drop and Service Lateral.....	35
		Unit 4—Review Questions	36
SECTION I—ELECTRICAL THEORY	7	Unit 6—Dangers of Electricity	39
Unit 1—Atomic Structure	9	6.1 Introduction.....	39
1.1 Introduction.....	9	6.2 <i>National Electrical Code (NEC)</i>	39
1.2 Atomic Theory.....	9	6.3 Electrical Fire.....	39
1.3 Electrostatic Field.....	10	6.4 Electric Shock.....	40
1.4 Atomic Charge of an Atom.....	11	6.5 Electric Arc Flash and Arc Blast.....	41
1.5 Electrostatic Charge and Discharge.....	12	6.6 Arc Flash Incident Energy.....	42
1.6 Lightning.....	13	6.7 Electrically Safe Work Condition.....	43
1.7 Lightning Protection System.....	14	6.8 Personal Protective Equipment (PPE).....	43
Unit 1—Review Questions	15	Unit 6—Review Questions	45
Unit 2—Electron Theory and Chemical Bonding	19	Unit 25—Overcurrent Protection	49
2.1 Introduction.....	19	25.1 Introduction.....	49
2.2 Electron Orbitals.....	19	25.2 Overcurrent Protection.....	49
2.3 Valence Electrons.....	19	25.3 Fuses.....	50
2.4 Freeing Valence Electron(s) from an Atom.....	20	25.4 Circuit Breakers.....	52
2.5 Conductance.....	20	25.5 Overcurrent Protective Devices, Time-Current Curves.....	53
2.6 Insulators.....	22	Unit 25—Review Questions	56
Unit 2—Review Questions	23	SECTION II—<i>NEC</i> RULES FOR BONDING AND GROUNDING	59
Unit 3—Electrical Circuits and Power Sources	25	Article 90—Introduction to the <i>National Electrical Code</i>	61
3.1 Introduction.....	25	90.1 Scope.....	61
3.2 The Electrical Circuit.....	25	90.2 Use and Application of the <i>NEC</i>	61
3.3 Electric Current Flow (Electricity).....	25	90.3 <i>Code</i> Arrangement.....	65
3.4 Electrical Power Sources.....	26	90.4 <i>NEC</i> Enforcement.....	66
Unit 3—Review Questions	30	90.5 Mandatory Requirements and Explanatory Material.....	67
Unit 4—The Electrical System	33	90.7 Examination of Equipment for Safety.....	68
4.1 Introduction.....	33	Article 90—Review Questions	69
4.2 Source of Electrical Generation.....	33		
4.3 Step-Up Transmission Voltage.....	33		

CHAPTER 1—GENERAL RULES	73	Part III. Grounding Electrode System and Grounding Electrode Conductor	154
Article 100—Definitions	75	250.50 Grounding Electrode System	154
Article 110—General Requirements for Electrical Installations	101	250.52 Grounding Electrode Types	155
Part I. General Requirements	101	250.53 Grounding Electrode Installation	159
110.1 Scope	101	Soil Resistivity	162
110.2 Approval of Conductors and Equipment	102	250.54 Auxiliary Grounding Electrodes	162
110.3 Use of Equipment	102	250.60 Lightning Protection Electrode	164
110.5 Conductor Material	104	250.62 Grounding Electrode Conductor	164
110.6 Conductor Sizes	104	250.64 Grounding Electrode Conductor Installation	164
110.7 Wiring Integrity	104	250.66 Sizing Grounding Electrode Conductors	169
110.8 Suitable Wiring Methods	104	250.68 Grounding Electrode Conductor Connection to Grounding Electrodes	170
110.11 Deteriorating Agents	105	250.70 Grounding Electrode Conductor Termination Fittings	172
110.12 Mechanical Execution of Work	106	Part IV. Enclosure and Raceway	173
110.14 Conductor Termination and Splicing	107	250.80 Service Raceways and Enclosures	173
Chapter 1—Review Questions	113	250.86 Other than Service Raceways and Enclosures	174
CHAPTER 2—WIRING AND PROTECTION	123	Part V. Bonding	174
Article 215—Feeders	125	250.92 Bonding Metal Service Raceways and Enclosures	174
215.1 Scope	125	250.94 Bonding for Communications Systems	177
215.6 Feeder Equipment Grounding Conductor	126	250.97 Bonding Metal Raceways and Metal Cables Containing 277V and 480V Circuits	178
Article 250—Grounding and Bonding	127	250.98 Bonding Loosely Jointed Metal Raceways	179
Part I. General	128	250.100 Bonding in Hazardous (Classified) Locations	179
250.1 Scope	128	250.102 Bonding Jumper Sizing	179
250.4 Performance Requirements for Grounding and Bonding	129	250.104 Bonding of Piping Systems and Exposed Structural Metal ...	183
Earth Shells	133	250.106 Lightning Protection Systems	186
250.6 Objectionable Current	134	Part VI. Equipment Grounding Conductors	186
Objectionable Current	134	250.109 Metal Enclosures, Effective Ground-Fault Current Path	186
Dangers of Objectionable Current	136	250.114 Equipment Connected by Cord and Plug	186
250.8 Connection of Grounding and Bonding Conductors	137	250.118 Types of Equipment Grounding Conductors	187
250.10 Protection of Ground Clamps and Fittings	137	250.119 Identification of Wire-Type Equipment Grounding Conductors	191
250.12 Clean Surfaces	137	250.120 Equipment Grounding Conductor Installation	193
Part II. System Grounding and Bonding	138	250.122 Sizing Wire-Type Equipment Grounding Conductors	193
250.20 Systems Required to be Grounded	138	Part VII. Equipment Grounding Conductor Connections	196
250.21 Ungrounded Systems	138	250.134 Equipment Connected by Permanent Wiring Methods	196
250.24 Service Grounding	139	250.138 Cord-and-Plug-Connected	197
250.28 Main Bonding Jumper and System Bonding Jumper	143	250.140 Frames of Ranges, Ovens, and Clothes Dryers	197
250.30 Transformer Separately Derived Systems	145	250.146 Connecting Receptacle Grounding Terminal to an Equipment Grounding Conductor	197
Generator Separately Derived Systems	151	250.148 Continuity and Attachment of Equipment Grounding Conductors in Boxes	200
250.32 Buildings Supplied by a Feeder	152	Chapter 2—Review Questions	202
250.36 Impedance Grounded Systems—480V to 1000V	153		

CHAPTER 3—WIRING METHODS AND MATERIALS.....221

Article 300—General Requirements for Wiring Methods and Materials.....225

Part I. General Requirements.....225

300.1 Scope225

300.3 Conductors226

300.6 Protection Against Corrosion.....227

300.10 Electrical Continuity.....228

300.12 Mechanical Continuity.....229

300.20 Reducing Inductive Heating.....230

Article 314—Boxes, Conduit Bodies, and Handhole Enclosures.....233

Part I. General233

314.1 Scope233

314.3 Nonmetallic Boxes234

314.4 Metal Boxes234

314.30 Handhole Enclosures.....234

Article 320—Armored Cable (Type AC).....237

320.1 Scope237

320.108 Equipment Grounding Conductor.....238

Article 330—Metal-Clad Cable (Type MC).....239

330.1 Scope240

330.108 Equipment Grounding Conductor.....240

Article 334—Nonmetallic-Sheathed Cable (Type NM).....243

334.1 Scope243

334.108 Equipment Grounding Conductor.....243

Article 340—Underground Feeder and Branch-Circuit Cable (Type UF).....245

340.1 Scope245

340.108 Equipment Grounding Conductor.....246

Article 342—Intermediate Metal Conduit (IMC).....247

342.1 Scope247

342.60 Equipment Grounding Conductor.....247

Article 344—Rigid Metal Conduit (RMC).....249

344.1 Scope249

344.60 Equipment Grounding Conductor.....250

Article 348—Flexible Metal Conduit (FMC).....251

348.1 Scope251

348.60 Equipment Grounding and Bonding Conductors.....252

Article 350—Liquidtight Flexible Metal Conduit (LFMC).....253

350.1 Scope253

350.60 Equipment Grounding and Bonding Conductors.....254

Article 352—Rigid Polyvinyl Chloride Conduit (PVC).....255

352.1 Scope255

352.60 Equipment Grounding Conductor.....256

Article 356—Liquidtight Flexible Nonmetallic Conduit (LFNC).....257

356.1 Scope257

356.60 Equipment Grounding Conductor.....258

Article 358—Electrical Metallic Tubing (EMT).....259

358.1 Scope259

358.60 Equipment Grounding Conductor.....260

Article 362—Electrical Nonmetallic Tubing (ENT).....261

362.1 Scope261

362.60 Equipment Grounding Conductor.....262

Article 376—Metal Wireways.....263

376.1 Scope263

376.60 Equipment Grounding Conductor.....264

Article 386—Surface Metal Raceways.....265

386.1 Scope265

386.60 Equipment Grounding Conductor.....266

Article 392—Cable Trays.....267

392.1 Scope267

392.60 Equipment Grounding Conductor.....268

Chapter 3—Review Questions.....270

CHAPTER 4—EQUIPMENT FOR GENERAL USE	275	Article 517—Health Care Facilities	307
Article 404—Switches	277	517.1 Scope	307
404.1 Scope	277	517.13 Equipment Grounding Conductor for Receptacles and Fixed Electrical Equipment in Patient Care Spaces.....	308
404.9 General-Use Snap Switches, Dimmers, and Control Switches	278	517.16 Isolated Ground Receptacles.....	310
404.12 Bonding of Enclosures.....	279	Article 547—Agricultural Buildings	313
Article 406—Receptacles, Attachment Plugs, and Flanged Inlets	281	547.1 Scope	313
406.1 Scope	282	547.44 Equipotential Planes	314
406.3 Receptacle Rating and Type	282	Article 555—Marinas, Boatyards, and Docking Facilities	317
406.4 General Installation Requirements.....	282	555.1 Scope	317
406.11 Connecting Receptacle Grounding Terminal to Equipment Grounding Conductor	284	555.37 Equipment Grounding Conductor.....	317
Article 408—Switchboards and Panelboards	285	Chapter 5—Review Questions	319
408.1 Scope	285	CHAPTER 6—SPECIAL EQUIPMENT	323
408.40 Equipment Grounding Conductor.....	285	Article 600—Electric Signs	325
Article 410—Luminaires	287	600.1 Scope	325
410.1 Scope	287	600.7 Grounding and Bonding.....	326
410.30 Supports	288	Article 645—Information Technology Equipment (ITE)	329
410.44 Connection to the Equipment Grounding Conductor	289	645.1 Scope	329
410.182 Equipment Grounding Conductor.....	290	645.15 Equipment Grounding and Bonding.....	329
Article 440—Air-Conditioning Equipment	291	Article 680—Swimming Pools, Spas, Hot Tubs, Fountains, and Similar Installations	331
440.1 Scope	291	Part I. General Requirements for Pools, Spas, Hot Tubs, and Fountains	332
440.9 Equipment Grounding Conductor.....	292	680.1 Scope	332
Article 450—Transformers	293	680.7 Grounding and Bonding.....	332
450.1 Scope	293	Part II. Permanently Installed Pools	333
450.10 Grounding and Bonding.....	294	680.23 Underwater Pool Luminaires	333
Chapter 4—Review Questions	295	680.24 Junction Box, Transformer, or GFCI Enclosure	336
CHAPTER 5—SPECIAL OCCUPANCIES	299	680.26 Equipotential Bonding	337
Article 501—Class I Hazardous (Classified) Locations	301	Part IV. Hot Tubs	342
501.1 Scope	301	680.40 General.....	342
501.30 Grounding and Bonding.....	301	680.42 Outdoor Installations.....	342
Article 502—Class II Hazardous (Classified) Locations	305	Part V. Fountains	343
502.1 Scope	305	680.50 General.....	343
502.30 Grounding and Bonding.....	306	680.54 Connection to an Equipment Grounding Conductor.....	343
		680.55 Methods of Equipment Grounding	344
		680.56 Cord-and-Plug-Connected Equipment.....	344

Part VII. Hydromassage Bathtubs.....344
 680.70 General.....344
 680.74 Equipotential Bonding344

Article 690—Solar Photovoltaic (PV) Systems.....347

Part I. General347
 690.1 Scope347
 690.43 Equipment Grounding Conductor.....348
 690.45 Size of Equipment Grounding Conductors349
 690.47 Grounding Electrode System349

Chapter 6—Review Questions.....351

CHAPTER 8—COMMUNICATIONS SYSTEMS357

Article 810—Antenna Systems359

Part I. General359
 810.1 Scope359
Part II. Receiving Equipment—Antenna Systems.....360
 810.15 Metal Antenna Supports—Bonding360
 810.20 Antenna Discharge Unit.....360
 810.21 Bonding Conductors and Grounding Electrode Conductors ..360

Chapter 8—Review Questions.....363

NEC FINAL EXAM A—STRAIGHT ORDER.....365

NEC FINAL EXAM B—RANDOM ORDER377

INDEX.....389

About the Author395

About the Illustrator396

About the Mike Holt Team397

2023 FUNDAMENTAL NEC CALCULATIONS

About This Textbook	viii	Part II. Branch-Circuit Ratings	48
Additional Products to Help You Learn	xi	210.19 Conductor Sizing.....	48
How to Use the <i>National Electrical Code</i>	1	210.20 Overcurrent Protection.....	52
Article 90—Introduction to the <i>National Electrical Code</i>	7	Article 215—Feeders	53
90.1 Scope.....	7	215.1 Scope.....	53
90.2 Use and Application of the <i>NEC</i>	7	215.2 Conductor Sizing.....	54
90.3 <i>Code</i> Arrangement.....	11	215.3 Overcurrent Protection Sizing.....	58
90.4 <i>NEC</i> Enforcement.....	12	215.6 Feeder Equipment Grounding Conductor.....	59
90.5 Mandatory Requirements and Explanatory Material.....	13	Article 220—Branch-Circuit, Feeder, and Service Load Calculations	61
90.7 Examination of Equipment for Safety.....	14	Part I. General	61
Article 90—Review Questions	15	220.1 Scope.....	61
CHAPTER 1—GENERAL RULES	19	220.3 Application of Other Articles.....	62
Article 100—Definitions	21	220.5 Calculations.....	62
Article 110—General Requirements for Electrical Installations	31	Part II. Branch-Circuit Load Calculations	63
Part I. General Requirements	31	220.11 Maximum Load.....	63
110.1 Scope.....	31	220.14 Other Loads—Occupancies.....	63
110.2 Approval of Conductors and Equipment.....	32	Part III. Standard Method—Feeder/Service Load Calculations	66
110.3 Use of Equipment.....	32	220.60 Noncoincident Loads.....	66
110.5 Conductor Material.....	34	220.61 Neutral Calculated Load.....	66
110.6 Conductor Sizes.....	34	220.70 Energy Management Systems.....	68
110.7 Wiring Integrity.....	34	Article 230—Services	69
110.8 Suitable Wiring Methods.....	35	230.1 Scope.....	69
110.12 Mechanical Execution of Work.....	35	Part IV. Service-Entrance Conductors	69
110.14 Conductor Termination and Splicing.....	36	230.42 Conductor Sizing.....	70
Chapter 1—Review Questions	39	Part VII. Service Conductor Overcurrent Protection	72
CHAPTER 2—WIRING AND PROTECTION	45	230.90 Overload Protection—Where Required.....	72
Article 210—Branch Circuits	47	Article 240—Overcurrent Protection	75
Part I. General Provisions	47	Part I. General	76
210.1 Scope.....	47	240.1 Scope.....	76
		240.3 Other Articles (Overcurrent Protection of Equipment).....	77
		240.4 Overcurrent Protection of Conductors.....	77
		240.5 Overcurrent Protection of Flexible Cords, Flexible Cables, and Fixture Wires.....	82

240.6 Standard Ampere Ratings..... 82
Part II. Location of Overcurrent Protective Device 83
 240.21 Location of Overcurrent Protective Device in Circuit..... 83
Chapter 2—Review Questions 91

CHAPTER 3—WIRING METHODS AND MATERIALS 97

Article 310—Conductors for General Wiring..... 99
Part I. General 99
 310.1 Scope 99
 310.3 Conductors, Minimum Size and Material..... 99
Part II. Construction Specifications..... 101
 310.4 Conductor Construction and Application 101
Part III. Installation 103
 310.12 Dwelling Services and Feeders 103
 310.14 Ampacities for Conductors Rated 0V to 2000V 106
 310.15 Ampacity Tables..... 107
 310.16 Ampacities of Insulated Conductors..... 114

Article 334—Nonmetallic-Sheathed Cable (Type NM)... 117
Part I. General 117
 334.1 Scope 117
Part II. Installation 118
 334.80 Conductor Ampacity..... 118

Article 376—Metal Wireways..... 121
Part I. General 121
 376.1 Scope 121
Part II. Installation 122
 376.22 Number of Conductors and Ampacity 122
 376.23 Wireway Sizing 123

Chapter 3—Review Questions 125

CHAPTER 4—EQUIPMENT FOR GENERAL USE 129

Article 422—Appliances..... 131
Part I. General 131
 422.1 Scope 131
Part II. Branch-Circuit Requirements 131
 422.10 Branch Circuits..... 131
 422.11 Overcurrent Protection 132

Article 424—Fixed Electric Space-Heating Equipment... 133
Part I. General 133
 424.1 Scope 133
 424.4 Branch Circuits..... 133

Article 430—Motor Circuits, Controllers, and Adjustable-Speed Drives 135

Part I. General 135
 430.1 Scope 135
 430.6 Motor Table FLC versus Motor Nameplate Current Rating..... 136
 430.17 Highest Rated Motor..... 137
Part II. Conductor Ampacity 138
 430.22 Motor Conductor Ampacity..... 138
Part IV. Branch-Circuit Short-Circuit and Ground-Fault Protection ... 139
 430.51 General..... 139
 430.52 Branch-Circuit Short-Circuit and Ground-Fault Protection..... 140
Part XIV. Tables 143
 Table 430.248 Full-Load Current, Single-Phase Motors..... 143
 Table 430.250 Full-Load Current, Three-Phase Motors 143

Article 440—Air-Conditioning Equipment..... 145
Part I. General 145
 440.1 Scope 145
 440.4 Marking on Hermetic Motor-Compressors and Equipment.... 146

Article 445—Generators..... 147
 445.1 Scope 147
 445.13 Conductor Ampacity..... 147

Article 450—Transformers 149
 450.1 Scope 149
 450.3 Primary Overcurrent Protection..... 150

Chapter 4—Review Questions 152

CHAPTER 6—SPECIAL EQUIPMENT 155

Article 625—Electric Vehicle Power Transfer System ... 157
Part I. General 157
 625.1 Scope 157
Part III. Installation 158
 625.40 Electric Vehicle Branch Circuit..... 158
 625.41 Overcurrent Protection 158
 625.42 Load..... 159

Chapter 6—Review Questions 161

FINAL EXAM	163
INDEX	173
About the Author	175
About the Illustrator	176
About the Mike Holt Team	177