

2020
NEC®

Mike Holt's Master Basic Video Program



This document includes the Table of Contents from each book so you can see the full scope of this library.

Title	page #
Electrical Exam Preparation	2
Master Electrician Practice Exam.....	7

Table of Contents

TABLE OF CONTENTS

About This Textbook	x	1.21 Ohm's Law	25
Passing Your Exam	xiii	1.22 Ohm's Law Formula Circle	26
Additional Products to Help You Learn	xvii	Part C—Summary	27
How to Use the <i>National Electrical Code</i>	1	Part C—Conclusion	28
 		Unit 1—Review Questions	29
CHAPTER 1—ELECTRICAL FUNDAMENTALS	7	Unit 1—Challenge Questions	32
Unit 1—Basic Math, Advanced Math, and Electrical Circuits and Ohm's Law	9	 	
Part A—Basic Math	9	Unit 2—Electrical Circuits	35
Introduction.....	9	Part A—Series Circuits	35
1.1 Whole Numbers and Integers.....	9	Introduction.....	35
1.2 Fractional Numbers	9	2.1 Practical Uses of Series Circuits.....	35
1.3 Decimal Numbers.....	9	2.2 Understanding Series Circuits	37
1.4 Percentages.....	10	2.3 Series Circuit Notes	39
1.5 Multipliers	10	2.4 Series-Connected Power Supplies	39
1.6 Percentage Increase.....	12	Part A—Summary	39
1.7 Reciprocals	13	Part A—Conclusion	40
1.8 Parentheses.....	13	Part B—Parallel Circuits	40
1.9 Squaring a Number.....	14	Introduction.....	40
1.10 Square Root.....	14	2.5 Practical Uses of Parallel Circuits.....	40
1.11 Kilo.....	15	2.6 Understanding Parallel Calculations	42
1.12 Rounding.....	16	2.7 Circuit Resistance	42
1.13 Testing Your Answer.....	16	2.8 Parallel Circuit Notes.....	46
Part A—Summary	17	2.9 Parallel-Connected Power Supplies	46
Part A—Conclusion	17	Part B—Summary	46
 		Part B—Conclusion	47
Part B—Advanced Math	18	Part C—Series-Parallel Circuits	47
Introduction.....	18	Introduction.....	47
1.14 Units of Measurement.....	18	2.10 Review of Series and Parallel Circuits.....	47
1.15 Surface Area.....	18	2.11 Working with Resistance in Series-Parallel Circuits.....	48
1.16 Volume.....	21	2.12 Working with Voltage in Series-Parallel Circuits.....	50
1.17 Geometry and Trigonometry.....	21	Part C—Summary	50
Part B—Summary	24	Part C—Conclusion	51
Part B—Conclusion	24	 	
Part C—Electrical Circuits and Ohm's Law	24	Part D—Multiwire Circuits	51
Introduction.....	24	Introduction.....	51
1.18 Electrical Circuit	24	2.13 Neutral Wire.....	51
1.19 Electrical Power Source	25	2.14 Current Flow through the Neutral Wire.....	52
1.20 Circuit Resistance	25	2.15 Balanced Systems.....	53
		2.16 Multiwire Branch Circuits	53
		2.17 Dangers of Multiwire Circuits.....	55

2.18	NEC Requirements.....	56	3.26	Using the Formula Wheel.....	82
	Part D—Summary.....	57	3.27	Power Losses of Wires.....	82
	Part D—Conclusion.....	57	3.28	Power Factor.....	84
	Unit 2—Review Questions.....	58	3.29	Unity Power Factor.....	85
	Unit 2—Challenge Questions.....	62	3.30	True Power (Watts).....	85
	Unit 3—Alternating Current.....	63	3.31	Power Factor Formulas.....	85
	Part A—Understanding Alternating Current.....	63	3.32	Effects of Power Factor.....	86
	Introduction.....	63	3.33	Efficiency.....	88
3.1	Current Flow.....	63	3.34	Efficiency Formulas.....	88
3.2	Use of Alternating Current and Direct Current.....	63		Part D—Summary.....	90
3.3	How Alternating Current is Produced.....	64		Part D—Conclusion.....	91
3.4	Alternating-Current Generator.....	64		Unit 3—Review Questions.....	92
3.5	Waveforms.....	64		Unit 3—Challenge Questions.....	98
3.6	Sine Wave—Sinusoidal Waveform.....	65		Unit 4—Motors and Transformers.....	101
3.7	Frequency.....	66		Part A—Motor Basics.....	101
3.8	Phase.....	66		Introduction.....	101
3.9	Phase Angle in Degrees.....	67	4.1	Motor Principles.....	101
3.10	Leading or Lagging Waveform.....	67	4.2	Dual-Voltage Alternating-Current Motors.....	102
3.11	Values in Alternating-Current Waveforms.....	68	4.3	Motor Horsepower Ratings.....	102
	Part A—Summary.....	69	4.4	Motor Current Ratings.....	103
	Part A—Conclusion.....	70	4.5	Calculating Motor FLA (Nameplate).....	104
	Part B—Capacitance.....	70	4.6	Motor Starting Current.....	105
	Introduction.....	70	4.7	Motor Running Current.....	106
3.12	How Capacitors Work.....	70	4.8	Motor Overload Protection.....	106
3.13	Determining Capacitance.....	72		Part A—Summary.....	107
3.14	Uses of Capacitors.....	73		Part A—Conclusion.....	107
	Part B—Summary.....	74		Part B—Transformers.....	108
	Part B—Conclusion.....	74		Introduction.....	108
	Part C—Induction.....	75	4.9	Transformers.....	108
	Introduction.....	75	4.10	Transformer Theory.....	108
3.15	How Induction Works.....	75	4.11	Primary vs. Secondary.....	108
3.16	Self-Induction.....	75	4.12	Transformer Induction.....	108
3.17	Conductor Alternating-Current Resistance.....	75	4.13	Induced Voltage, Secondary.....	109
3.18	Conductor Shape.....	77	4.14	Transformer Turns Ratio.....	109
3.19	Magnetic Cores.....	77	4.15	Autotransformers.....	112
3.20	Self-Induced (CEMF) and Applied Voltage.....	78	4.16	Power Losses.....	113
3.21	Phase Relationship.....	78	4.17	Efficiency.....	114
3.22	Uses of Induction.....	78	4.18	Transformer kVA Rating.....	114
	Part C—Summary.....	79	4.19	Current Rating.....	115
	Part C—Conclusion.....	79		Part B—Summary.....	116
	Part D—Power, Power Factor, and Efficiency.....	80		Part B—Conclusion.....	117
	Introduction.....	80		Unit 4—Review Questions.....	118
3.23	Power.....	80		Unit 4—Challenge Questions.....	122
3.24	PIE Power Formula Circle.....	80			
3.25	Formula Wheel.....	81			

CHAPTER 2—NEC CALCULATIONS	125	6.8	Ambient Temperature Correction [310.15(B)].....	181
Unit 5—Raceway and Box Calculations	127	6.9	Ampacity Adjustment [310.15(C)]	183
Part A—Raceway Sizing	127	6.10	Combining Ambient Temperature Correction and Conductor Bundling Adjustment	185
Introduction.....	127	6.11	Current-Carrying Conductors [310.15(E)].....	186
5.1 Conductor Dimensions—Chapter 9, Tables 5 and 8.....	128	6.12	Wireways—Conductor Ampacity Adjustment.....	188
5.2 Raceway Properties.....	131	6.13	Overcurrent Protection and Conductor Sizing	189
5.3 Raceways with Different Size Conductors	133	6.14	Feeder Tap Rules [240.21].....	200
5.4 Raceway Sizing Steps.....	134	6.15	Transformer Secondary Conductors [240.21(C)].....	204
5.5 Multiconductor and Optical Fiber Cables—Chapter 9, Note (5) and Note (9).....	136	Unit 6—Conclusion	206	
5.6 Cables with Elliptical Cross Sections—Chapter 9, Note (9).....	138	Unit 6—Review Questions	207	
5.7 Sizing Raceways Using Annex C.....	139	Unit 6—Challenge Questions	213	
5.8 Conductor Jamming—Chapter 9, Table 1, Note 2	142	Unit 7—Motor, Air-Conditioning, and Transformer Calculations	217	
5.9 Sizing Wireways	143	Part A—Motor Calculations	217	
5.10 Sizing Wireways for Conductor Bending Radius [376.23(A)].....	146	7.1 Scope of Article 430	217	
5.11 Tips for Raceway Calculations.....	146	7.2 Motor Full-Load Current (FLC)	218	
Part B—Outlet Box Fill	146	7.3 Motor Full-Load Current and Motor Nameplate Current Rating [430.6(A)].....	219	
Introduction.....	146	7.4 Branch-Circuit Conductor Sizing [430.22].....	220	
5.12 Box Sizing—Conductors All the Same Size [314.16(A)].....	147	7.5 Feeder Conductor Sizing [430.24]	223	
5.13 Box Fill Calculations [314.16(B)].....	149	7.6 Overcurrent Protection	225	
5.14 Outlet Box Sizing Steps	153	7.7 Overload Protection Sizing	226	
5.15 Tips for Outlet Box Sizing	155	7.8 Branch-Circuit Short-Circuit and Ground-Fault Protection.....	230	
Part C—Pull Boxes, Junction Boxes, and Conduit Bodies	155	7.9 Branch-Circuit Summary	234	
Introduction.....	155	7.10 Combined Branch-Circuit Overcurrent Protection [430.55]	235	
5.16 Pull/Junction Box Sizing Requirements	155	7.11 Feeder Short-Circuit and Ground-Fault Protection [430.62].....	235	
5.17 Tips for Pull/Junction Box Sizing.....	157	7.12 Motor Watts versus Motor Volt-Amperes (VA)	238	
5.18 Pull Box Examples.....	157	7.13 Adjustable-Speed Drives	241	
5.19 Tips for Pull Box Sizing	160	7.14 Fire Pump Motor Circuits.....	242	
Unit 5—Conclusion	160	Part B—Air-Conditioning Calculations	243	
Unit 5—Review Questions	161	7.15 Scope of Article 440	243	
Unit 5—Challenge Questions	167	7.16 Multimotor Air-Conditioning Equipment [440.4(B)].....	244	
Unit 6—Conductor Sizing and Protection Calculations	169	Part C—Transformers	245	
Part A—Conductor Requirements	169	7.17 Transformer Overcurrent Protection [450.3(B)]	245	
Introduction.....	169	7.18 Primary Conductor Sizing.....	248	
6.1 Conductor Insulation [310.4]	169	7.19 Secondary Conductor Sizing.....	249	
6.2 Conductor Sizes	172	7.20 Bonding and Grounding.....	252	
6.3 Minimum Conductor Size [310.3]	172	Unit 7—Conclusion	256	
6.4 Conductor Size—Equipment Terminal Rating [110.14(C)].....	172	Unit 7—Review Questions	257	
6.5 Overcurrent Protection [240.4].....	175	Unit 7—Challenge Questions	264	
Part B—Conductor Ampacity	179			
Introduction.....	179			
6.6 Conductor Ampacity [310.14]	180			
6.7 Ampacity Table [310.15].....	180			

Unit 8—Voltage-Drop Calculations	267	Part C—Neutral Load Calculations	317
Part A—Conductor Resistance Calculations	267	9.13 Service Neutral Calculations—Dryers and Ranges [220.61]	317
Introduction.....	267	9.14 Neutral Service and Feeder Calculation [220.61(B)] Example	317
8.1 Conductor Size	267	9.15 Number of General Lighting and General-Purpose Receptacle	
8.2 Conductor Resistance	269	Circuits [210.11(A)]	318
8.3 Alternating-Current Conductor Resistance	272	Unit 9—Conclusion	319
8.4 Alternating-Current Resistance [Chapter 9, Table 9]	272	Unit 9—Review Questions	320
8.5 Alternating-Current Resistance versus Direct-Current		Unit 9—Challenge Questions	326
Resistance	274		
Part B—Voltage-Drop Considerations	275	CHAPTER 3—ADVANCED NEC CALCULATIONS	333
Introduction.....	275	Unit 10—Multifamily Dwelling Calculations	335
8.6 Voltage-Drop—Manufacturer and NEC Recommendations.....	275	Part A—Optional Method Load Calculations [Article 220, Part IV]	336
8.7 Determining Circuit Conductors' Voltage Drop—Ohm's Law		Introduction.....	336
Method	278	10.1 Multifamily Dwelling Optional Load Calculations [220.84].....	336
8.8 Sizing Conductors for Voltage-Drop Consideration	279	10.2 Multifamily Dwelling Optional Method [220.84] Examples.....	337
8.9 Determining Circuit Conductors' Voltage Drop—Formula		Part B—Standard Method Load Calculations [Article 220, Part III]	339
Method	283	Introduction.....	339
8.10 Limiting Conductor Length (Distance) to Minimize Voltage		10.3 General Lighting and General-Use Receptacle Demand Load	
Drop	285	[220.42].....	340
8.11 Limiting Current to Limit Voltage Drop	288	10.4 Appliance Demand Load [220.53]	341
Unit 8—Conclusion	291	10.5 Dryer Demand Load [220.54].....	342
Unit 8—Review Questions	292	10.6 Electric Cooking Equipment Demand Load [220.55].....	346
Unit 8—Challenge Questions	297	10.7 Air-Conditioning versus Heating Demand Load [220.60]	350
		10.8 Service Conductor Sizing [310.16]	353
Unit 9—Dwelling Unit Calculations	299	10.9 Multifamily Dwelling Calculations—Standard Method Examples	354
Introduction.....	299	10.10 Two-Family Dwelling Units [220.85].....	356
Part A—Optional Method Load Calculations [Article 220, Part IV]	299	Part C—Neutral Load Calculations	358
Introduction.....	299	10.11 Dryers and Cooking Equipment [220.61]	358
9.1 Dwelling Unit Optional Load Calculations [220.82]	300	10.12 Service Neutral [220.61(B)].....	360
9.2 Dwelling Unit Optional Load Calculation [220.82] Example	301	Unit 10—Conclusion	361
9.3 Existing Dwelling Unit Optional Load Calculations [220.83]	302	Unit 10—Review Questions	362
9.4 Existing Dwelling Unit Optional Load Calculation [220.83]		Unit 10—Challenge Questions	368
Example.....	303		
Part B—Standard Method Load Calculations [Article 220, Part III]	304	Unit 11—Commercial Calculations	373
9.5 Dwelling Unit Standard Load Calculation	304	Part A—General	373
9.6 General Lighting and General-Use Receptacle Demand Load		Introduction.....	373
[220.42].....	304	11.1 General Lighting Demand Factors [Tables 220.12 and 220.42].....	373
9.7 Fixed Appliance Demand Load [220.53]	306	11.2 General Lighting Load Examples.....	376
9.8 Dryer Demand Load [220.54].....	307	11.3 Sign Circuit [220.14(F) and 600.5(A)].....	377
9.9 Electric Cooking Equipment Demand Load [220.55].....	307	11.4 Show-Window Lighting [220.14(G)].....	377
9.10 Air-Conditioning, Heating, and Air Handlers [220.60].....	311	11.5 Multioutlet Receptacle Assemblies [220.14(H)]	378
9.11 Feeder and Service Conductor Size [Table 310.12].....	312	11.6 Receptacle Load [220.14(I) and 220.44]	378
9.12 Standard Method Load Calculations Example [Article 220,		11.7 Offices—Receptacle Demand Load [220.14(K)]	381
Part III].....	315	11.8 Air-Conditioning versus Heating Demand Load [220.60]	382

Part B—Examples	383	<i>NEC</i> Practice Quiz 13—Straight Order [430.1–525.23].....	475
11.9 Office Buildings.....	383	<i>NEC</i> Practice Quiz 14—Random Order [90.1–525.23].....	480
11.10 Manufactured Home Parks [550.31].....	385	<i>NEC</i> Practice Quiz 15—Straight Order [547.1–680.25].....	485
11.11 Recreational Vehicle Parks [551.73].....	385	<i>NEC</i> Practice Quiz 16—Random Order [90.1–680.25].....	491
11.12 Marinas [555.6].....	386	<i>NEC</i> Practice Quiz 17—Straight Order [680.26–701.12].....	496
Part C—Optional Method—New Restaurant Feeder/Service Load Calculations	387	<i>NEC</i> Practice Quiz 18—Random Order [90.1–701.12].....	501
Introduction.....	387	<i>NEC</i> Practice Quiz 19—Straight Order [90.1–820.100].....	506
11.13 New Restaurant—Optional Method [220.88].....	387	<i>NEC</i> Practice Quiz 20—Random Order [90.1–820.100].....	512
Part D—Welders	390	<i>NEC</i> Challenge Exam 1—Articles 90–820.....	517
Introduction.....	390	<i>NEC</i> Challenge Exam 2—Articles 90–820.....	522
11.14 Arc Welders.....	390	<i>NEC</i> Challenge Exam 3—Articles 90–820.....	527
11.15 Resistance Welders.....	392	<i>NEC</i> Challenge Exam 4—Articles 90–820.....	532
Part E—Light Industrial and School Calculations Examples	394	<i>NEC</i> Challenge Exam 5—Articles 90–820.....	537
11.16 Light Industrial Calculations Examples.....	394	<i>NEC</i> Challenge Exam 6—Articles 90–820.....	543
11.17 School Optional Method Load Calculations [220.86].....	396	<i>NEC</i> Challenge Exam 7—Articles 90–820.....	548
Unit 11—Conclusion	397	<i>NEC</i> Challenge Exam 8—Articles 90–820.....	553
Unit 11—Review Questions	398	<i>NEC</i> Challenge Exam 9—Articles 90–820.....	558
Unit 11—Challenge Questions	402	<i>NEC</i> Challenge Exam 10—Articles 90–820.....	563
 		<i>NEC</i> Challenge Exam 11—Articles 90–820.....	568
CHAPTER 4—NEC PRACTICE QUIZZES AND CHALLENGE EXAMS	409	<i>NEC</i> Challenge Exam 12—Articles 90–820.....	573
<i>NEC</i> Practice Quiz 1—Straight Order [90.1–110.16].....	411	<i>NEC</i> Challenge Exam 13—Articles 90–820.....	578
<i>NEC</i> Practice Quiz 2—Random Order [90.1–110.16].....	416	<i>NEC</i> Challenge Exam 14—Articles 90–820.....	583
<i>NEC</i> Practice Quiz 3—Straight Order [110.21–225.39].....	421	<i>NEC</i> Challenge Exam 15—Articles 90–820.....	588
<i>NEC</i> Practice Quiz 4—Random Order [90.1–225.39].....	426	<i>NEC</i> Challenge Exam 16—Articles 90–820.....	593
<i>NEC</i> Practice Quiz 5—Straight Order [230.1–250.64].....	432	<i>NEC</i> Challenge Exam 17—Articles 90–820.....	599
<i>NEC</i> Practice Quiz 6—Random Order [90.1–250.64].....	437	<i>NEC</i> Challenge Exam 18—Articles 90–820.....	604
<i>NEC</i> Practice Quiz 7—Straight Order [250.66–314.16].....	442	<i>NEC</i> Challenge Exam 19—Articles 90–820.....	610
<i>NEC</i> Practice Quiz 8—Random Order [90.1–314.16].....	448	<i>NEC</i> Challenge Exam 20—Articles 90–820.....	615
<i>NEC</i> Practice Quiz 9—Straight Order [314.17–362.30].....	454	<i>NEC</i> Final Exam.....	621
<i>NEC</i> Practice Quiz 10—Random Order [90.1–362.30].....	459		
<i>NEC</i> Practice Quiz 11—Straight Order [376.22–422.31].....	464	About the Author	631
<i>NEC</i> Practice Quiz 12—Random Order [90.1–422.31].....	469	About the Illustrator	632
		About the Mike Holt Team	633

Mike Holt's

Master Electrician Practice Exam

TABLE OF CONTENTS

About the Author vi

Practice Exam Instructions vii

Part 1—Electrical Theory

Electrical Theory Exam (4 Hours) 1

Electrical Theory Answer Key 31

Electrical Theory Answer Sheet 59

Part 2—National Electrical Code®

National Electrical Code Exam (4 Hours) 11

National Electrical Code Answer Key 35

National Electrical Code Answer Sheet 61

Part 3—Electrical Calculations

Electrical Calculations Exam (8 Hours) 21

Electrical Calculations Answer Key 37

Electrical Calculations Answer Sheet 63