Chapter 1 Electrical Theory			
Unit 1 E	Tectrician's Math and Basic Electrical	3	
Part	13 A _ Flectrician's Math	3	
1_1	Fractions	3	
1_2	Kilo	3 4	
1_3	Knowing Your Answer	4	
1-4	Multiplier	5	
1–5	Parentheses	5	
1–6	Percentages	5	
1–7	Percent Increase	5	
1–8	Percentage Reciprocals	6	
1–9	Rounding	6	
1–10	Squaring	7	
1–11	Square Root	7	
Part 1	B – Basic Electrical Formulas	8	
1–12	Electrical Circuit	8	
1–13	Electron Flow	8	
1–14	Power Source	8	
1–15	Conductance and Resistance	9	
1–16	Electrical Circuit Values	10	
1–17	Ohm's Law $I = E/R$	10	
1–18	Pie Circle Formula	12	
1–19	Formula Wheel	13	
1–20	Power Changes with the Square of the Voltage	15	
1–21	Electric Meters	15	
Unit	1 – Calculations Questions	18	
Unit 2 E	lectrical Circuits	25	
Part A	A – Series Circuits	25	
Introd	luction to Series Circuits	25	
2-1	Understanding Series Calculations	26	
2–2	Series Circuit Summary	28	
Part 1	B – Parallel Circuits	29	
Introd	luction to Parallel Circuits	29	
2–3	Practical Uses of Parallel Circuits	30	
2–4	Understanding Parallel Calculations	30	
2–5	Parallel Circuit Resistance Calculations	32	
2–6	Parallel Circuit Summary	33	

	Part C Circui	C – Series–Parallel and Multiwire Brand its	ch 34
	Introdu	uction to Series-Parallel Circuits	34
	2–7	Review of Series and Parallel Circuits	34
	2–8	Series-Parallel Circuit Resistance	
		Calculations	34
	Part I) – Multiwire Branch Circuits	35
	Introdu	uction to Multiwire Branch Circuits	35
	2–9	Neutral Current Calculations	36
	2–10	Dangers of Multiwire Branch Circuit	38
	Unit 2	– Calculations Questions	40
Uı	nit 3 Uı	nderstanding Alternating Current	46
	Part A	- Alternating-Current Fundamentals	47
	3–1	Current Flow	47
	3–2	Alternating Current	47
	3–3	Alternating-Current Generator	47
	3–4	Waveform	48
	3–5	Armature Turning Frequency	48
	3–6	Phase – In and Out	49
	3–7	Phase Differences in Degrees	49
	3–8	Values of Alternating Current	50
	Part E	B – Induction	51
	Induct	ion Introduction	51
	3–9	Induced Voltage and Applied Current	51
	3–10	Conductor Impedance	52
	3–11	Induction and Conductor Shape	52
	3–12	Induction and Magnetic Cores	52
	Part C	C – Capacitance	53
	Capac	itance Introduction	53
	3–13	Charge, Testing and Discharging	54
	3–14	Use of Capacitors	55
	Part I) – Power Factor and Efficiency	56
	Power	Factor Introduction	56
	3–15	Apparent Power (Volt-Ampere)	56
	3–16	Power Factor	57
	3–17	True Power (Watts)	58
	3–18	Efficiency	59
	Unit 3	- Calculations Questions	61

Table of Contents	Tab
-------------------	-----

Unit 4 N	lotors and Transformers	70	
Part A – Motors			
Motor	Motor Introduction		
4–1	Motor Speed Control	71	
4–2	Reversing a Direct-Current Motor	71	
4–3	Alternating-Current Motors	71	
4–4	Reversing Alternating-Current Motors	72	
4–5	Motor Volt-Ampere Calculations	72	
4–6	Motor Horsepower/Watts	73	
4–7	Motor Nameplate Ampere	74	
Part l	B – Transformer Basics	75	
Transt	former Introduction	75	
4–8	Transformer Primary and Secondary	76	
4–9	Transformer Secondary and		
	Primary Voltage	76	
4–10	Autotransformers	76	
4-11	Transformer Power Losses	76	
4–12	Transformer Turns Ratio	77	
4–13	Transformer kVA Rating	78	
4–14	Transformer Current	78	
Unit 4	4 – Calculations Questions	80	
Chapter	2		
NEC Cal	culations	87	
Unit 5 R	aceway, Outlet Box and Junction Box		
Calculat	tions	<i>88</i>	
Part A	A – Raceway Fill	88	
5-1	Understanding the Nec, Chapter 9	88	
5–2	Raceway and Nipple Calculations	93	
5–3	Existing Raceway Calculations	95	
5–4	Tips For Raceway Calculations	96	
Part l	B – Outlet Box Fill Calculations	97	
Introd	uction [314.16]	97	
5–5	Sizing Box – Conductors All the Same Size [Table 314.16(A)]	97	
5–6	Conductor Equivalents [314.16(B)]	97	
5–7	Sizing Box – Different Size Conductor [314.16(B)]	s 99	
Part (Bodie	C – Pull, Junction Boxes, and Conduit	101	
Introd	uction	101	

5–8 Pull and Junction Box Size Calculations101

	5–9	Depth of Box and Conduit Body Sizing [314.28(A)(2), Ex.]	102
	5-10	Junction and Pull Box Sizing Tips	103
	5-11	Pull Box Examples	103
	Unit 5	5 – Calculations Questions	105
11	nit 6 Ca	anductor Sizing and Protection	
Cá	alculat	ions	109
	Part A	A – General Conductor Requirements	109
	6–1	Conductor Insulation Property [Table 310.13]	109
	6–2	Conductor Allowable Ampacity [310.15]	111
	6–3	Conductor Sizing [110.6]	112
	6–4	Terminal Ratings [110.14(C)]	113
	6–5	Conductors in Parallel [310.4]	115
	6–6	Conductor Size – Voltage Drop	116
	6–7	Overcurrent Protection [Article 240]	116
	6–8	Overcurrent Protection of Conductors – General Requirements [240.4]	117
	6–9	Overcurrent Protection of Conductors Specific Requirements	119
	6–10	Equipment Conductors Size and Protection Examples	120
	Part B	B – Conductor Ampacity Calculations	121
	6–11	Conductor Ampacity [310.10]	121
	6–12	Ambient Temperature Ampacity Adjust Factor [Table 310.16]	ment 121
	6–13	Conductor Bundling Ampacity Adjustm Factor [Table 310.15(B)(2)]	ent 123
	6–14	Ambient Temperature and Conductor Bundling Adjustment Factors	124
	6–15	Current-Carrying Conductors	124
	6–16	Conductor Sizing Summary	127
	Unit 6	6 – Calculations Questions	128
Unit 7 Motor Calculations 1			134
	Introd	uction	134
	7–1	Motor Branch-Circuit Conductors [430.22(A)]	134
	7–2	Motor Overcurrent Protection	135
	7–3	Overload Protection [430.32(A)]	136
	7–4	Branch-Circuit Short-Circuit Ground-Fa Protection [430.52(C)(1)]	ult 137

V

	7–5	Feeder Conductor Size [430.24]	139
	7–6	Feeder Protection [430.62(A)]	140
	7–7	Highest-Rated Motor [430.17]	141
	7-8	Motor Calculations Steps	141
	7-9	Motor Calculation Review	143
	7-10	Motor VA Calculations	144
	Unit 7	– Calculations Questions	146
Uı	nit 8 Vo	Itage Drop Calculations	150
	Part A Calcul	– Conductor Resistance lations	150
	8-1	Conductor Resistance	150
	8–2	Conductor Resistance – Direct-Current Circuits, [Chapter 9, Table 8]	151
	8–3	Conductor Impedance – Alternating-Current Circuits	152
	8–4	Alternating-Current Impedance as Compared to Direct-Current Resistance	152
	8–5	Impedance [Chapter 9, Table 9 of the NEC]	153
	Part B	B – Voltage-Drop Calculations	155
	8-6	Voltage-Drop Considerations	155
	8–7	NEC Voltage-Drop Recommendations	155
	8–8	Determining Circuit Conductors Voltage Drop	156
	8–9	Sizing Conductors to Prevent Excessive Voltage Drop	159
	8–10	Limiting Conductor Length to Limit Voltage Drop	160
	8–11	Limiting Current to Limit Voltage Drop	161
	8–12	Extending Circuits	162
	Unit 8	- Calculations Questions	164
UI Cá	nit 9 Si alculati	ngle-Family Dwelling Unit Load ions	170
	Part A	- General Requirements	170
	9–1	General Requirements	170
	9–2	Voltages [220.2(A)]	170
	9–3	Fraction of an Ampere [220.2(B)]	170
	9–4	Appliance (Small) Circuits [210.11(C)(1)]	171
	9–5	Cooking Equipment – Branch Circuit [Table 220.19, Note 4]	171
	One C	ounter-Mounted Cooking Unit and	

Up to	Two Ovens [220.19 Note 4]	172
9–6	Laundry Receptacle(S) Circuit	. – .
	[210.11(C)(2)]	174
9–7	Lighting and Receptacles	174
Numł Exam	per of Circuits Required [Chapter 9, ple No. D1(A)]	175
Part 1	B - Standard Method – Feeder/Service	
Load	Calculations	176
9–8	Dwelling Unit Feeder/Service Load Calculations (Part Ii of Article 220)	176
9–9	Dwelling Unit Feeder/Service Calculation Examples	177
Part C	C - Optional Method – Feeder/Service Load Calculations	181
9-10	Dwelling Unit Optional Feeder/Service Calculations [220.30]	181
9–11	Dwelling Unit Optional Calculation Examples	182
9–12	Neutral Calculations – General [220.22]	184
Unit	9 – Calculations Questions	185
Chapter	3	
Advance	ed NEC Calculations	193
Advance Unit 10 Calculat	ed NEC Calculations Multifamily Dwelling Unit Load tions	193 194
Advance Unit 10 Calculat 10–1	ed NEC Calculations Multifamily Dwelling Unit Load tions Multifamily Dwelling Unit	193 194
Advance Unit 10 Calculat 10–1	ed NEC Calculations Multifamily Dwelling Unit Load tions Multifamily Dwelling Unit Calculations – Standard Method	193 194 194
Advance Unit 10 Calculat 10–1 10–2	ed NEC Calculations Multifamily Dwelling Unit Load tions Multifamily Dwelling Unit Calculations – Standard Method Multifamily Dwelling Unit Calculation Examples – Standard Method	193 194 194 195
Advance Unit 10 Calculat 10–1 10–2 10–3	ed NEC Calculations Multifamily Dwelling Unit Load tions Multifamily Dwelling Unit Calculations – Standard Method Multifamily Dwelling Unit Calculation Examples – Standard Method Multifamily Dwelling Unit Calculations	193 194 194 195
Advance Unit 10 Calculat 10–1 10–2 10–3	ed NEC Calculations Multifamily Dwelling Unit Load tions Multifamily Dwelling Unit Calculations – Standard Method Multifamily Dwelling Unit Calculation Examples – Standard Method Multifamily Dwelling Unit Calculations Sample – Standard Method	193 194 194 195 199
Advance Unit 10 Calculat 10–1 10–2 10–3 10–4	ed NEC Calculations Multifamily Dwelling Unit Load tions Multifamily Dwelling Unit Calculations – Standard Method Multifamily Dwelling Unit Calculation Examples – Standard Method Multifamily Dwelling Unit Calculations Sample – Standard Method Multifamily Dwelling Unit Calculations [220.32] – Optional Method	193 194 195 199 200
Advance Unit 10 Calculat 10–1 10–2 10–3 10–4 10–5	ed NEC Calculations Multifamily Dwelling Unit Load tions Multifamily Dwelling Unit Calculations – Standard Method Multifamily Dwelling Unit Calculation Examples – Standard Method Multifamily Dwelling Unit Calculations Sample – Standard Method Multifamily Dwelling Unit Calculations [220.32] – Optional Method Multifamily – Optional Method Examp [220.32]	193 194 195 199 200 le 200
Advance Unit 10 Calculat 10–1 10–2 10–3 10–4 10–5 Unit	ed NEC Calculations Multifamily Dwelling Unit Load tions Multifamily Dwelling Unit Calculations – Standard Method Multifamily Dwelling Unit Calculation Examples – Standard Method Multifamily Dwelling Unit Calculations Sample – Standard Method Multifamily Dwelling Unit Calculations [220.32] – Optional Method Multifamily – Optional Method Examp [220.32] 10 – Calculations Questions	193 194 195 199 200 le 200 202
Advance Unit 10 Calculat 10–1 10–2 10–3 10–4 10–5 Unit 11	ed NEC Calculations Multifamily Dwelling Unit Load tions Multifamily Dwelling Unit Calculations – Standard Method Multifamily Dwelling Unit Calculation Examples – Standard Method Multifamily Dwelling Unit Calculations Sample – Standard Method Multifamily Dwelling Unit Calculations [220.32] – Optional Method Multifamily – Optional Method Examp [220.32] 10 – Calculations Questions Commercial Load Calculations	193 194 195 199 200 le 200 202 206
Advance Unit 10 Calculat 10–1 10–2 10–3 10–4 10–5 Unit 1 Unit 11 Part 4	ed NEC Calculations Multifamily Dwelling Unit Load tions Multifamily Dwelling Unit Calculations – Standard Method Multifamily Dwelling Unit Calculations Examples – Standard Method Multifamily Dwelling Unit Calculations Sample – Standard Method Multifamily Dwelling Unit Calculations [220.32] – Optional Method Examp [220.32] 10 – Calculations Questions Commercial Load Calculations A – General	193 194 194 195 199 200 2 00 2 00 2 00 2 02 2 06 2 06
Advance Unit 10 Calculat 10–1 10–2 10–3 10–4 10–5 Unit 11 Part 1 11–1	 A NEC Calculations Multifamily Dwelling Unit Load tions Multifamily Dwelling Unit Calculations – Standard Method Multifamily Dwelling Unit Calculation Examples – Standard Method Multifamily Dwelling Unit Calculations Sample – Standard Method Multifamily Dwelling Unit Calculations [220.32] – Optional Method Multifamily – Optional Method Example [220.32] 10 – Calculations Questions Commercial Load Calculations A – General General Requirements 	193 194 194 195 199 200 2 00 2 00 2 00 2 00 2 06 206 206
Advance Unit 10 Calculat 10–1 10–2 10–3 10–4 10–5 Unit 1 Unit 11 Part 1 11–1 11–2	 A NEC Calculations Multifamily Dwelling Unit Load tions Multifamily Dwelling Unit Calculations – Standard Method Multifamily Dwelling Unit Calculation Examples – Standard Method Multifamily Dwelling Unit Calculations Sample – Standard Method Multifamily Dwelling Unit Calculations [220.32] – Optional Method Multifamily – Optional Method Example [220.32] 10 – Calculations Questions Commercial Load Calculations A – General General Requirements Conductor Ampacity [Article 100] 	193 194 195 195 200 202 206 206 206 206
Advance Unit 10 Calculat 10–1 10–2 10–3 10–4 10–5 Unit 1 Unit 11 Part 1 11–1 11–2 11–3	 A NEC Calculations Multifamily Dwelling Unit Load tions Multifamily Dwelling Unit Calculations – Standard Method Multifamily Dwelling Unit Calculation Examples – Standard Method Multifamily Dwelling Unit Calculations Sample – Standard Method Multifamily Dwelling Unit Calculations [220.32] – Optional Method Multifamily – Optional Method Example [220.32] 10 – Calculations Questions Commercial Load Calculations A – General General Requirements Conductor Ampacity [Article 100] Conductor Overcurrent Protection [240.4] 	193 194 194 195 200 200 200 200 200 202 206 206 206 206 206

	Tak	ole	of	Contents
--	-----	-----	----	----------

11–5 Rounding an Ampere [220.2(B)]	207
Part B – Loads	207
11–6 Air-Conditioning	207
11–7 Dryers	208
11–8 Electric Heat	209
11–9 Kitchen Equipment	210
11–10 Laundry Equipment	211
11–11 Lighting – Demand Factors [Table 220.3(A) and 220.11]	212
11–12 Lighting Without Demand Factors [Tab	ole
220.3(A), 215.2(A)(1) and 230.42].	212
11–13 Lighting – Miscellaneous	213
11–14 Multioutlet Receptacle Assembly	
[220.3(B)(8)]	213
11–15 Receptacles VA Load [220.13]	214
11–16 Banks and offices – General Lighting and Receptacles	215
11-17 Signs [220.3(B)(6) and 600.5]	216
11–18 Neutral Calculations [220.22]	216
Part C – Load Calculation Examples	217
Marina [555.12]	217
Mobile/Manufactured Home Park [550.31]	218
Recreational Vehicle Park [551.73]	218
Restaurant – Optional Method [220.36]	219
School – Optional Method [220.34]	221
Service Demand Load Using the Standard Method	222
Bank (120/240V, 1Ø)	222
Office Building (480Y/277V, 3Ø).	224
Restaurant - Standard Load Calculation	
(208Y/120V, 3Ø)	225
Unit 11 – Calculations Questions	227

Unit 12 Delta/Delta	and Delta/Wye	Transformer
Calculations	-	233

Introduction	
Definitions	
Current Flow	237
Part A – Delta/Delta Transformers	
Delta Transformer Voltage	239
Delta High-Leg	239
Delta Line Currents	239
	uction ations Current Flow A – Delta/Delta Transformers Delta Transformer Voltage Delta High-Leg Delta Line Currents

12–5	Delta Phase Currents	240
12–6	Delta Phase Versus Line Current	241
12–7	Delta Current Triangle	242
12-8	Delta Transformer Balancing	242
12–9	Delta Transformer Sizing	243
12–10	Delta Panel Balancing	243
12-11	Delta Panelboard and Conductor Sizing	243
12-12	Delta Neutral Current	244
12–13	Delta Maximum Unbalanced Load	244
12–14	Delta/Delta Example	244
Part E	B – Delta/Wye Transformers	247
12–15	Wye Transformer Voltage	247
12–16	Wye Voltage Triangle	247
12–17	Wye Transformers Current	248
12–18	Wye Line Current	248
12–19	Wye Phase Current	248
12-20	Wye Phase Versus Line Current	249
12-21	Wye Transformer Balancing	250
12-22	Wye Transformer Sizing	251
12-23	Wye Panel Balancing	251
12–24	Wye Panelboard and Conductor Sizing	252
12–25	Wye Neutral Current	252
12–26	Wye Maximum Unbalanced Load	252
12–27	Delta/Wye Example	253
12–28	Delta Versus Wye	255
Unit 1	2 – Calculations Questions	256