

Academy of Residential Construction
National Association of Home Builders
Home Builders Institute

Residential Electrician Standards

An Overview of HBI Framework for Skill Standards

We are pleased to present the second in a series of National Skill standards for the residential construction industry. The goal of this project is to establish national standards for the residential construction industry that reflect industry skill requirements. The standards will provide a basis for the certification and training of workers and provide employers with objective benchmarks for selecting employees and evaluating training needs. In addition, educators will find the standards useful for designing curriculum and evaluating an individual's training outcomes.

These standards in and by themselves do not represent a model-training program. These standards are designed to be a source for developing program and curriculum and evaluating the outcomes of residential electrician training programs.

Residential Electrician standards have been developed and validated, and incorporate Level I standards for semi-skilled electricians and Level II standards for skilled electricians. Standards were developed and validated for 117 critical work functions and 9 duty areas. Critical work functions describe the major tasks and content areas of work within each specialty. Key activities or major tasks and knowledge involved in completing critical work functions are also provided.

Performance Indicators, which help determine when critical work functions and key activities are being performed competently and meet NEC 2002 (National Electrical Code) standards, are referenced to critical work functions where applicable. Specific NEC references have been linked with critical work functions and key activities or tasks.

In addition, applied academic skills required to perform key activities are provided. These include measurement, arithmetic, layout, algebra, communications and use of materials. Safety requirements involved in completing key activities have also been identified. Tools required for performing key activities are also identified.

Committees of subject matter experts (SMEs) representing residential electricians from different parts of the nation were used to establish and validate the standards. The final list of 8 critical work functions and 117 key activities or tasks reflects and accommodates regional differences.

How the Standards Were Developed

The project called for the formation of a committee of National Association of Home Builders (NAHB) industry leaders in the field of residential electrical service from small and large volume companies as well as carpentry instructors and trainers. In addition, the author and editor of Delmar's electrical text were included in this committee. The Vice President of Apprenticeship and Training Standards and Safety from the Independent Electrical Contractors Association also participated. These leaders represented the following regions of the country: Northwest, Southeast, Southwest, Mid-Atlantic and Mid-Continent. Thus, residential electricians from different regions of the nation provided input with respect to electrical performance standards, practices and materials unique to these various regions. The list of residential electrician work functions and key activities produced in this project is appropriate for all regions of the nation, according to these committee industry leaders.

The initial group of six industry leaders participated in reviewing and rating critical work functions and key activities and applied academic skills. During a two-day meeting, the committee reviewed, commented on and rated the importance of more than 150 critical work functions and key activities. The committee also reviewed and referenced applied academic skills and safety requirements to each of these functions and activities. In addition, the committee identified tools related to performance of critical work functions and key activities.

A second group of six industry leaders validated the original 150 critical work functions and key activities by reviewing and rating these functions and activities. Other critical work functions and key activities were added and some deleted to the original list. The final list includes 8 work functions and 117 key activities. This process allowed the project to develop a more robust set of standards than would have been possible if only one group of industry leaders was used.

Key activities were also cross-referenced by page numbers, where applicable, to the NEC 2002 code and Delmar's *Electrical Wiring Residential* 14th edition, 2002 and Delmar's *Standard Textbook of Electricity* 2nd edition, 1999 texts.

Applied Academic Skills

The following are examples of applied academic skills statements developed in conjunction with industry leaders and review of authoritative references. The process involved using the residential electrician critical work functions (duty areas) and key activities (tasks). Committee members were asked to identify the applied academic skills required to perform each key activity. Applied academic skills include measurement, mathematics and communications. Appendix A indicates which academic skill goes with each key activity. Also, Appendix A reports safety requirements for each key activity. General statements describing academic skills were developed, reviewed and checked by industry committee members.

Applied Math Standards

1. Convert measures from feet/inches to decimals and vice versa.
2. Convert oral information into math forms and vice versa.
3. Solve construction problems using whole numbers and fractions.
4. Solve problems using fractions, decimals, ratios and percentages.
5. Solve problems using conventional electrical symbols.
6. Calculate required dimensions from blueprints.
7. Use tape measure and other measurement tools to verify that dimensions of features conform to plan specifications or manufacturer's tolerances.
8. Apply simple equations for estimating voltage, amperage, wattage, etc.
9. Interpret multi-column tables containing numerical data.

Applied Measurement Standards

1. Measure using tape or rule with +/- 1/8" of specifications.
2. Determine approximate distance by pacing.
3. Use tape measure to verify relationship of structural components of building.
4. Use tape measure and other measurement tools to verify that dimensions of features conform to plan specifications or manufacturer's tolerances.
5. Determine data needed to solve measurement problems.

Applied Communications Standards

1. Read and apply MSDS and other safety information.
2. Listen and follow verbal directions for work activity.
3. Give accurate verbal directions for work activity.
4. Locate electrical fixtures, switches, outlets, etc. using symbols from blueprints.
5. Read/apply manufacturers' specifications for equipment and materials.
6. Understand and interpret hand signals for rigging and lifts.
7. Follow standard work procedures for job-site safety.
8. Know how to treat effects of hazardous materials on job site.
9. Read and apply NEC rules for products, installation procedures, and use of electrical equipment.

Applied Materials Standards

1. Understand impact of NEC rules on electrical safety.
2. Identify proper electrical products from electrical symbols or specs.
3. Install electrical products that meet NEC and manufacturer's specifications.
4. Read and apply NEC code as found in NEC "Pocket Guide".
5. Understand NEC code and electrical symbols.
6. Understand electrical wire coding systems.
7. Select and apply proper fasteners and sealants in electrical installation.
8. Perform required electrical tests of circuits and products installed.

Analysis of committee members ratings found in Appendix A indicates that slightly more than three-quarters of the 117 key activities (performance and knowledge based) require measurement (77%) and arithmetic skills (76%). About half require layout (52%) and higher-level algebra skills (52%). Approximately 90% of all key activities require following verbal (91%) and written directions (90%). Three-quarters of the key activities require electricians to give simple directions and only 28% to give complex directions.

Safety Skills

Industry committee members identified safety related skills and knowledge for each key activity as found in Appendix B. Safety-related skills and the percent of key activities that require these skills are displayed in Table 1 below. Electrical protection is required by more than 80 percent of all key electrical activities. Safety-related skills and knowledge required by about half of all key activities are as follows: personal protection equipment 53%; safe use of ladders and scaffolds 52%; power and hand tools 50%; ergonomic protection 49%; fall protection 46%; HAZMAT 41% and trenching 41%. In addition, knowledge of OSHA regulations that apply to residential electricians is required.

Tools

Industry committee members identified standard hand tools and power tools required by each of the 117 residential electrician key activities and knowledge as reported in Appendix B.

Table 1. What safety-related skills and knowledge are required to perform key activities safely?

	Percent
Electrical Protection	83%
Personal Protection Equipment	53%
Ladders and Scaffolds	52%
Power Tools	50%
Hand Tools	50%
Ergonomic	49%
Fall Protection	46%
HAZMAT	41%
Trenching	41%

Skill Levels and Training

Level I residential electrician standards can be met in a six months to one-year training program depending upon the student’s prior educational background (especially in the area of measurement and applied mathematics), work experience, interests and mechanical aptitude, as well as breadth, scope and sequence of the training program. Level I residential electrician standards are commonly referred to as core or training standards. Electricians at this level usually perform work under the direction of a skilled or Level II residential electrician. Level I or core standards are typically learned in a high school or community college program, apprenticeship program, informal and formal electrician-based training program, on-the-job training or some combination of these. Level II skilled residential electricians typically perform work independently and may be required to supervise semi-skilled Level I residential electricians. Level II standards typically require two years of training as well as two or more years of experience mastering skills learned in training. Incumbent workers with extensive experience in residential electrical work experience may be able to demonstrate competence on standards with little or no additional structured training.

Residential Electrician Occupational Standards

Critical work functions (duty areas) and key activities (tasks) of a residential electrician are listed in the Table 2. Duty areas and tasks were determined through committee meetings with residential electrician industry leaders and reviews of authoritative texts and other references in the field of residential electrical services. Industry leaders were drawn from different regions of the country and represented small and large electrical companies as well as carpentry instructors and trainers. A second group validated the preliminary results of an initial meeting with industry leaders and the results are shown in this table. The relative importance of each task for Level I semi-skilled and Level II residential electricians is reported. Industry leaders identified a total of 117 tasks or content areas.

Importance Rating. The importance of each task or content area reported in the following table is the product of the proficiency or skill required to perform each task and the impact or risk to the electrician, builder, and homeowner if the task is performed improperly. Impact or risk includes possible structural failure to the building, injury to the worker or homeowner, and financial exposure to the builder, to name but a few.

Proficiency was estimated by asking the industry experts the following: **What skill level is required of a semi-skilled and skilled residential electrician?** This scale ranged from a rating of 1= Minimally Skilled to 4= Highly Skilled.

Impact on the building process was estimated by asking industry experts the question: **What is the impact of lack of knowledge or skills in this task or content area on building integrity, public confidence or safety?** The impact scale ranged from 1= Minimal to 4= Catastrophic.

Overall Importance Rating. The product of these two scales produced a 16-point importance scale that includes proficiency or skill in performing a task as well as impact on the building process if the task is performed improperly.

- 0-4 (L) Low Importance
- 5-8 (M) Moderate Importance
- 9-12 (V) Very Important
- 13-16 (E) Extremely Important

Percent Performing column is the percent of all residential electricians who perform task or need to know content area. This can be used as a measure for determining core standards. A rating of 100% means that all residential electricians perform this task or require knowledge of this content area.

Table 2. Residential Electrician Standards

Importance E=Extremely Important V=Very Important M=Moderate Importance L=Least Important

Critical Work Functions, Tasks and Knowledge Standards	Importance		Percent
	Level I	Level II	Performing
1 Planning & Preparing Electrical Project			
A. Workplace safety requirements	E	E	100%
1. MSDS, OSHA, & Manufacturers' Instructions	E	E	100%
2. Inspect & maintain personal protection equipment	E	E	100%
3. Use appropriate tools & equipment	E	E	100%
4. Follow electrical, fall protection and other safety requirements	E	E	100%
5. Handle hazardous materials safely	E	E	100%
6. Respond to hazardous materials threats	E	E	100%
7. Respond to other worksite emergencies	E	E	100%
	E	E	100%
	E	E	100%
B. NEC Introduction & Definitions			
1. NEC 90 Apply basic provisions & purpose	L	V	100%
2. NEC 100 Apply definitions for residential electrician	L	V	100%
3. NEC 110 Apply basic requirements for installations	L	V	100%
	L	V	100%

Table 2. Residential Electrician Standards

Importance E=Extremely Important V=Very Important M=Moderate Importance L=Least Important

Critical Work Functions, Tasks and Knowledge Standards	Importance		Percent
	Level I	Level II	Performing
C. Basic Concepts of Electricity (AC/DC)			
1. Electricity & electron flow	L	V	100%
2. Electrical measurement -- amp, ohm, watt, volt	L	V	100%
3. Apply Ohm's Law	L	V	100%
4. Interpret resistance values & coding	L	V	100%
5. Series circuits	L	V	100%
6. Parallel circuits	L	V	100%
7. Combination circuits	L	V	100%
D. Meters & Wire Tables			
1. Voltmeters, ammeters, ohmmeters	L	V	100%
2. Use wire tables to determine conductor sizes, voltage drop	L	V	100%
E.AC Circuits			
1. Apply AC concepts -- resistance, VA, etc.	L	V	90%
2. Understand AC circuits with inductance	L	V	75%
3. Understand resistive-inductive AC circuits	L	V	75%
4. Understand resistive-inductive parallel circuits	L	V	75%
	L	V	79%

Table 2. Residential Electrician Standards

Importance E=Extremely Important V=Very Important M=Moderate Importance L=Least Important

Critical Work Functions, Tasks and Knowledge Standards	Importance		Percent
	Level I	Level II	Performing
G.Three-Phase Power			
1. Understand three-phase circuits	L	V	35%
	L	V	35%
H.Transformers			
1. Understand single-phase transformers (VA, kVA)	L	V	100%
	L	V	100%
I.Generators, Motors & Alternators			
1. Understand power production & distribution	L	V	75%
2. Understand single-phase motors	L	V	75%
3. Understand single-phase alternators/generators	L	V	75%
	L	V	75%
J.Batteries (dry cell, wet cell)			
	L	V	50%
	L	V	50%

Table 2. Residential Electrician Standards

Importance E=Extremely Important V=Very Important M=Moderate Importance L=Least Important

Critical Work Functions, Tasks and Knowledge Standards	Importance		Percent
	Level I	Level II	Performing
2Establish Temporary Power			
A.NEC 527 Install temporary wiring/construction site wiring	L	V	100%
	L	V	100%
3Blueprints			
A.Interpret & follow blueprints & specifications	L	V	100%
B.Interpret drawing symbols & electrical designs	L	V	100%
C.Interpret plans & specifications accurately	L	V	100%
	L	V	100%
4Service Entrances			
A.Meet applicable NEC Requirements	L	V	100%
1. NEC 220 Select appropriate size service & panelboards	L	V	100%
2. NEC 230 Install appropriate service conductors & equipment	L	V	100%
3. NEC 215 Install feeders	L	E	100%
4. NEC 408 Install panelboards and disconnects	L	V	100%
5. NEC 240 Install overcurrent protection	L	E	100%
6. NEC 220 Identify & install grounded conductors	L	V	100%
7. NEC 250 Install service ground	L	V	100%
	L	V	100%

Table 2. Residential Electrician Standards

Importance E=Extremely Important V=Very Important M=Moderate Importance L=Least Important

Critical Work Functions, Tasks and Knowledge Standards	Importance		Percent
	Level I	Level II	Performing
B.Perform Required Calculations for Installation			
1. NEC 220 Complete load calculations	L	V	100%
2. NEC 220 Complete wire sizing calculations	L	V	100%
3. NEC 220 Determine minimum number of branch circuits	L	V	100%
	L	V	100%
C.Assemble Required Tools & Materials			
1. Select appropriate types of cables & conductors	L	V	100%
2. Use appropriate connectors, tubing & conduit	L	V	100%
Note: some regions do not use conduit	L	V	100%
D.Install Grounding Conductors & Connections			
1. NEC 250 Lay out grounding system from plans	L	E	100%
2. NEC 250 & 200 Install grounding system & connections	L	E	100%
3. NEC 250 & 200 Install equipment grounding	L	E	100%
	L	E	100%

Table 2. Residential Electrician Standards

Importance E=Extremely Important V=Very Important M=Moderate Importance L=Least Important

Critical Work Functions, Tasks and Knowledge Standards	Importance		Percent
	Level I	Level II	Performing
5 Install Raceway Systems			
A. Prepare & Layout System from Plans (NEC 342, 344, 348, 350, 352, 356, 358, 360, & 362)			
1. Calculate raceway bends, saddles & offsets	L	V	50%
2. Locate junction boxes, conduit, raceways	L	V	100%
3. Measure, bend & cut to specifications	L	V	100%
4. Determine number of conductors per raceway	L	V	100%
	L	V	100%
6 Rough-In & Run Conductors			
A. Select appropriate wiring methods & conductors			
1. NEC 300 General wiring requirements	L	V	100%
2. NEC 310 General requirements for conductors	L	V	100%
	L	V	100%

Table 2. Residential Electrician Standards

Importance E=Extremely Important V=Very Important M=Moderate Importance L=Least Important

Critical Work Functions, Tasks and Knowledge Standards	Importance		Percent
	Level I	Level II	Performing
B. Install appropriate cables			
1. NEC 334 Nonmetallic-Sheathed Cable	L	V	100%
2. NEC 330 Metal Clad Cable	L	V	100%
3. Armored cable	L	V	100%
4. NEC 338 Service Entrance Cable	L	V	100%
5. NEC 340 Underground Feeder & Branch Circuit Cable	L	V	100%
	L	V	100%
C. Select & install appropriate raceways			
1. NEC 358 Electrical Metallic Tubing (EMT)	L	V	75%
2. NEC 344 Rigid Metal Conduit (RMC)	L	V	75%
3. NEC 352 Rigid Nonmetallic Conduit (RNC)	L	V	100%
4. NEC 348 Flexible Metal Conduit (FMC)	L	V	100%
5. NEC 350 Liquidtight Flexible Metal Conduit (LFMC)	L	V	100%
6. NEC 356 Liquidtight Flexible Nonmetallic Conduit (LFNC)	L	V	100%
	L	V	92%

Table 2. Residential Electrician Standards

Importance E=Extremely Important V=Very Important M=Moderate Importance L=Least Important

Critical Work Functions, Tasks and Knowledge Standards	Importance		Percent
	Level I	Level II	Performing
D.NEC 314 Install boxes & enclosures	M	V	100%
	M	V	100%
E.Install Branch Circuits NEC 210			
1. Install lighting circuits	L	V	100%
2. Install lighting & receptacle circuits	L	V	100%
3. Install luminaries (fixtures) & fan outlets	L	V	100%
4. Install kitchen small appliance branch circuits	L	V	100%
5. Install kitchen oven & range outlets	L	V	100%
6. Install other special purpose circuits (disposals, dishwashers, etc.)	L	V	100%
	L	V	100%
F.NEC 404 Install Switch Control of Circuits (low/full voltage)			
1. Identify appropriate conductors	L	V	100%
	L	V	100%

Table 2. Residential Electrician Standards

Importance E=Extremely Important V=Very Important M=Moderate Importance L=Least Important

Critical Work Functions, Tasks and Knowledge Standards	Importance		Percent
	Level I	Level II	Performing
G.Install Other Indoor Residential Circuits			
1. NEC 424 Install electric resistance-heating equipment	L	V	100%
2. NEC 410 Install track lighting & dimmer lighting circuits	L	V	100%
3. NEC 410 Install valance lighting	L	V	100%
4. NEC 210 Install laundry & utility room circuits	L	V	100%
5. NEC 410 Install lay-in fixtures/recessed fixtures	L	V	100%
6. NEC 210 Install receptacle, wet bar & bathroom circuits	L	V	100%
7. NEC 210 Install workshop circuits & receptacles	L	V	100%

Table 2. Residential Electrician Standards

Importance E=Extremely Important V=Very Important M=Moderate Importance L=Least Important

Critical Work Functions, Tasks and Knowledge Standards	Importance		Percent
	Level I	Level II	Performing
H.Install Special-Purpose Outlets & Circuits			
1. NEC 210 Install dryer and cooking circuits	L	V	100%
2. NEC 422 Install water pump & water heater circuits	L	V	100%
3. NEC 210 Install ceiling fans, vents & hydromassage circuits	L	V	100%
4. NEC 440 Install HVAC outlets & circuits	L	V	100%
5. Install control circuits for gas & oil heating	L	V	100%
6. NEC 800 Install voice, data & communication circuits	L	V	100%
7. NEC 800 Install detector & alarm circuits (security & fire)	L	V	100%
8. Install low voltage circuits	L	V	100%
9. NEC 230 Install service entrance equipment	L	V	100%
10. Install standby power	L	V	100%

Table 2. Residential Electrician Standards

Importance E=Extremely Important V=Very Important M=Moderate Importance L=Least Important

Critical Work Functions, Tasks and Knowledge Standards	Importance		Percent
	Level I	Level II	Performing
I. Other Residential Electrical Requirements			
1. NEC 225 Wiring separate buildings or structures	L	V	100%
2. NEC 680 Swimming pools, spas, fountains, hot tubs and other water sources	L	E	100%
3. Install outdoor branch lighting circuits	L	V	100%
4. Install garage lighting & door opener circuits	L	V	100%
5. NEC 250 Install grounding for second building	L	V	100%
	L	V	100%

Table 2. Residential Electrician Standards

Importance E=Extremely Important V=Very Important M=Moderate Importance L=Least Important

Critical Work Functions, Tasks and Knowledge Standards	Importance		Percent
	Level I	Level II	Performing
7Trim Out			
A.NEC 410 Install luminaires (fixtures)	L	V	100%
B.NEC 404, 406 & 210 Connect switches, receptacles & outlets	L	V	100%
C.NEC 210 Install GFCIs, AFCIs	L	V	100%
D.NEC 240 Install surge suppressors	L	V	100%
E.NEC 422 Install & connect appliances	L	V	100%
F.NEC 422 Install ceiling suspended (paddle) fans	L	V	100%
G.NEC 440 Connect HVAC equipment wiring	L	V	100%
H.NEC 800 Install data, voice & communication devices	L	V	100%

Table 2. Residential Electrician Standards

Importance E=Extremely Important V=Very Important M=Moderate Importance L=Least Important

Critical Work Functions, Tasks and Knowledge Standards	Importance		Percent
	Level I	Level II	Performing
8 Perform Checks on Energized Systems			
A. Check current, voltage & continuity			
1. Panelboards	L	E	100%
2. Circuits (outlets & receptacles), luminaires, & appliances	L	E	100%
	L	E	100%
9 Troubleshoot & Repair Electrical Systems			
A. Analyze non-functioning wiring & equipment	L	V	100%
B. Conduct appropriate tests	L	V	100%
C. Make repairs if required	L	V	100%
	L	V	100%

Appendix A. Applied Academics and Safety

Applied Academics			
Math	Comm.	Comm.	Safety

1 Planning & Preparing Electrical Project

A. Workplace safety requirements

1. MSDS, OSHA, & Manufacturers' Instructions	1,3	1,2	1,2,3,4,5,6,7,8,9
2. Inspect & maintain personal protection equipment		1,2,	6
3. Use appropriate tools & equipment	1,2,3,	1,2,3	2,3,4,5,6,8,9
4. Follow electrical, fall protection and other safety requirements	1	1,2,3	1,5
5. Handle hazardous materials safely		1,2,3	2
6. Respond to hazardous materials threats	1	1,2,3,4	2
7. Respond to other worksite emergencies	1	1,2,3,4	1,2,3,4,5,6,7,8,9

B. NEC Introduction & Definitions

1. NEC 90 Apply basic provisions & purpose	1,2,3	1,2,3,4	3
2. NEC 100 Apply definitions for residential electrician	1,2,3	1,2,3,4	3
3. NEC 110 Apply basic requirements for installations	1,2,3	1,2,3,4	3

Appendix A. Applied Academics and Safety

Applied Academics			
Math	Comm.	Comm.	Safety

C. Basic Concepts of Electricity (AC/DC)

1. Electricity & electron flow	2	1,2	3
2. Electrical measurement -- amp, ohm, watt, volt	2,4	1,2	3
3. Apply Ohm's Law	2,4	1,2	3
4. Interpret resistance values & coding	2,4	1,2	3
5. Series circuits	2,4	1,2	3
6. Parallel circuits	2,4	1,2	3
7. Combination circuits	2,4	1,2	3

C. Basic Concepts of Electricity (AC/DC)

D. Meters & Wire Tables

1. Voltmeters, ammeters, ohmmeters	1,2,4	1,2,3,4	3
2. Use wire tables to determine conductor sizes, voltage drop	1,2,4	1,2,3,4	3

Appendix A. Applied Academics and Safety

Applied Academics		
Math	Comm.	Safety

E. AC Circuits

- | | | | |
|---|--------|-------|-------------------|
| 1. Apply AC concepts -- resistance, VA, etc. | | | |
| 2. Understand AC circuits with inductance | 1,3 | 1,2 | 1,2,3,4,5,6,7,8,9 |
| 3. Understand resistive-inductive AC circuits | | 1,2, | 6 |
| 4. Understand resistive-inductive parallel circuits | 1,2,3, | 1,2,3 | 2,3,4,5,6,8,9 |

F. Capacitors

- | | | | |
|---|-------|---------|---|
| 1. Apply capacitor ratings appropriately | 1,2,4 | 1,2,3,4 | 3 |
| 2. Understand AC circuits with capacitance | 1,2,4 | 1,2,3,4 | 3 |
| 3. Understand resistive-capacitive series circuits | 1,2,4 | 1,2,3,4 | 3 |
| 4. Understand resistive-capacitive parallel circuits | 1,2,4 | 1,2,3,4 | 3 |
| 5. Understand resistive-inductive-capacitive circuits | 1,2,4 | 1,2,3,4 | 3 |

G. Three-Phase Power

- | | | | |
|------------------------------------|-------|---------|---|
| 1. Understand three-phase circuits | 1,2,4 | 1,2,3,4 | 3 |
|------------------------------------|-------|---------|---|

H. Transformers

- | | | | |
|---|-------|---------|---|
| 1. Understand single-phase transformers (VA, kVA) | 1,2,4 | 1,2,3,4 | 3 |
|---|-------|---------|---|

Appendix A. Applied Academics and Safety

Applied Academics		
Math	Comm.	Safety

I. Generators, Motors & Alternators

1. Understand power production & distribution	1,2,4	1,2,3,4	3
2. Understand single-phase motors	1,2,4	1,2,3,4	3
3. Understand single-phase alternators/generators	1,2,4	1,2,3,4	3

J. Batteries (dry cell, wet cell)

	2	1,2,	2,3
--	---	------	-----

2 Establish Temporary Power

A. NEC 527 Install temporary wiring/construction site wiring	1,2,3	1,2,3,4	3,4,5,6,7,8,9
--	-------	---------	---------------

3 Blueprints

A. Interpret & follow blueprints & specifications	1,2,3	1,2,3,4	
B. Interpret drawing symbols & electrical designs		1,2	
C. Interpret plans & specifications accurately	1,2,3	1,2,3,4	

Appendix A. Applied Academics and Safety

Applied Academics		
Math	Comm.	Safety

4 Service Entrances

A. Meet applicable NEC Requirements

1. NEC 220 Select appropriate size service & panelboards	1,2,3,4	1,2,3	3
2. NEC 230 Install appropriate service conductors & equipment	1,2,3	1,2,3,4	1,2,3,4,5,6,7,8,9
3. NEC 215 Install feeders	1,2,3	1,2,3,4	1,2,3,4,5,6,7,8,9
4. NEC 408 Install panelboards and disconnects	1,2,3	1,2,3,4	1,2,3,4,5,6,7,8,9
5. NEC 240 Install overcurrent protection	1,2,3	1,2,3,4	1,2,3,4,5,6,7,8,9
6. NEC 220 Identify & install grounded conductors	1,2,3	1,2,3,4	1,2,3,4,5,6,7,8,9
7. NEC 250 Install service ground	1,2,3	1,2,3,4	1,2,3,4,5,6,7,8,9

B. Perform Required Calculations for Installation

1. NEC 220 Complete load calculations	1,2,4	1,2	3
2. NEC 220 Complete wire sizing calculations	1,2,4	1,2	3
3. NEC 220 Determine minimum number of branch circuits	1,2,4	1,2	3

Appendix A. Applied Academics and Safety

Applied Academics		
Math	Comm.	Safety

C. Assemble Required Tools & Materials

- | | | | |
|--|-----|-----|-----|
| 1. Select appropriate types of cables & conductors | 1,3 | 1,2 | 6,7 |
| 2. Use appropriate connectors, tubing & conduit | 1,3 | 1,2 | 6,7 |

Note: some regions do not use conduit

D. Install Grounding Conductors & Connections

- | | | | |
|---|-------|-------|-----------------|
| 1. NEC 250 Lay out grounding system from plans | 1,2,3 | 1,2,3 | 3 |
| 2. NEC 250 & 200 Install grounding system & connections | 1,2,3 | 1,2,3 | 1,3,4,5,6,7,8,9 |
| 3. NEC 250 & 200 Install equipment grounding | 1,2,3 | 1,2,3 | 1,3,4,5,6,7,8,9 |

Appendix A. Applied Academics and Safety

Applied Academics		
Math	Comm.	Safety

5 Install Raceway Systems

A. Prepare & Layout System from Plans

- | | | | |
|---|-------|-------|-------------------|
| 1. Calculate raceway bends, saddles & offsets | 1,2,3 | 1,2,3 | 3 |
| 2. Locate junction boxes, conduit, raceways | 1,2,3 | 1,2,3 | 3 |
| 3. Measure, bend & cut to specifications | 1,2,3 | 1,2,3 | 3,4,6,9 |
| 4. Determine number of conductors per raceway | 1,2,3 | 1,2,3 | 1,2,3,4,5,6,7,8,9 |

6 Rough-In & Run Conductors

A. Select appropriate wiring methods & conductors

- | | | | |
|--|-------|--------|---|
| 1. NEC 300 General wiring requirements | 1,2,3 | 1,2,3, | 3 |
| 2. NEC 310 General requirements for conductors | | | |

B. Install appropriate cables

- | | | | |
|--|-------|-------|-------------------|
| 1. NEC 334 Nonmetallic-Sheathed Cable | 1,2,3 | 1,2,3 | 1,2,3,4,5,6,7,8,9 |
| 2. NEC 330 Metal Clad Cable | | | |
| 3. Armored cable | | | |
| 4. NEC 338 Service Entrance Cable | | | |
| 5. NEC 340 Underground Feeder & Branch-Circuit Cable | | | |

Appendix A. Applied Academics and Safety

Applied Academics		
Math	Comm.	Safety

C. Select & install appropriate raceways	1,2,3	1,2,3	1,2,3,4,5,6,7,8,9,
1. NEC 358 Electrical Metallic Tubing (EMT)			
2. NEC 344 Rigid Metal Conduit (RMC)			
3. NEC 352 Rigid Nonmetallic Conduit (RNC)			
4. NEC 348 Flexible Metal Conduit (FMC)			
5. NEC 350 Liquidtight Flexible Metal Conduit (LFMC)			
6. NEC 356 Liquidtight Flexible Nonmetallic Conduit (LFNC)			
D. NEC 314 Install boxes & enclosures	1,2,3	1,2,3	1,2,3,4,5,6,7,8,9
E. Install Branch Circuits NEC 210	1,2,3	1,2,3	1,2,3,4,5,6,7,8,9
1. Install lighting circuits	1,2,3	1,2,3	1,2,3,4,5,6,7,8,9
2. Install lighting & receptacle circuits	1,2,3	1,2,3	1,2,3,4,5,6,7,8,9
3. Install luminaries (fixtures) & fan outlets	1,2,3	1,2,3	1,2,3,4,5,6,7,8,9
4. Install kitchen small appliance branch circuits	1,2,3	1,2,3	1,2,3,4,5,6,7,8,9
5. Install kitchen oven & range outlets	1,2,3	1,2,3	1,2,3,4,5,6,7,8,9
6. Install other special purpose circuits (disposals, dishwashers, etc.)	1,2,3	1,2,3	1,2,3,4,5,6,7,8,9

Appendix A. Applied Academics and Safety

Applied Academics		
Math	Comm.	Safety

F. NEC 404 Install Switch Control of Circuits (low/full voltage)

1. Identify appropriate conductors

1,2,3	1,2,3	1,2,3,4,5,6,7,8,9
-------	-------	-------------------

G. Install Other Indoor Residential Circuits

1. NEC 424 Install electric resistance-heating equipment
2. NEC 410 Install track lighting & dimmer lighting circuits
3. NEC 410 Install valance lighting
4. NEC 210 Install laundry & utility room circuits
5. NEC 410 Install lay-in fixtures/recessed fixtures
6. NEC 210 Install receptacle, wet bar & bathroom circuits
7. NEC 210 Install workshop circuits & receptacles

1,2,3	1,2,3	1,2,3,4,5,6,7,8,9
1,2,3	1,2,3	1,2,3,4,5,6,7,8,9
1,2,3	1,2,3	1,2,3,4,5,6,7,8,9
1,2,3	1,2,3	1,2,3,4,5,6,7,8,9
1,2,3	1,2,3	1,2,3,4,5,6,7,8,9
1,2,3	1,2,3	1,2,3,4,5,6,7,8,9
1,2,3	1,2,3	1,2,3,4,5,6,7,8,9

Appendix A. Applied Academics and Safety

Applied Academics		
Math	Comm.	Safety

H. Install Special-Purpose Outlets & Circuits

1. NEC 210 Install dryer and cooking circuits	1,2,3	1,2,3	1,2,3,4,5,6,7,8,9
2. NEC 422 Install water pump & water heater circuits	1,2,3	1,2,3	1,2,3,4,5,6,7,8,9
3. NEC 210 Install ceiling fans, vents & hydromassage circuits	1,2,3	1,2,3	1,2,3,4,5,6,7,8,9
4. NEC 440 Install HVAC outlets & circuits	1,2,3	1,2,3	1,2,3,4,5,6,7,8,9
5. Install control circuits for gas & oil heating	1,2,3	1,2,3,4	1,2,3,4,5,6,7,8,9
6. NEC 800 Install voice, data & communication circuits	1,2,3	1,2,3,4	1,2,3,4,5,6,7,8,9
7. NEC 800 Install detector & alarm circuits (security & fire)	1,2,3	1,2,3,4	1,2,3,4,5,6,7,8,9
8. Install low voltage circuits	1,2,3	1,2,3,4	1,2,3,4,5,6,7,8,9
9. NEC 230 Install service-entrance equipment	1,2,3	1,2,3,4	1,2,3,4,5,6,7,8,9
10. Install standby power	1,2,3	1,2,3,4	1,2,3,4,5,6,7,8,9

I. Other Residential Electrical Requirements

1. NEC 225 Wiring separate buildings or structures	1,2,3	1,2,3	1,2,3,4,5,6,7,8,9
2. NEC 680 Swimming pools, spas, fountains, hot tubs and other water sources	1,2,3	1,2,3,4	1,2,3,4,5,6,7,8,9
3. Install outdoor branch lighting circuits	1,2,3	1,2,3	1,2,3,4,5,6,7,8,9
4. Install garage lighting & door opener circuits	1,2,3	1,2,3	1,2,3,4,5,6,7,8,9
5. NEC 250 Install grounding for second building	1,2,3	1,2,3	1,2,3,4,5,6,7,8,9

Appendix A. Applied Academics and Safety

Applied Academics		
Math	Comm.	Safety

7Trim Out

A.NEC 410 Install luminaires (fixtures)		1,2	3
B.NEC 404, 406 & 210 Connect switches, receptacles & outlets	1,2,3	1,2,3	1,3,4,5,6,7,9
C.NEC 210 Install GFCIs, AFCIs	1,2,3	1,2,3	3,4,5,6,7,9
D.NEC 240 Install surge suppressors		1,2,3	3,4,5,6,7,9
E.NEC 422 Install & connect appliances		1,2,3	3,4,5,6,7,9
F.NEC 422 Install ceiling suspended (paddle) fans	1	1,2,3	1,3,4,5,6,7,9
G.NEC 440 Connect HVAC equipment wiring	1	1,2,3	1,3,4,5,6,7,9
H.NEC 800 Install data, voice & communication devices	1	1,2,3	1,3,4,5,6,7,9

8Perform Checks on Energized Systems

A.Check current, voltage & continuity	1,2,3,4	1,2,3,4	1,3,5,9
1. Panelboards			
2. Circuits (outlets & receptacles), luminaires, & appliances			

9Troubleshoot & Repair Electrical Systems

A.Analyze non-functioning wiring & equipment		1,2,3,4	1,3,4,5,9,7,9
B.Conduct appropriate tests	1,2	1,2,3,4	1,3,4,5,6,9
C.Make repairs if required	1,2,3	1,2,3,4	1,2,3,4,5,6,7,8,9

Appendix A Coding

Mathematics

- 1= Measurement
- 2= Arithmetic
- 3= Layout
- 4= Algebra

Communications

- 1=Follow Verbal Directions
- 2=Follow Written Directions
- 3=Give Simple Directions
- 4=Give Complex Directions

Materials

- 1=Select Appropriate Materials
- 2=Apply Materials as Specified

Safety

- 1=Fall Protection
- 2=Hazardous Materials
- 3=Electrical Protection
- 4=Power Tools
- 5=Ladders and Scaffolds
- 6=PPE
- 7=Ergonomics
- 8=Trenching
- 9=Hand Tools

Appendix B. Residential Electrician Tools and Safety Equipment

Safety Equipment

Safety glasses
Face shields
Safety shoes
Safety or dust filter mask
Hard hat
Gloves
Individual fall arrest
Protective clothing (blast suits, etc.)

Hand Tools

Allen wrench	Adapter cables
Crimping tools	Architect scale
File	Awl
Fish tape	Block & tackle
Hacksaw	Clamps
Hammer	Fuse puller
Handsaw	Hand bender
Keyhole saw	Hand reamer
Knife	Knock out sets
Ladder	Pipe wrench
Level	Plumb bob
Measuring tape & ruler	Shovel
Pliers	Tamp tool
Punch	Tap & dies
Screw drivers	Torque wrench
Socket set	Transit
Wire cutters	Wood chisels
Wire stripper	Ratchet cable puller
Wrench	

Meters

Voltmeter
Ammeter
Ohmmeter
Dielectric test set
Ground Megger (Meg Ohm Meter)

Power-Assisted Tools

Electric drill
Electric screw drivers (battery powered)
Electric hammer drill
Air hammer
Powder-actuated stud gun
Power cutting and threading machine
Reciprocating saw
Circular saw

Heavy Equipment

Trencher