Introduction: The purpose of this manual is to prepare the electrician licensee candidate to pass his/her state’s electrical exam based on the 2011 National Electrical Code. (HTPYEE) Will also satisfy 2008 Exam needs. You will need a copy of the 2011 NEC and a non-scientific calculator with the basic functions of Addition, Subtraction, Multiplication, Division, and Square Root.

Instead of repetitive exercises, How to Pass Your Electrical Exam (HTPYEE) will show you each type of question that could be on your exam only once. There is no way to know the exact question or the values of voltage, current, and loads that will be tested, but there are only so many standard calculations in the code book, most residing within Chapter 2. Many calculations rely on NEC Tables rather than Ohms Law formulas or engineering formulas alone. Improper use of the Tables is quite enough to get yourself a failing grade. Using engineering formulas will also get you an “F”. It would not be uncommon for a Professional Engineer to fail the Master Electrician exam. The code has its own way of calculating loads and protections. Engineering formulas are built-in the tables.

The National Electrical Code (NEC) is a minimum standard. HTPYEE teaches you ONLY what you need to pass the exam. Most courses overload the electrician with too much information. Generally the test, in most cases, is open book, 100 questions or less, and a time limit of four hours or less. It is pass or fail in most cases and your final score will not be printed on your license. You must check with your examination authority to see what materials can be brought to your test site. Most formats are open book but a few may be closed book. You also want to ask them if you can use a Hi-liter to mark code passages. It is your responsibility to obtain a copy of your state and/or local codes that may apply to your exam. Also each state may have prerequisite minimums that must be met before you may take the exam such as documented hours of job training and/or task experience.
Author’s Note: You’ll notice sometimes I don’t use code references such as 90.1(A) etc... because HTPYEE would rather teach you the simpler material in a way you are not wasting exam time looking it up. I will show you the magic of the INDEX for the more complex questions as needed. Practice tests may be downloaded when you finish this course. At the end of this course I’ll give you the link for the practice tests and my personal e-mail addresses. I would suggest you spend at least three months (90 days) studying this material inside and out before taking the practice tests.

The Master’s NEC Classroom is no longer a website. My webhost of over ten years shut down their server with no notice to their customers. FOR ACCESS SEND ME YOUR USER NAME AND PASSWORD FROM THE SAME E-MAIL ADDRESS YOU USED TO PURCHASE THE CLASSROOM. I am sorry for your inconvenience but this is the very best I can do under the circumstances.

O. K. Let’s get started! And good luck!
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Follow along in your code book—the references will be different between 2008 NEC and the 2011 NEC but still in the same general area of the code. There are only two changes that affect the Wisconsin exam in particular: Ampacity Tables and one item in Health Care Facilities.

After you’ve went through each lesson have someone ask you the questions or cover up the answers with a piece of colored construction paper or just scroll down the screen far enough to cover the answer. I’ll give you questions I have seen on exams.

This e-book might seem “too simplified”, however it was written to teach you the components of harder exam questions. Yes, these are simple questions, even on the practice exams which can be downloaded at: http://www.stateelectricallicense.com/htpyeudupins.html

Very Important: ALWAYS “REFRESH” THE DOWNLOAD PAGE TO GET THE UPDATES

Everything you read in this e-book is on the exam in some form!

Lesson I

Scope and Purpose of the NEC

What is the NEC?

The National Electrical Code is NFPA 70. NFPA stands for the National Fire Prevention Association and is used primarily by fire departments. The NEC is the minimum electrical safety standard.

What is the purpose of the NEC?

The purpose of the NEC is the practical safeguarding of persons and property from hazards arising from the use of electricity.

Is the NEC to be used as a design specification or an instruction manual for untrained persons?

No.

The NEC covers all installations where people are gathered and where materials are stored, including mobile homes, RVs, warehouses, and floating buildings. What is not covered by the NEC?

Installations in ships, railways, automobiles, trucks, and all utilities including communications utilities. (Although communications installations are covered in Chapter 8 which is a standalone NEC article). However, public administration buildings for utilities are covered same as office areas.
How is the NEC arranged?

Chapters 1, 2, 3, and 4 apply to all electrical installations. Chapters 5, 6, and 7 supplement or modify Chapters 1 thru 4. Chapter 8 is not subject to Chapters 1 thru 7 except where they are specifically referenced within Chapter 8.  

How are Mandatory, Permissive, and Explanatory information differentiated within the NEC?

Mandatory rules are characterized by the words “shall” or “shall not”. Permissive rules use the terms “shall be permitted” or “shall not be required”. Explanatory information is presented as FPNs (fine print notes) which are suggestions and are not enforceable under NEC requirements.

Definitions

{Definitions that are used more than once within the code are defined in Art. 100. Definitions used only once are defined within their specific code section}

What is the NEC definition of “accessible”?

Accessible (as applied to equipment) Admitting close approach, not guarded by locked doors, elevation or other means. Accessible (as applied to wiring methods) capable of being removed or exposed without damaging the building structure. Readily Accessible – can be reached quickly by anyone without the use of a ladder, etc.

What is the AHJ?

The AHJ is the Authority Having Jurisdiction and is the state department in charge of enforcing the NEC and levying fines and fees. Generally the representative or your AHJ is the state electrical or building inspector.  
{In Wisconsin the AHJ is the Department of Commerce}

Define a bathroom.

An area including a basin (sink) with either one of the following: a toilet, tub, urinal, shower or similar plumbing device. {Your guess is as good as mine as to what constitutes a similar plumbing device}

The connection between the grounded circuit conductor and the equipment grounding conductor at a separately derived system is called?

The System Bonding Jumper
What is a ‘building’?

A structure that stands alone or is cut off from adjoining structures by fire walls and approved doors. (Your state and local codes should tell you what the fire rating in hours for the walls and doors should be). [3-hours in Wisconsin]

What is a bonding conductor?

A reliable conductor that assures the electrical conductivity between metal parts such as conduits, junction boxes, and enclosures etc...

What is an equipment bonding jumper?

The connection between two or more portions of the equipment grounding conductor.

What is the main bonding jumper?

The connection of the grounded conductor (the neutral) and the equipment grounding conductor (green or bare copper) at the service.

What is the difference between a branch circuit, an appliance branch circuit, a general purpose branch circuit, and individual branch circuit, and a multi-wire branch circuit?

A multi-wire branch circuit (a network) consists of two or more ungrounded conductors (hots) and one common grounded circuit (neutral); and individual branch circuit is one that supplies only one utilization equipment a.k.a. dedicated circuit for the furnace or water heater in a dwelling for example; a general purpose branch circuit may supply both lights and equipment at the same time; a branch circuit consists of the conductors from the last overcurrent device to the outlet(s) of a circuit.

What is a covered conductor?

One that is covered in a material not considered as electrically insulated.

What is a continuous load?

One in which the maximum current is expected to continue for 3 hours or more.
What does coordination mean?

Selective coordination means that over-current devices are set in such a way that a fault downstream in a system won’t necessarily trip the main breaker(s). This is used in conjunction with arc flash protection.

What is a demand factor?

The ratio of the maximum demand load of a system compared to the considered demand. i.e. it is a reduction in the size of conductors due to the fact that not all the equipment in a system will be in use at any one time. Most demand factors are limited to dwellings, residential and commercial apartments (multi-family dwellings), hospitals, trailer and RV parks, hotels etc.

What is a device?

Electrical equipment that carries electricity but does not consume it; a receptacles and switches are good examples.

What is a feeder?

All circuit conductors between the electrical service to the branch circuit over-current devices.

What is a ground fault?

An unintentional electrical connection between the ungrounded conductors of a system to the metal parts of the system or to earth.

What constitutes being “within sight of or from”?

“Within sight of or from” is where one piece of equipment is within 50 feet of another that is required to be within sight of each other such as a disconnect and the motor it supplies.

What is interrupting rating?

The rating of a device or switch that is identified as being capable of opening at the highest current at the operating voltage of a piece of equipment (switch, breaker etc..); usually rated in HP (horse power) or locked rotor current.

What is a kitchen?

An area with a sink and permanent provisions for cooking. Permanent provisions can be as simple as a hard-wired-in microwave oven.
What is a luminaire?

A light fixture or lamp, but not the lamp-holder itself.

What is the difference between a wet location and a damp location?

A wet location is exposed to weather, underground raceways, shower rooms, etc.; a damp location would be under an outside porch roof where equipment would be exposed to minimal amounts of moisture. {Any conductor that is used underground must either have a U or W in its identification markings. THHN is not legal underground. THWN is.}

What is the difference between overcurrent and overload?

*Overcurrent* is any current in excess of the rated full load current (FLC) of equipment or the ampacity of conductors. Overcurrent may be caused by an overload, short circuit or ground-fault. An overload, on the other hand, is an operating current of equipment in excess of its full load current (FLC) rating. A short circuit or fault is not an overload.

Explain rain-tight and rain-proof?

*Raintight* means that in exposure to a beating rain water will not enter an enclosure, while *rainproof* means that water entering the enclosure won’t interfere with normal operation. The same goes for dusttight, dustproof; watertight, weatherproof.

What is a separately derived system?

Electrical power that comes from other than a service; examples are a transformer, generator, PV (photovoltaic) solar system, battery; inverter etc...

What is the service lateral?

The underground conductors from the utility system (transformer) to the service point (where it connects to the service point (the point of connection between the utility and the premises wiring).

What are the overhead service conductors?

The overhead conductors between the service point (splices at the weather head) and the service entrance conductors at the building or another structure on the premises.
What is **special permission**?

Written permission from the AHJ (Authority Having Jurisdiction).

What is an **isolating switch**?

One that has no interrupting rating intended to be opened only after the system or equipment is de-energized.

What is **nominal voltage**?

Voltages such as 120, 110, 115; 220, 230, 240 etc. equipment can operate within a range of voltages instead of just 110, 220, 240 etc.

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**Lesson II**

**General Installation Requirements**

If equipment that arrives at the job site has a NEMA label and a UL sticker on it what does that tell you, the electrician?

The equipment is identified, labeled, listed, and approved. {Please go back right now and read these four definitions in Art. 100}

Listed or labeled equipment shall be used in accordance with any manufacturer’s installation instructions that came with it. True or False?

True.

Conductors will normally be of copper material unless otherwise stated. True or False?

True. {This is true on the exam as well—they have to tell you if the conductors are aluminum for example}

Equipment identified for use as **Indoor Equipment** shall be protected from weather and wet conditions during construction while exposed to the elements. True or False?

True
Equipment such as connections, enclosures, and cabinets shall be protected from paint, plaster, dust and mud etc. during construction. True or False?

True

Wooden plugs shall not be used to mount equipment on masonry, concrete, plaster or other similar structures. True or False?

True. {Nobody has used wooden plugs since plastic was invented}

Dissimilar metals, connectors, screws, splices etc. shall not be used ever during construction unless it is listed and identified for the purpose, such as certain fluxes, solders, and pastes. True or False?

True.

Equipment must be installed so that heat is dissipated freely and not blocked by being enclosed in too small an area. True or False?

True

Connections by means of wire binding screws with up turned lugs shall be permitted for #10AWG conductors or smaller. True or False?

True

**Temperature Limitations**

Unless otherwise marked the temperature limitations of terminals and conductors shall be determined by what code section of Chapter 1?

110.14(C) 1 [This section applies to Table 310.15(B)16 also 310.16 2008NEC]

Conductors rated at 100 amps or less and sized from #14AWG to #1AWG may only be connected to terminals rated at 60°C while those rated over 100 amps and larger than #1AWG shall be connected to 75°C terminations. You may only use the 90°C column of Table 310.15(B)16 to derate conductors.
Identification of Equipment Installations

On a 3-wire grounded wye system the high leg shall be marked orange in color. True or False?

False. The high leg of a grounded Delta 4-wire system must be orange. A wye transformer does not have a high leg. (This is how they trick you—although examiners will tell you time and time again there are no trick questions—ha!)

All electrical equipment such as panel boards and switchboards must be marked for arc flash protection including dwelling units. True or False?

False. Not required in dwelling units.

Working Spaces

What is the minimum clear working distance between the front of a motor control center and a concrete wall when the primary operating voltage is 480v? [Hint: Table 110.26(A)(1)]

3 1/2 feet Condition 2

For equipment rated at 1200 amperes or more and containing over-current and switching devices there shall be an opening for egress at both ends of the area with panic hardware installed on the doors, each door 24" wide and 6 1/2 ‘ tall.
True or False?

True

The minimum headroom of working equipment such as services, switchboards, and motor control centers shall be a minimum of _______ and where the equipment exceeds that measurement it shall not be ________?

6 1/2 feet, less than the height of the equipment

Sprinkler protection is never allowed in the dedicated space above a motor control center. True or False?

False 110.26(l) (c) (When you see words like NEVER and ALWAYS, the statements are rarely true)

[Note: Generally there are no exam questions that pertain to the Over 600V Nominal Sections of the NEC. Also optional calculations are rarely used by any state. If they are, a fifth grader could do it]
Lesson III

Chapter 2 makes up the meat of the NEC Master’s exam. Identification of grounded conductors, branch circuits, feeder, services, overcurrent protection, and bonding and grounding. Most of your calculations come out of this section; the simpler calculations are found on the Journeyman’s test; the Master’s test is loaded with more complex calculations.

[Motor calculations are located in Article 430 followed by heating and air conditioning, then transformers. Special calculations such as welders and mobile home and RV parks reside in Articles 500 and 600.]

Chapter 2 also covers both residential and commercial cooking equipment which is a favorite topic of electrical exam writers. You’ll also need to know how to calculate commercial services and general lighting loads from beauty shops and banks to motels and apartment complexes.

My intent is to make this as easy a lesson as my title suggests. Some calculations show up on every electrical test. Those are the ones I will concentrate on. If for some reason you get a question on the test that looks unfamiliar skip it and go back to it after you’ve completed the rest of the exam. Use your INDEX and look up the key word or phrase in the question and that will lead you to the correct section. Answer every question but don’t use more than five minutes before guessing.

Don’t let the code run you in circles. I’ve already told you at the beginning of this lesson what is located within Article 200. If the question has anything to do with a motor you know to look in Article 430. Again follow along in your code book. You can find most of these on your own without me typing in the references. It’s good practice. If you get lost use the INDEX.

Identification of Grounded Conductors

An insulated grounded conductor 6AWG or smaller shall be identified by a continuous white or gray color or by three continuous white stripes on colored wire other than green insulation. True or False?

True

White or gray marking tape is not allowed at terminations for grounded conductors 6AWG or larger. True or False?

False
**Branch Circuits**

Each multiwire branch circuit must have a disconnecting means that simultaneously disconnects all three ungrounded conductors at the point the branch circuit originates. True or False?

**True 210.4(B)**

Ground-fault-circuit-interrupters (GFCIs) are required in all unfinished basements EXCEPT for a permanently installed _____ alarm or _____ alarm.

Fire alarm, burglar alarm 210.8(A)5

In other than dwellings a GFCI must be installed within _____ of the outside edge of a sink.

6 feet (must be installed within 3 ft of a bathroom sink in a dwelling)

All 120 Volt single-phase 15 and 20 ampere branch circuits supplying outlets installed in dwelling family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, rec-rooms, closets, hallways or similar rooms shall be protected by a listed_____.?

Arc-fault-circuit-interrupter AFCI

Guest rooms and guests suites with permanent provisions for cooking shall have branch circuits installed to meet the rules for dwellings. True or False?

**True**

For ranges 8 3/4 KW or more the minimum branch circuit rating is _____ amperes 210.18(A) 3

(I’m going to back up for a moment to Table 210.2. This table is handy because it gives you the specific section of the code where specific-purpose branch circuit information is located)

Using Table 210.2 what specific section of the code covers welding related branch circuits?

Article 630
A non-GFCI outlet may be used to connect a freezer or refrigerator in the unfinished portion of a residential basement provided the outlet is not readily accessible. True or False?

False. (In the old days you could get by with a regular receptacle but not anymore. Whatever is not required to have AFCI protection in a home must be GFCI protected. The quick cure is to install only GFCI and AFCI breakers in the service panel.)

{Chapter 2 tells you what locations need to be protected by what means. Chapter 2 will also tell you the where the outlets must be located on the walls, counters, rooftops, and crawlspaces etc.}

Where a branch circuit supplies noncontinuous loads and continuous loads the rating of the overcurrent device shall not be less than the noncontinuous load plus 125% of the continuous load.

noncontinuous, continuous 210.20(A)

The rating of the overcurrent device determines the rating of the circuit.

O.C.D. (overcurrent device)

A continuous load is one that is energized for longer than 3 hours.

3 hours (Residential loads are not considered continuous. Most of the time this applies to motors and commercial lighting loads—hotel hallways and parking lots for instance)

The receptacle rating of a 40 amp circuit is 40, 50, or either 40 or 50?

40 or 50 Table 210.21(B)3

What is the maximum cord and plug connected load on a receptacle when the circuit is rated at 20 amps and the receptacle is rated for 20 amps?

16 amps. You may only load a receptacle to 80% of its rating.

The total rating of utilization equipment fastened in place, other than luminaires, shall not exceed of the branch circuit ampere rating where cord and plug connected loads, or lighting, or both are supplied by the same circuit.

50%, 210.23(A)2

What is the minimum branch circuit rating for circuits supplying heavy duty lamp holders?

30 A, Table 210.24 (It’s impossible to cover every possible question. Questions like this one require use of the INDEX. The key phrase here would be either branch circuit ratings, or heavy duty lamp}
holders. You’ll also notice in the notes underneath the table that discharge lighting branch circuit ratings are located in 410.62(C))

Receptacles shall be installed along the floor line of any wall so that there is no point along the floor line that is more than ___ ft from a receptacle.

6 feet, (also any wall space of a minimum of two feet requires an outlet.)

In addition to the two required 20 amp small appliance circuits along kitchen counters it is permissible to install a separate 15 or 20 amp circuit for a refrigerator. These two small appliance circuits may also supply an outlet for a breakfast nook in the dining room as well as in the kitchen pantry. True or False?

True 210-52(A) and (C)

(Take a look at Fig.210.52(C) 1 for the locations of counter top receptacles and islands. The only installation measurements involved are 24 inches and 12 inches)

For each dwelling in a multi-family dwelling a receptacle must be installed at each outside entrance not more than ____ from ground level?

6 1/2 feet

One ___ amp circuit must be installed in the laundry that supplies no other loads?

20

A 125 volt single phase 15 or 20 amp receptacle shall be installed within ____ of heating, air conditioning, and refrigeration equipment on the same level as the equipment?

25 feet

At least one receptacle outlet shall be installed within____ of the top of a show window for each 12 linear feet measured horizontally across its length.

18 inches    210.62
Part I Calculations

Feeder conductors shall have an ampacity not less than the noncontinuous load plus 125% of the continuous load. True or False?

True 215.2(A)1

The ampacity of feeders supplying transformers shall not be less than the sum of the _______ ratings of the transformers supplied?

Name plate 215.2(B)1

[Take a look at Figure 220.1 – this figure tells you how the branch-circuit, feeder, and services calculations methods are laid out. Since I am based in Wisconsin I know that there are no optional calculations on our exam. Also there are no questions on voltages 600V or over. Check with your testing authority to see what areas you will be tested on. Just beneath Figure 220.1 you will see a string of nominal voltages upon which you will make your calculations unless told otherwise.]

Where calculations result in a fraction of an ampere less than _____ such fractions may be permitted to be dropped.

.5A If it’s .5 or greater you may round up to the next ampere

[Table 220.3 shows you where to find additional load calculations]

Outlets for heavy duty lamp holders shall be calculated at a minimum of _____VA (volt-amps)?

600 VA (volt-amps for calculations are the same as watts. Unless told otherwise, all calculations will assume a power factor of 1 or Unity. Also all conductors, unless told otherwise, are copper, and the ambient temperature is 30°C or 86°F)

{Take a moment and look over Table 220.12—General Lighting Loads by Occupancy. Read the foot notes ‘z’ and ‘b’ at the bottom of the table and follow them to their respective sections and read the code section for each until you thoroughly understand them. I am only going to show you how to use the table instead of giving you an example for each occupancy. We will ONLY be using the right hand column titled ‘Volt-Amperes /Square Foot’}

A duplex receptacle is made up of two receptacles, each worth 90VA. For these calculations receptacles, single or duplex each count 180VA. So a receptacle is calculated at 180VA. A quad is calculated at 360VA. 220.14(K) tells you if the number of receptacles is known the general lighting load is calculated by the larger of (1) the calculated load from 220.14(I), or (2) 1 VA per Square Foot
area. Receptacles in dwellings and guest rooms in hotels and motels and apartments with no provisions for cooking require no additional calculation for receptacles because they are included in the General Lighting Load calculation.

Now, if the exam asks for the general lighting load of a commercial location, includes every one of these on the list that would normally have their lights on for 3 hours or more. That means you must calculate for continuous load, by using the 125% factor. In dwellings as well as guest rooms, lighting loads are not considered continuous so you don’t multiply by 125%. This section has caused many an electrician to fail the exam. I hope I’ve made it clear.

**What is the General lighting load for a 3000 square foot home?**

3000 sq.ft. x 3VA = 9000VA Not so fast. Now we go to **Table 220.42 Lighting Load Demand Factor**. A demand factor simply means we can reduce the calculated load because it’s unlikely we will have everything in the house turned on at once. The demand factor according to Table 220.42 says that the first 3000VA must be counted, plus 35% of the remainder between 3001 and 120,000VA which is 6000 x 35% = 6000 x .35 = 2100VA then:

3000VA + 2100VA = 5100VA

[You will also note that ONLY Dwellings, Hospitals, Hotels, and Warehouses are allowed demand factors. Every other occupancy on the list is calculated at 100%]

**What is the General lighting load for a 2500 sq.ft. Beauty shop?**

2500 sq.ft. x 3VA x 125% = 9,375VA {the 125% is because it’s continuous. Businesses are open more than 3 hours a day.}

**What is the general lighting load for a 4000Sq.Ft. Bank with unknown number receptacles?**

4000 sq ft. x 3.5VA x 1.25 = 17500VA

Receptacle load @ 1VA per square foot = 4000VA

So general lighting load = 17500VA + 4000VA = 21500VA
What is the demand for 108 receptacles in a department store?

\[ 108 \times 180VA = 19440VA \]

\[ 19440VA - 10,000VA = 9440VA \times 50\% = 4720VA \]

\[ 10,000VA + 4720VA = 14,720VA \]

(Commercial receptacle loads are not considered continuous)
There is a demand factor for non-dwelling receptacle loads over 10KVA in Table 220.44. The first 10KVA @ 100% plus 50% of the remainder VA.

How many 20A lighting circuits are required for a 6000 sq ft discount store supplied by a 120/240Vac service?

Number of branch circuits = Lighting Load/Circuit Capacity

\[
\text{Number of circuits} = \frac{(3VA \times 6000)}{(20A \times 120V \times 80\%)} \quad \{80\% \text{ is the reciprocal of } 125\% \}
\]

Number of circuits = 9.375 or 10 circuits

Show window lighting shall be calculated at 200VA per linear feet measured horizontally at its base? True or False?

True 220.43(B)

Fixed electric space heating shall be calculated at ___% of the load?

125%

The two small appliance loads required for the kitchen in a dwelling shall be calculated at _____VA each and the required laundry room circuit shall be calculated at ____ VA for a total of the three of ____ VA?

1500, 1500, 4500

An electric clothes dryer shall be calculated at a minimum of______?

5000VA 220.54 (Please read this section and look over Table 220.54)
Where two or more single phase ranges are connected to three-phase power the total load shall be calculated on twice the maximum number of ranges connected between any two phases. True or False?

True 220.55

In dwelling units what is the maximum demand factor for four or more appliances fixed in place?

75%

Go to the INDEX and look up Demand Factor (the index will tell you to also look up “loads”)

You then look under ‘loads’ and the first sub topic is ‘appliances and cooking equipment 220.55’ This is why the INDEX cures the old statement, “The code just sends you in circles”

The truth is if you start with the INDEX and you know how the code is arranged (which I’ve shown you the layout in lesson 1) this is the fastest way to get the answers to the questions on the exam.

So if you get lost in any of these lessons use your INDEX to find where I’m at. I didn’t give the code reference on purpose. By the way this demand factor can be taken when an apartment only has one appliance fixed in place. Why? If that apartment is at least one of four apartments or more in an apartment building. After the first four apartments you have met the demand factor requirement and can take 75% of the appliance load off the apartment complex. These appliances have to be other than ranges, clothes dryers, space heaters, or air conditioners. What they are talking about are garbage disposals, water heaters, and trash compactors etc.

This concludes Lesson III but it does not conclude Article 200. Half the exam comes out of this Article.

Lesson IV

Part II Calculations

Cooking Equipment

[Examiners love commercial and residential cooking equipment questions. I’ll go through Table 220.55 in detail and cover all the notes underneath. We won’t go through three-phase cooking calculations because you’ll have just as much luck guessing the right multiple choice answer as you would wasting time doing a very long calculation in my opinion. Hardly anyone in my local code]
classes gets it right anyway. I promised you I’d only teach you what you needed to know to pass the exam and I’ll stick by that. They don’t put your score on your license—it’s pass or fail plain and simple

Table 220.55 lets you calculate demand factors and loads for electric ranges, counter top cooking units, and wall mounted ovens. Two wall mounted ovens plus one counter top unit may be counted as one range.

The two columns you will be using the most are the left hand one that reads “Number of Appliances” and Column C on the right which is “Maximum Demand not over 12KW rating”

***
(Read note 1 before going farther—I’ll wait):
***

Note 1 translation: For ranges over 12KW through 27KW. As an example let’s arbitrarily use 14KW. The exam question asks for the demand load for either one range of 14KW or several ranges of 14KW. (I just want you to recognize which note to do the calculation by for now. We’ll do a calculation after I have translated all the notes)

***
Read note 2
***

Note 2 translation: For ranges over 8 3/4 KW through 27KW of unequal ratings. Let’s use one 12KW range, two 14KW ranges, and one 16KW range.

***
Read Note 3
***

Note 3 translation: For all household cooking appliances between 1 3/4 KW and 8 3/4 KW. For example if you have two 1.5KW countertop units you add their name plates together and multiply the sum by 75%. If you notice the demand factor for columns A and B is in per cent (%). If you also had two 3 1/2KW fryers you would add their nameplates together and multiply by 65%. Because the units fell under both column A and column B you add the results together for the final demand.

***
Read Note 4
***
Note 4 translation: The branch circuit calculation for one counter top cooking unit and two wall mounted ovens on the same circuit and in the same room is permitted to be calculated as one range. Just add the nameplate ratings together. For any one single range use Table 220.56.

For a single counter top unit or wall oven the demand load will be their nameplate KW.

***
Read Note 5
***

Cooking equipment located in a Home-Economics class or culinary school is treated as household cooking equipment—not commercial equipment which we will cover later.

What is the demand load for one 14 KW household range?

This is covered in Note 1. Note 1 says you must increase the demand load on the service by 5% for each KW over 12KW so: 14KW – 12KW = 2KW  (2 x 5% = 10%)
Column C demand for one range is 8KW
So 8KW x 10% = .8KW
8KW + .8KW = 8.8KW
(You could have multiplied 8KW by 1.10 (110%) and got the same answer 8.8KW)

What is the demand load for four 14KW household ranges?
(Using Note 1 again) O.K. there are four 14KW ranges so across from the number of ranges column the demand for four ranges is 17KW under column C. Again 14KW is 2KW over 12KW or a 10% increase.

Therefore: 17KW x 1.10 = 18.7KW

Isn’t this easy?

What is the household demand load for 1-12KW range, 2-14KW ranges and 1-16KW range?

(Note 2) Find the average KW by adding the KW’s together and dividing by the number of ranges (4) and increase that demand by 5% for the average KW over 12KW.

12KW + 14KW+14KW+16KW=56KW

56KW / 4 = 14KW

14KW is 2KW over 12KW or 10% increase to the demand under the four ranges in column C
17KW x 1.10 = 18.7KW
What is the household kitchen load demand for two 1.5KW countertop cooking units and two 3 1/2KW fryers?

(Note3) 2 x 1.5KW = 3KW Column A says multiply by 75% so .75 x 3KW = 2.25KW

2 x 3.5KW = 7KW Column B says multiply by 65% so .65 x 7KW = 4.55KW

4.55KW + 2.25KW = 6.8KW

What is the service demand for a household 6KW wall oven?

(Note 4)

6KW (Nameplate)

A range used in a Home Economics class in a junior high school must be treated as a commercial cooking load and has no allowable demand factor? True or False?

(Note 5) False

What is a noncoincident load?

Where it is unlikely that two or more loads will be used simultaneously it is permissible to use the largest load to calculate demand on the service.

When calculating the service demand load for a commercial kitchen it is permissible to use Table 220.56 to reduce the service demand, however the demand can never be less than the two largest loads.

True or False?

True

What is the calculated load in a restaurant kitchen that operates with a 16KW pizza oven, a 12KW grill, a 5KW dishwasher, a 3KW booster pump, a 3 1/2KW disposal, and a 4KW trash compactor?

28.275KW (the two largest loads add to 28KW but Table 22.56 is a 65% demand on a total of 6 appliances or (16+12+5+3.5+4= 43.5KW x 65% = 28.275KW which is larger than the two largest loads)
Clothes Dryers

[Table 220.54 is used to calculate the demand factor for household electric dryers. Apartment buildings generally have a central laundry for all tenants. Don’t confuse the household calculation with a commercial laundry. A commercial laundry would more than likely be fed by a 3-phase service.]

**What is the demand for 4-4500KW electric clothes dryers in a 16 unit apartment building fed by a 240/120V single phase service?**

20 KW, calculate at 5KW each minimum. (Table 220.54, 1-4 dryers @ 100%)

**What would be the demand in the example above if each apartment had its own dryer?**

36KW

Table 220.54 7 dryers exceed 11, so 47%-7%=40%

16 x 5KW min. = 80KW

80,000VA x 40% = 32,000VA or 32KW

**What is the demand for 10-5KW dryers in a commercial laundry fed by a 208/120V 3-phase service?**

24KW

220.54 [you are an electrician so you must balance the load by placing 3 dryers between B and C phase, 3 dryers between A and B, and 4 dryers between A and C phase] The demand factor is twice the maximum number of dryers between any two phases or 2 x 4 = 8. You would use the name plate values.

Thus 8 x 5KW = 40KW x 60% = 24kw

**A 70% demand reduction of the neutral conductor supplying household electric dryers and cooking equipment as calculated by Tables 220.54 and 220.55 shall be permitted. An additional ____% shall be permitted for any unbalanced neutral load over _____ amps?**

70%, 200amps 220.61

**The allowable service demand reduction for a 4-wire 3-phase wye connected system is ____?**

None, 220.61(C)
Article 2 General Information

What is the minimum overhead clearance for a tri-plex cable supplying 240/120V single phase residential driveway not subject to truck traffic?

12ft. 225.18

In an apartment building only the maintenance supervisor shall have access to the disconnecting means of each apartment. True or False?

False 225.35

Use Fig. 230.1 as a handy roadmap to find the correct service calculation.

Conductors buried beneath ____ of concrete are considered outside the building?

2 inches, 230.6

Vegetation or trees shall not be used for support of overhead service conductors; however luminaires may be supported outdoors in trees. True or False?

True 230.10, 410.36(G)

What is the minimum overhead clearance for residential service conductors above a roof?

8 feet 230.24(A)

The minimum ampacity of the service entrance conductors shall be the sum of the_______ and 125% of the_______?

Noncontinuous load, continuous load 230.42

Overcurrent Protection

[Table 240.3 Other Articles will let you find the proper overcurrent protection means for specific installations. Also while we are going through the basics of overcurrent protection image a big stone wall between this article and Article 430 Motors. The only place that has relevance to motor calculations for the exam is 240.6 Standard Size Overcurrent Devices.]
#12AWG Aluminum and copper-clad aluminum conductors may be fused at a maximum of _____ amperes?

15A, 240.4(D) {I would read 240.4 in its entirety. You don’t have to memorize anything just read it once because your subconscious mind will remember where the information is}

[240.6 lists the standard size ampere ratings. For branch circuit calculations that do not come out exactly as a standard size you are allowed to go to the next highest O.C.D. For feeder circuits that don’t calculate to standard sizes you must go down. Picture a tree with branches and roots (feeders). The feeders go DOWN and the branches go UP]

Overcurrent devices shall be readily accessible and the center of their operating handles not more than___ above any floor, grade, or platform?

6’7” 240.24

Every circuit breaker having an interrupting rating other than________ amps shall have its current interrupting rating stamped or labeled on the breaker?

5,000 240.83(C)

43.3A [You won’t find this formula in the code but this is what you use. It looks large but it’s not really that hard. Usually you may write the formula on one of the blank pages in your code book—but check with your testing authority first just to make sure]

Is there a simple formula for determining the unbalanced neutral current in a 3p-4w system? I know how to calculate it if the line to neutral loads on two phases is equal and the line to neutral load on the third phase is different, but what if the line to neutral load is different on each phase?

In other words, if I have a 3ph-4w 208/120v panel board and connect three circuits, one on phase A, one on phase B, and one on phase C and the corresponding 120v loads are 10A on phase A, 8A on phase B, and 6A on phase C, what would my neutral current be from the unbalanced loads which are all 120 degrees out of phase?

\[ \text{SQRT} (I^A + I^B + I^C) - (IA \times IB) + (I B \times IC) + (IC \times IA) \]

\[ \text{SQRT} (10 \times 10 + 8 \times 8 + 6 \times 6) - (10 \times 8) + (8 \times 6) + (6 \times 10) \]

\[ \text{SQRT} (100 + 64 + 36) - (80) + (48) + (60) \]

\[ \text{SQRT} 200 - 188 = 12 \]

\[ \text{SQRT} 12 = 3.46 \]

\[ \text{SQRT} = \text{Square Root} \quad ^\wedge = \text{I Squared} \]
Lesson V

[Figure 250.1 will guide you to the type of grounding question you are asked. Definitions are the most important part of grounding. You must know the difference between a grounded conductor (neutral white) and a grounding conductor (equipment green or bare) and a grounding electrode conductor (the one tied to the water pipe, ground ring, building steel, or concrete slab or supplementary electrodes such as ground rods and other made electrodes). You as the electrician must also provide a means to ground auxiliary systems such as cable TV, telephone, and gas company connections. Pay attention to your state codes. For example here in Wisconsin anytime we drive one ground rod we must drive two ground rods not less than 6 feet apart by order of the state code Comm. 16—also we don’t use formulas to determine the size of conductors used for grounding. Instead we use Tables]

Grounding

{Table 250.3 Will show you the where to find the grounding and bonding requirements of specific systems.}

The earth shall not be considered to be an effective ground path. True or False?

True 250.4(A)5

Alternating current systems of less than 50Volts shall be grounded where supplied by a transformer with a primary voltage exceeding ________ Volts?

150V 250.20(A)1

A premises wiring system supplied by a grounded ac service shall have a grounding electrode conductor connected to the___________ at each service.

Grounded service conductor 250.24(A)

When sizing for a single raceway the grounded conductor shall not be smaller than the grounding electrode conductor as specified by Table 250.66 but is not required to be larger than the___________ ungrounded service entrance conductor.

Largest 250.24(C)1

Table 250.66 is used to size the grounding electrode conductor for an ac service and is dependent upon the size of the___________ conductor(s).

Largest service entrance or the largest parallel conductor
If the service entrance conductors of a 208/120 Volt ac service were 400 kcmil what size grounding electrode conductor is required?

Table 250.66 1/0 copper (we always assume copper unless otherwise told)

In an industrial facility that has a maintenance supervision policy that insures only qualified persons work on the equipment, the grounding electrode conductor may be attached to the incoming metal cold water pipe beyond 5 feet of its entry point into the building.

True or False?

True 250.68(C)1 exception:

The equipment bonding conductor on the load side of an ac service shall be sized in accordance with__________?

Table 250.122 250.102(D)

In Table 250.122 the size of the equipment bonding jumper is based upon______ ahead of the equipment?

The rating or setting of the automatic overcurrent device (o.c.d.)

What is the minimum required size of the equipment grounding conductor on a 200A 240/120 Volt ac residential service?

#6 AWG copper Table 250.122

**Conduit, Conductors, and Cables**

The metric designator for a 1 1/2” PVC conduit is ________?

41 Table 300.1(C)

What is the minimum burial depth for a 2” PVC conduit listed for burial (not encased in concrete) beneath a hospital parking lot supplying 10 - 277 Volt street lights?

24 inches Table 300.5

Direct buried cables shall be protected from physical damage from a minimum of____ below ground level and extended to______ at the point it emerges above grade.

18 inches 8 feet
Three 1/0 conductors leading from basement to the penthouse of a sixty-three story building measuring 635 feet in height at the motor they supply shall be supported at the top of the conduit and at intervals not to exceed__________ ft? What is the total number of supports required?

200ft, 4 (One at the top and then one every 200 feet) Table 300.19(A)

It is legal according to the NEC to run THHN conductors in PVC underground? True or False?

False 310.10(C)2 (underground installations are considered wet locations). A damp location is located above ground—generally under a porch roof or in an area of high humidity like a pool or shower room drying area.

The minimum conductor size allowed for paralleling is________? 1/0 Chapter 250 [look it up]

If I install a 1” rigid conduit on a roof top exposed to direct sunlight 1/2” above the roof and the average ambient temperature is 80°F at what temperature do I make my correction?

140°F add 60° (80°F + 60°F = 140 °F) Table 310.15(B)(3)(c)

If I have 8 current carrying conductors in a 1” IMC conduit what percentage must I derate the ampacity of the conductors?

70% Table 310.15(B)3(a) Adjustment factors for more than three current carrying conductors in a raceway.

Using Table 310.15(B)3(a) the neutral conductor that carries only the unbalanced current from all the other circuit conductors _______ count as a current carrying conductor while the neutral of a 4-wire three-phase way system_______ count as a current carrying conductor.

Does not, does 310.15(B)(5)a-b

What is the minimum size XHHW conductor allowed for a 240/120Volt, 200A ac service to a dwelling?

2/0 Table 310.15(B)7
NM (non-metallic cable) a.k.a. Romex may be used in any family dwelling.
True or False?

False 334.10 and 334.12 NM is only permitted in types III, IV, and V construction.

Service entrance cable having a flame retardant, moisture-resistant covering is called _____ cable
and service entrance cable identified for underground use is that is moisture-resistant but
doesn’t require flame retardant is called cable?

SE, USE 338.2

RMC (rigid metal conduit) running through framing members must be supported every ____ feet
and within _____ inches of each termination point?

10ft, 36 inches 344.30

{As you can see if they ask you a question about any other cable, cable tray, wireway, or conduit
type, just go to the INDEX to find the correct section. Table 392.10(A) also tells you the article for
specific wiring methods}
{Flexible cords or cable information can be found in Table 400.4}

What’s the difference between SJO cord and SJOW cord?

SJO cord is constructed of oil-resistant thermoset insulation and can be used in damp locations
while SJOW also has thermoset insulation but can be used in wet locations. Table 400.4

What is the allowable ampacity of an SOO 14-3 cord?

18A Column B Table 400.5(A)1

Installations

A recessed fluorescent luminaire inside a clothes closet must be placed at a minimum distance
away from any combustible material by _______inches?

6” 410.16(C)4 {take a look at fig. 410.2 also}

When a luminaire is connected to a multiwire branch circuit the disconnecting means shall open
all conductors connected to the ballast including the grounded conductor.
True or False?
True. 410.130(G)2
A fixed storage type water heater of 120 gallons or less shall be considered a ______ load and the branch circuit conductors shall have an ampacity of _____% of the nameplate current rating?

Continuous, 125  422.13

Lesson VI

Motors

[Article 430 contents are mapped out in Fig. 430.1]

[Motors and controllers shall comply with the applicable provisions of Table 430.5]

[Locked rotor current designation letters are shown in Table 430.7(B)]

[Imagine a brick wall encircling article 430 Motors separating 430 from the rest of the code. We'll be using Tables 430.247 thru 430.250—Table 430.52 and section 430.32 instead of engineering formulas. YOU MUST USE TABLES IN ORDER TO PASS]

Conductors supplying several motors or a motor and other loads shall have an ampacity not less than the sum of 125% of the full load current of the highest rated motor, plus the sum of all the full load currents of the rest of the motors in the group, plus 100% of the non-continuous non-motor load, plus 125% of the non-motor continuous load.

True or False?

True  430.24

[There are three sections dealing with types of motors. We will encounter 430.32(A)1 on the test 90% of the time. The values for continuous duty motors over 1HP with a separate overload device. Motors marked with a SF (service factor) over 115 and motors rated with a temperature rise of 40°C or less shall trip at no more than 125% of the nameplate full load current (FLC from now on) All other motors (which is primarily what we’re dealing with on the exam) shall trip at no more than 115% of the FLC. 43032(A)2 covers motors with a thermal protector and 430.32(C) covers separate overload device trip settings when the other two ratings don’t allow the motor to start without nuisance tripping]

Any three-phase motor requires _____ trip coils, one on _____ of the phases?

3, each  Table 430.37
By what percentage do I multiply the FLC of an ac squirrel cage motor to set the short-circuit ground-fault inverse time circuit breaker?

250% Table 430.52 (an inverse time breaker is a regular circuit breaker)

What is the FLC of a single phase 115V 2HP motor?

24amps Table 430.248 (In this case it doesn’t matter what the nameplate says—the only time we use the nameplate FLC is for overload protection 430.32)

What is the FLC of a 3-phase 208V 5 HP motor?

16.7A Table 430.250

What is the maximum locked rotor current of a 3-phase 480V 10HP ‘Design B’ motor?

81A Table 430.251(B)

What is the maximum setting of the overload trip for a 2HP 230VAC single phase motor with a nameplate of 10.7A?

12.3A, 10.7A x 115% = 12.305

What size time delay fuse do I use for short-circuit ground-fault protection for a 1.5HP, 2-phase 240VAC motor with a nameplate of 3.7A?

10A 175% x 4.5A = 7.875A Table 430.249 (Round UP to the next higher standard size fuse or breaker 240.6 lists standard size breakers and fuses. (Nameplate is only used for calculating overload protection) (Remember you can go UP for a branch circuit and you have to go DOWN for a feeder) Table 430.52

What is the minimum ampacity for the branch circuit conductor for a 230V 3-phase 2HP motor?

8.5A Table 430.250 6.8A x 125% = 8.5A (motors are considered continuous loads unless
When you are doing the motor questions draw them out. It makes calculations so much easier.

(Converting Word to pdf. Doesn’t lend itself well to converting illustrations, but then again you won’t have any illustrations on the exam either)

On the exam the supply voltage, the HP and type of motor are usually given.

First you look up the FLC in the proper motor table and then go to 430.52 to determine the size of the short-circuit ground-fault (SCGF) protection. Check those against 240.6 to go UP to the next highest standard fuse size.

The ampacity of the individual branch circuit conductors depends on the FLC x 125%. Motors are continuous loads. The size of the branch conductors could then be selected from Table 310.15(B)(16).

The overloads (O.L.) are sized by the nameplate FLC x 115% or (whatever 430.32 tells you). Next you would calculate the size of the feeder breaker or fuse. The size of the feeder breaker or fuse is found by: The sum of the highest Short-circuit Ground-fault O.C.D. plus the FLC(s) of the remaining motor(s).

The ampacity of the feeder would be the sum of 125% x the highest rated motor FLC plus the FLC(s) of the remaining motor(s). [Don’t make it any harder than it is. You now know all you need to know about motors to pass the exam]

[I’ll give you a ‘heads up’ on this question—a favorite of examiners. 90% of examinees get it wrong]

The minimum feeder conductor for a 5HP 3-phase 208V motor and three additional 120V 1HP motors supplied by a 3-phase 4-wire wye system requires a minimum ampacity of ____amps?

36.875A As an electrician you must balance the load. Most examinees add 125% of the 5HP motor FLC to the FLC of all three single phase motors. BUT here’s how you are required to split the load. The single-phase motors are divided between A, B, and C phases. Just calculate one of them plus the 3-phase motor.
1 HP or horsepower = 746 watts. This is what you use if you have to find the horsepower in an exam question and you are given insufficient information to use the tables.

This is a good place to cover voltage drop. The code wants you to keep the voltage drop to a minimum and as a fine print suggestion that is a maximum of a 3% in a branch circuit and 5% in the combination of a feeder and branch circuit. 210.19(A)1 note 4

This is the formula for voltage drop:

\[ V_{\text{drop}} = \frac{2 \times K \times I \times D}{\text{CM}} \]

\( K = 12.9 \) ohms constant for copper; 21.2 for aluminum
\( D = \) Distance in feet
\( I = \) the load in amperes at 100% (not at 125% for motors or continuous loads
\( 2 = \) two conductors for a circuit
\( \text{CM} = \) circular mils area of conductors necessary

Lesson VII

Transformers

[We’re going to start Lesson VII with transformers. Here is where we use a combination of Tables and Ohm’s Law formulas. First we’ll tackle Ohm’s Law]

\( E = \) Voltage
\( I = \) Current
\( R = \) Resistance
\( P = \) Power in Watts (same as VA, Volt-amps in calculations)

\[ E = I \times R \quad I = \frac{E}{R} \quad R = \frac{E}{I} \quad P = I \times E \quad I = \frac{E}{P} \quad E = \frac{P}{I} \quad P = I \times I \times R \]

[We’ll assume a power factor of 1 or Unity, which is 100% Efficiency. They have to tell you otherwise on the exam]

The formula for Efficiency is: \( \text{Eff} = \frac{\text{Output}}{\text{Input}} \)

The basic rule in calculating transformer problems is that the KVA rating of the primary @ 100% efficiency or Unity or Pf (power factor) of 1 is equal to the KVA of the secondary.

What this means is that if your transformer is a single phase step up transformer i.e. 120V to 240V and the primary current \( I_p = 20A \), the secondary current \( I_s = 10A \) Why?
Because $\text{KVAPrimary} = 120V \times 20A = .240\text{KVA}$ [and that has to equal the secondary KVA which is:] $\text{KVASEcondary} = 240V \times 10A = .240\text{KVA}$

Now it gets interesting. Did you ever wonder how a Delta-Wye transformer can produce the dual voltage secondaries of 480/277V and 208/120V?

The answer is: $\sqrt{3}$

The square root of three which is 1.732

If you multiply 277V x 1.732 you get 479.764 or 480V rounded off.
The same thing with 120 x 1.732 = 207.84 or 208V rounded off

When we’re dealing with three-phase systems we have to include $\sqrt{3}$

Now when we use our Ohms Law formulas they look like this for three-phase:

$I = (E \times 1.732)/R$   
$P = I \times (E \times 1.732)$

For 3-phase multiply the voltage by 1.732 in your formulas

**What is the primary line current of a 150 KVA, 480V to 208Y/120V, three-phase transformer?**

$I_{\text{primary}} = 180A$

$I_{\text{primary}} = \frac{\text{KVA}}{E} \times 1.732$   
$I_{\text{primary}} = \frac{150,000\text{VA}}{E} \times 1.732$   
$150,000\text{VA} / 831 = 180A$

[Be careful when you are doing transformer problems. There are two tables concerning transformers. Table 450.3(A) and 450.3(B). Look at them both closely and decide which one to use on the exam]

**Answer -- Table 450.3(B)** Why? Because 450.3(A) is for transformers OVER 600V. Typically you won’t have any questions over 600V

If you’ll look at Table 450.3(B) you’ll notice that this table helps you calculate the maximum overcurrent protection for a transformer 600V or less. The two main columns are *Primary protection* and *Secondary protection*. 
Underneath Primary Protection are three columns; primary currents of 9A or greater, Less than 9A, and less than 2A. By looking straight across at the Secondary protection column you’ll see there is no secondary protection required when secondary currents is 9A or greater or less than 9A.

In the exam question they will give you primary current rating and you will either multiply that value by either of 125%, 167%, or 300%.

**Note 1** says that for primary current of 9A or more you multiply that value by 125%. If the result does not match the standard fuse size you may go up to the next higher standard size.

Where secondary protection is required for secondary current of 9A or more you multiply secondary current by 125% and note 1 applies once again. For secondary current less than 9A you multiply by 167% and you see note 2. Read Note 2 if you like but you will never use it on an exam.

**Note 3** shows that anytime you protect the primary and secondary the primary current is multiplied by 250% regardless of the current rating. Note 3 deals with impedance of the transformer. A transformer with an impedance of 6% or less may be protected by an O.C.D. six times its rated current; and four times its rated current if its impedance is between 6 and 10%.

**What is the maximum current rating of a circuit breaker protecting a 120V/240V booster transformer primary with a primary current of 10A amperes and 6% impedance?**

15A \[10 \times 125\% = 12.5A\] 240.6 next higher standard size

**What if in the above question the primary current rating was 7A; what would be the maximum sized fuse you could use?**

10A \[7A \times 167\% = 11.69A\] (There is no note to say you can go higher) the question also doesn’t say you have to protect the primary and secondary. If it did then you could go 6 times the rated current. Chances are the test isn’t going to complicate this one.

**Ampacity**

Ampacity is the maximum operating current of a conductor that doesn’t cause damage to its insulation.

110.14(C)1(a) Termination provisions. A conductor sized from #14AWG thru #1AWG shall be terminated as 60°C terminations of 100 amperes or less.

110.14(C)1(b) Termination for conductors over 100 amperes and over #1AWG in size shall be terminated as 75°C terminations.
Remember these two sections when you use Table 310.15(B)16 to size conductors.

Table 310.15(B)16 and Table 310.15(B)2(b) shall be used to select conductors and calculate ambient temperature corrections respectively. Table 310.15(B)3(a) shall be used to derate ampacity for more than three current-carrying conductors in a raceway.

You may use THHN (which is 90°C) to derate conductors starting with its 90°C rating but you can’t violate 110.14. Therefore all your ampacity answers will come from the 60°C and the 75°C columns.

Table 310.15(B)7 may be used for selecting conductors for 240/120V residential single phase services.

#14AWG, #12AWG, and #10AWG have maximum protection limits

( #14 15A max.) ( #12 20A max.) ( #10 30A max.)

What is the ampacity of a #3AWG conductor used on a 240/120V, 100A service?

100A 75°C column Table 310.15(B)16

What is the ampacity of one of four #1AWG TW current-carrying conductors in a raceway in a steel mill with an ambient temperature of 130°F?

44A 110x.80x.41 = 36.08A (ampacity 60°C column, more than 3 conductors, ambient temperature correction factors) Conduits that are exposed to high temperatures for only ten feet of their length don’t need any extra temperature derating for that small section.

**Boxfill**

When you deal with boxfill you are dealing with VOLUME.

Article 314 Tables 314.16A junction box types, sizes, and cu.in. VOLUMES and 314.16B conductor VOLUMES (cubic inches may also be written this way in.³)

How many #12AWG conductors can legally fit into a 4 x 1 1/4” square junction box?

8 Table 314.16A far right column

What minimum size box do I need for 3-#12AWG conductors that splice inside the box and 2-#14AWG conductors that terminate on a single pole light switch?
$4 \times 2.125''$ Round $6 \times 2.25 + 2 \times 2.00 + 2 \times 2.00 = 21.5 \text{ in}^3$ A $4 \times 2.125''$ “round box has a volume of 21.5 in$^3$. The key is ‘minimum’ size box. Although it’s not practical to mount a switch in a round box.

[A device yoke counts double volume based on the largest conductor connected to it which in this case was 2-#14AWG. (Read 314 entirely and see how much volume is counted for a clamp, fitting, splice, wires that run through the box etc...) ]

**Conduit Fill**

When we are dealing with conduit fill we are dealing with **AREA which is in$^2$**

You’d be surprised at how many guys taking the test screw up because they get volume and area screwed up. Box fill is volume. Conduit fill is area.

Table 4 in chapter 9 will give you the **area dimensions of all conduit types**. There are 12 different tables.

If a conduit is 24 inches or under it is a **nipple**. Nipples may be filled to 60% capacity. Anything over 24 inches in long can only be filled 40%. Please find the columns marked either 40% or 60%. Take a hi-liter and mark the in$^2$ columns in both the 60% and 40% columns. These are the figures you will need.

Table 5 contains the **dimensions of conductors** that go into the conduits at either 60% or 40% fill. Notice there are different types and sizes of wire. Again you are looking for the square AREA or in$^2$ columns AND the type of wire called for in the exam question. A wire with a heavier rubber coating takes up more AREA than one with plastic insulation.

Conduit fill simply becomes the act of totaling the square inch area (in$^2$) of the wires and then finding an area in the 40% or 60% column of the specified conduit in which it will fit.

IN Annex C on page 70-748 you have a list of tables that show you the conduit fill for conductors **all of the same size** according to conduit type. There are 24 tables in all. Just pick the right one.

What is the maximum number of #12 THHN conductors that can fit inside a 2 1/2 “PVC schedule 40 conduit?

141 Table C10 Find THHN #12 in the left hand column and the 2 1/2” column on the right

What is the minimum size EMT conduit for the following group of conductors: 3-#6AWG THW, 3-#12AGW THWN, and 6-#14AWG RHW?
Table 5 \[3 \times x + 0.0726 \text{ in}^2 + 3 \times x \times 0.0133 \text{ in}^2 + 6 \times x \times 0.0293 \text{ in}^2 = 0.4335 \text{ in}^2\]

Table 4 (EMT) 40% column = 0.598

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**Pull Boxes**

[When calculating pull boxes for conductors over #4AWG entering the box you will calculate each wall of the box separately and chose the larger dimensions for the length and width of the box]

For straight pulls the length of the box shall not be less than \[\text{_____ the trade size of the largest raceway.}\]

8, 314.28

For angle pulls or U-pulls the distance between each raceway entry and the opposite side of the box shall not be less than \[\text{_____ times the largest raceway plus the _____ of the diameters of the additional raceways on the same wall.}\]

6, sum 314.28

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**Lesson VIII**

**Special Occupancies**

What is a Class I Division 1 location? What is a Class I Division 2 location?

A **Class I Division 1 location** is where flammable gases or liquids are present in the atmosphere or dispensed and there is a danger of explosion or ignition. A **Class I Division 2 location** is where flammable liquids or gases are stored and handled.
What is a Class II Division 1 Location? What is a Class II Division 2 Location?

A Class II division 1 Location is where combustible dust is present. A Class II Division 2 Location is one where combustible dust is contained in materials and handled without dispersing it into the atmosphere.

What is a Class II Division 1 Location? What is a Class II Division 2 Location?

A Class III division 1 Location is one where combustible fibers are present in the atmosphere. A Class III Division 2 Location is one where combustible fibers are stored in materials and handled without dispersing into the atmosphere.

If a hazardous location is intrinsically safe it means it has been protected by non-incendive wiring methods, ignitionproof fittings, and devices. True or False?

True.

Is it permitted to use sealed fittings in Class I, Class II, and Class III Division 1 and Division 2 locations?

Yes it’s permitted but not necessary in some of those locations.

Where shall sealed fittings with at least 5/8” sealing compound thickness be used in a Class I Division 1 location?

Within 18” of any termination, enclosure, or device.

When a horizontally installed conduit used for communications passes through the wall from a Class II Division 1 location into a Class II Division 2 location on which side of the wall must a seal be placed?

Neither. If the conduit was 5 ft in length and passed downward vertically you wouldn’t need one there either.

If a motor operating in a Class II Division 1 location is labeled dusttight ignitionproof do I need a seal?

No. A dust tight ignition-proof motor is intrinsically safe and non-incendiary.
Healthcare Facilities

A hospital is a building or portion thereof used on a 24 hour basis for medical, surgical, or obstetrical care for ____ or more people?

4

The power system of a healthcare facility consists of a_______ branch, an_____branch and A _________ branch?

Critical, Equipment, Life safety

In Patient Care Areas the grounding terminals of all receptacles, the metal boxes containing receptacles and equipment operating over ____ volts shall be connected to an insulated copper equipment grounding conductor.

100

Where two or more panel boards supplying the same patient care vicinity are served from separate transfer switches on the emergency transfer system the equipment grounding terminals of those panel boards shall be connected together with an insulated, continuous copper conductor not smaller than_______ ?

#10AWG

In a general care patient bed location there shall be a minimum of ____ hospital grade receptacles; in a critical care patient bed location there shall be a minimum of ____ hospital grade receptacles?

4, 14 {Remember a duplex receptacle is made up of 2 single receptacles; a quad is four receptacles; 14 receptacles would be 7 duplexes}. { 6 in critical in 2008 NEC}

In general patient care and critical patient care areas the required receptacles must be supplied by a combination of _____ and _____ power?

Emergency, normal

The branch circuit that serves patient bed locations shall not be  ?

A multi-wire branch circuit
Ground-fault circuit interrupter protection shall not be required in critical care areas where the toilet and basin area installed within the patient room. True or False?

True

Where general care areas and critical care areas are supplied by two different systems, the two systems wiring must be separated from each other. True or False?

True

In a healthcare facility the life safety branch must be kept entirely independent of all other wiring and equipment and shall not enter the same raceways, boxes, or cabinets with other wiring EXCEPT: I. in transfer switches; II. In exit or emergency luminaires; III. In a common junction box attached to an exit light.

a) I
b) I and II
c) III only
d) I, II, and III
e) None of the above
d

The life safety branch shall be installed and connected to an alternate power source and shall be automatically restored within ____ seconds of normal power failure?

10

In a location where flammable anesthetics are employed an area upward to ____ ft above the floor is considered a Class I, Division 1 hazardous location. From 5 ft to the structural ceiling is considered _____ the hazardous area?

5, above
Any room or location where flammable anesthetics or disinfecting agents are stored is considered a Class I, division 2 location from floor to ceiling.
True or False?

False. Class I, division 1 location 517.60(A)2
[Table 500.8(B) gives you Maximum Surface Temperature Classifications; the "T" Codes. One of these will be on the exam. "T" Classifications for group II Electrical Equipment are in Table 505.9(D)(1) ]

Mobile Home and RV Parks

[FYI Mobile homes and manufactured homes are the same thing. This section of the code hasn’t been updated in years. The AHJ’s generally leave the wiring of mobile and manufactured homes up to the manufacturer. Although you’ll see a lot in this section about 50Amp cords and services the mobile and manufactured homes today automatically come with 100 or 200A load panels. The outside park pedestal is your service equipment and the new parks use a 200A pedestal. This means you remove the bonding screw inside the mobile home electrical panel when you hook it up for the first time. The neutral is bonded to the ground outside at the pedestal and a ground rod is also driven by the pedestal. When a mobile or manufactured home is put on a private lot it is mounted on pillars or a concrete slab or on top of a basement. In these cases your electrical panel is your service and you must bond the neutral to the ground at the service and drive a ground rod (or two depending upon your state or local codes)

Mobile home service equipment shall not be located in sight of and not more than ____ft from the nearest outside wall of the mobile home?

30 feet 550.32

Mobile home park electrical wiring shall be calculated at 120/240Volts by one of the following criteria:

I – 16,000VA
II – The largest mobile home allowed in the park
III – Neither of the above
IV – Both of the above

IV- both of the above

What is the demand factor for a mobile home park service containing 40 trailers?

24% of the total calculated load
What is the service feeder demand for a mobile home park that contains 20 mobile homes, one of which requires a 200A service?

\[
80 \text{kVA} \times 20 = 1,600,000 \text{VA} = 320 \text{kVA} \\
320 \text{kVA} \times 25\% = 80 \text{kVA}
\]

A minimum of ____% of the total number of RV park sites shall be equipped with a 30A 125Vac receptacle?

70% 551.71

An RV park site equipped with only one 20A and one 30A supply receptacle shall be calculated at_______ VA?

3600VA 551.73(A)

20 RV park sites calculated at 45% of 3600VA results in a permissible demand of 1620VA per site or a total of _____VA?

32,400VA 551.73(C)

Lesson IX

Special Equipment

Branch circuits that supply all other electric signs and outline lighting shall not be rated at more than _____. Such circuits will be considered _____ loads?

20A, continuous

A working space ____ high, ____ wide, and ____ deep shall be provided around any enclosure that contains a (sign) ballast not installed outside of the sign?

3 ft, 3ft, 3 ft

The duty cycle multiplier for a non-motor generator as applied to arc welders when the welder has a duty cycle of 70% is ____?

.84 Table 630.11(A)

The ampacity of the feeders for automatic resistance welders shall be not less than _____ of the primary current and ____ of the primary current for manually operated resistance welders when the welders are to be operated at different times and different duty cycles.

70%, 50% 630.31(A)(1)
What is the duty cycle multiplication factor for a resistance welder operating on a 50% duty cycle?

.71 Table 630.31(A)(2)

For x-ray equipment connected to a 120V nominal branch circuit rated 30A or less, a grounding-type attachment plug cap and properly rated receptacle is permitted to be used as a disconnect? True or False?

True 660.5

Several motors of 2HP or less on irrigation equipment are allowed to be connected to the same branch circuit protected at not more than 600V and 30 amps provided the FLC of any motor in the group shall not exceed______?

6A 675.10

In a swimming pool area a ‘dry-niche luminaire’ is one that is completely sealed against the entry of______ while a ‘wet-niche luminaire’ is one that is completely surrounded by______?

Water, water 680.2 definitions

Fixed or stationary equipment for permanently installed pools may be cord-and-plug connected, however the cord for other than a storable pool shall not exceed ____ in length?

3 ft. 680.7(A)

What is the minimum horizontal clearance by an in-ground pool for an overhead tri-plex cable supplying 240/120V to the premises service equipment?

10ft. Table 680.8 Row C

What is the minimum overhead clearance for the cable described in the preceding question?

22.5 ft Table 680.8 and Fig. 680.8

All 15 and 20A receptacles located within ____ ft of the inside walls of a pool must be GFCI protected?

20 {Be careful with these receptacle distance questions. Read the problem carefully. The answer could be 5, 6, 10, 15 or 20 ft respectively.}
PV (photovoltaic systems) that have D.C. source circuits and/or D.C. input circuits of ___Volts or higher, on or penetrating a building shall be protected by a listed DC Arc-Fault device.

80 690.11

[I wouldn’t worry too much about photovoltaic, batteries, wind power, or fuel cell questions on the exam at this point in time. Say five years down the road these alternate power systems will play a crucial role in everyone’s life and will constitute a shift into these areas]

**Special Conditions**

Transfer equipment shall be automatic, identified for emergency use, and approved by the AHJ. True or False?

True. 700.6

Fire protection shall be required for places of assembly in buildings of over _____ft tall and those that occupy not less than _____ people?

75 ft., 1000 700.9

Current supply shall be such that a transfer from normal power to emergency power shall not exceed _____ seconds in the event of normal power failure?

10 seconds 700.12

Prime movers shall not solely be dependent upon a public utility gas system for their fuel supply or a municipal water system for cooling. Means shall be provided for transferring from one fuel supply to another where dual fuel supplies are used, no exceptions. True or False?

False 701.11(B)3

___________ are those systems designed to supply onsite generator power to public or private facilities where *life safety* doesn’t depend on the performance of the system?

Optional Standby Systems 702.2

{Table 705.3 is useful providing you with the specific sections for various alternate power sources}
Class 2 and Class 3 circuits shall be permitted to be installed together with the conductors of electric light power, Class 1 non-power limited fire alarm, and medium powered broadband communication circuits where they are separated by a barrier.

True or False?

True 725.136(B) (The key to questions like this one is to pick out the key element which is Class 1, 2, and 3 circuits. If you look that up in the INDEX you’ll be directed to Remote signaling circuits. Look down that column almost to the bottom of the page and you’ll find the heading separation. That will put you close enough to the answer)

CMP, CL3P, and _____ cable are permitted substitutions for CL3R cable?

CMR Table 725.154(G)

CL2P stands for Class 2 Plenum Cable. True or False?

True Table 725.179

The branch circuit supplying fire alarm circuits shall supply no other loads and shall not be protected by either _______ or _________?

GFCIs AFCIs  760.41(B)

Chapter 800

Communications Systems

[800.3 The requirements of Chapters 1-7 shall not apply to Chapter 800 except where the requirements are specifically referenced within Article 800.]
Supply service drops of 0-750Volts running above and parallel to communications service drops shall have a separation of ________?

12 inches 800.44(A)(4)

Underground communications circuits ran with fire alarm or power circuits shall be separated by a __________?
Suitable barrier 800.47(A)

Communications circuits not in a raceway shall be separated from power or lighting circuits not in a raceway by a minimum of _____?

4 inches 800.50(B)

Unlisted outside plant communications cable shall be permitted to be installed in plenums of environmental air where the length of cable does not exceed _____ft from its point of entrance to the building?

50 ft. 840.48

{Table 800.154 Applications of Communications Cables, Wires, and Raceways tells you what communications cables can be used where}

Antennas and lead-in conductors of Radio and TV stations must be of hard drawn copper, bronze, aluminum alloy, copper-clad steel, or other high strength corrosion-resistant material except when the maximum span of points between supports is less than_______ft?

35 ft 810.11 exception (Also Table 810.16(A) gives the size of receiving antenna conductors)

Antennas and lead-in conductors of Radio and TV stations must be of hard drawn copper, bronze, aluminum alloy, copper-clad steel, or other high strength corrosion-resistant material except when the maximum span of points between supports is less than_______ft?

35 ft 810.11 exception (Also Table 810.16(A) gives the size of receiving antenna conductors) [Table 830.47 Burial depth for broadband cables]

[We covered Tables 4 and 5- Conductor and conduit properties. Table 5A gives the dimensions of compact conductors. Table 8 is used for calculating the D.C. resistance of conductors. This table comes in handy for Voltage Drop Calculations. The other Tables in this section won’t be used on the exam.]
Lesson X

The Annexes are not part of the NEC and are included only for informational purposes.

Annex A -- UL and ISA listings.

Annex B – Conductor ampacity and duct bank installations and ambient temperature corrections.

Annex C -- Conduit fill tables for single conductor types.

Annex D – Examples of different residential calculations from a park trailer to one family and multi-family service sizing and neutrals. Just substitute values from the test questions.

Annex E--Types of construction. Fire resistance ratings for I through V constructions. Check your state and local codes for definition modifications as to fire ratings.


Annex H – Deals with Inspections, enforcement, and procedures that are only enforced if the AHJ adopts article 80.

The Index

It’s true every exam candidate should have purchased tabs with their code book and installed them; HOWEVER they are to be used in conjunction with your INDEX. Once you’ve found the correct sections in the INDEX only then may you use your tabs so you’re in the right vicinity faster than with no tabs.

If after reading a test question and you don’t understand the meaning of some or all the terms simply look them up in the INDEX. Article 100—Definitions contain definitions of terms used more than once throughout the code. Terms that are used only once in the code will be defined in the .2 sections of each article such as 700.2 for example.

The areas hi-lited in gray are the most recent changes to the code. As of now most test questions will come from parts of the code that don’t change so often. Only significant changes make it to the test such as the requirement for AFCIs and GFCIs in nearly every location imaginable. Besides that examiners hate writing tests as much as we hate taking them.
The INDEX can be frustrating at times but follow its instructions when it gives you the “See such and such” if it’s not in the INDEX it’s not in the code. Trust me.

**Table of Contents**

It doesn’t hurt just to skim through the table of contents at least once. I’m a big believer in the ability of the subconscious mind to absorb the general locations that will pop into your mind as you read an exam question. Of course if you use the code on the job regularly you should be able to zoom in on at least half the exam areas without doing a lot of searching or thinking.

You just have to be careful because these familiar areas are where examiners like to use phrases like “which of the following is NOT a code violation?” or the words NEVER, and ALWAYS. They are famous for finding exceptions to common electrical installations. So never answer a question just from memory alone.

Document the section where you found the answer by each test question. Use your test booklet and transfer your answers to your answer sheet the last half hour of the exam. It’s hard to erase a wrong answer well enough to satisfy the optical scanner that grades your exam.

Make sure you don’t miss an answer and get a whole string wrong just because they are in the wrong place. The exams are computer graded.

Now we are ready to put what we’ve learned to the test.

Use the download link I sent you to download the e-book for the practice exam
Feel free to contact me at any time at:

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