PART 1 ELECTRICAL THEORY EXAM (4 HOURS)

The questions for this exam are extracted from *Mike Holt's Illustrated Guide to Basic Electrical Theory* textbook.

CHAPTER 1— ELECTRICAL FUNDAMENTALS

UNIT 1—MATTER

1. Providing a path to the earth often helps reduce electrostatic charge.

   (a) True
   (b) False

2. Lightning frequently terminates to a point of elevation and strikes nonmetallic as well as metallic objects with the same frequency.

   (a) True
   (b) False

3. The termination of the lightning stroke is unlikely to ignite combustible materials.

   (a) True
   (b) False

4. Lightning protection is intended to protect the building itself, as well as the electrical equipment on or inside the structure.

   (a) True
   (b) False

UNIT 3—MAGNETISM

5. Nonmagnetic metals are ferrous, meaning they do not contain any iron, and cannot be magnetized.

   (a) True
   (b) False

6. Magnetic lines of force can cross each other and they are called flux lines.

   (a) True
   (b) False

UNIT 4—ELECTRICITY

7. It is not the force of the magnetic field through a conductor that produces electricity; it is the relative motion of the field to the electrons within the conductor that produces the movement of electrons.

   (a) True
   (b) False

8. People become injured and death occurs when voltage pushes electrons through the human body causing the heart to go into ventricular fibrillation.

   (a) True
   (b) False

9. The severity of an electric shock is dependent on the current flowing through the body, which is impacted by circuit voltage and contact resistance.

   (a) True
   (b) False

10. An electrical arc blast can approach _____, which vaporizes metal parts and produces an explosive and deadly pressure wave.

   (a) 10,000°F
   (b) 15,000°F
   (c) 25,000°F
   (d) 30,000°F

UNIT 5—ELECTROMAGNETISM

11. If a conductor carrying current is next to another conductor carrying current in the opposite direction, the electromagnetic field attempts to push the conductors apart.

   (a) True
   (b) False

UNIT 6—USES OF ELECTROMAGNETISM

12. A clamp-on ac ammeter has a coil that is clamped around the conductor and detects the rising and falling _____ field being produced due to the ac flow through the conductor.

   (a) static
   (b) current
   (c) power
   (d) magnetic

13. Ohmmeters measure the _____ or opposition to current flow of a circuit or component.

   (a) voltage
   (b) current
   (c) power
   (d) resistance

14. The megger is used to measure very high-_____ values, such as those found in cable insulation, or motor and transformer windings.

   (a) voltage
   (b) current
   (c) power
   (d) resistance

15. The electric motor works on the principle of the attracting and repelling forces of _____ fields.

   (a) voltage
   (b) current
   (c) power
   (d) magnetic

16. The _____ of a generator is forced to rotate while it is being subjected to the magnetic field of the stator.

   (a) winding
   (b) rotor
   (c) stator
   (d) b or c

17. A holding relay is primarily used for worker convenience.

   (a) True
   (b) False

CHAPTER 2—BASIC ELECTRICITY

UNIT 7—THE ELECTRICAL CIRCUIT

18. According to the Electron Current Flow Theory, electrons flow away from the negative terminal of the source, through the circuit and load, toward the positive terminal of the source.

   (a) True
   (b) False

19. According to the Conventional Current Flow Theory, electrons travel from positive to negative.

    (a) True
    (b) False

UNIT 9—ELECTRICAL FORMULAS

20. The major advantage of ac over dc is the ease of voltage regulation by the use of a transformer.

    (a) True
    (b) False

21. The best conductors, in order of their conductivity, are gold, silver, copper, and aluminum.

    (a) True
    (b) False

22. In a dc circuit, the only opposition to current flow is the physical resistance of the material. This opposition is called "reactance" and is measured in ohms.

    (a) True
    (b) False

23. What is the voltage drop of two 12 AWG conductors (0.40 ohms) supplying a 16A load, located 100 ft from the power supply? Formula: $E = I \times R$

    (a) 1.60V
    (b) 3.20V
    (c) 6.40V
    (d) 12.80V

24. What is the resistance of the circuit conductors when the conductor voltage drop is 7.20V and the current flow is 50A?

    (a) 0.14 ohms
    (b) 0.30 ohms
    (c) 3 ohms
    (d) 14 ohms

25. What is the power loss in watts of a conductor that carries 24A and has a voltage drop of 7.20V?

    (a) 175W
    (b) 350W
    (c) 700W
    (d) 2,400W

26. What is the approximate power consumed by a 10 kW heat strip rated 230V, when connected to a 208V circuit?

    (a) 8.2 kW
    (b) 9.5 kW
    (c) 11.3 kW
    (d) 12.4 kW

27. The formulas in the power wheel apply to _____.

    (a) dc
    (b) ac with unity power factor
    (c) dc or ac circuits
    (d) a and b

28. The total circuit resistance of two 12 AWG conductors (each 100 ft long) is 0.40 ohms. If the current of the circuit is 16A, what is the power loss of the conductors in watts?

    (a) 75W
    (b) 100W
    (c) 300W
    (d) 600W

29. What is the conductor power loss in watts for a 120V circuit that has a 3 percent voltage drop and carries a current flow of 12A?

    (a) 43W
    (b) 86W
    (c) 172W
    (d) 1,440W

30. What does it cost per year (at 8 cents per kWh) for the power loss of a 12 AWG circuit conductor (100 ft long) that has a total resistance of 0.40 ohm and current flow of 16A?

(a) $30
(b) $50
(c) $70
(d) $90

31. What is the power consumed by a 10 kW heat strip rated 230V connected to an 115V circuit?

(a) 2.50 kW
(b) 5 kW
(c) 7.50 kW
(d) 15 kW

CHAPTER 3—BASIC ELECTRICAL CIRCUITS

UNIT 10—SERIES CIRCUITS

32. The opposition to current flow results in voltage drop.

(a) True
(b) False

33. Kirchoff's Voltage Law states, "In a series circuit, the sum of the voltage drops across all of the resistors will equal the applied voltage."

(a) True
(b) False

34. Kirchoff's Current Law states, "In a series circuit, the current is _____ through the transformer, the conductors, and the appliance."

(a) proportional
(b) distributed
(c) additive
(d) the same

UNIT 11—PARALLEL CIRCUITS

35. According to Kirchoff's Current Law, the total current provided by the source to a parallel circuit will equal the sum of the currents of all of the branches.

(a) True
(b) False

36. The total resistance of a parallel circuit can be calculated by the _____ method.

(a) equal resistance
(b) product-over-sum
(c) reciprocal
(d) any of these

37. When power supplies are connected in parallel, the voltage remains the same, but the current or amp-hour capacity will be increased.

(a) True
(b) False

UNIT 13—MULTIWIRE CIRCUITS

38. A balanced 3-wire, 120/240V, single-phase circuit is connected so that the ungrounded conductors are from different transformer phases (Line 1 and Line 2). The current on the neutral conductor will be _____ percent of the ungrounded conductor current.

(a) 0
(b) 70
(c) 80
(d) 100

39. If the ungrounded conductors of a multiwire circuit are not terminated to different phases, this can cause the neutral current to be in excess of the neutral conductor rating.

(a) True
(b) False

40. The current flowing on the neutral conductor of a multiwire circuit is called "unbalanced current."

    (a) True
    (b) False

41. Improper wiring or mishandling of multiwire branch circuits can cause _____ connected to the circuit.

    (a) overloading of the ungrounded conductors
    (b) overloading of the neutral conductors
    (c) destruction of equipment because of overvoltage
    (d) b and c

42. Because of the dangers associated with an open neutral conductor, the continuity of the _____ conductor cannot be dependent upon the receptacle.

    (a) ungrounded
    (b) grounded
    (c) a and b
    (d) none of these

CHAPTER 4— ELECTRICAL SYSTEMS AND PROTECTION

UNIT 14—THE ELECTRICAL SYSTEM

43. Electrons leaving a power supply are always trying to return to the same power supply; they are not trying to go into the earth.

    (a) True
    (b) False

44. To prevent fires and electric shock, the *NEC* specifies that neutral current can flow on metal parts of the electrical system.

    (a) True
    (b) False

45. Metal parts of premises wiring must be bonded to a low-impedance path designed so that the circuit protection device will quickly open and clear a ground fault.

    (a) True
    (b) False

46. Because of the earth's high resistance to current flow, it cannot be used for the purpose of clearing a line-to-case ground fault for _____ wiring.

    (a) utility
    (b) premises
    (c) a or b
    (d) none of these

UNIT 15—PROTECTION DEVICES

Part A—Overcurrent Protection Devices

47. The purpose of overcurrent protection is to protect the conductors and equipment against excessive or dangerous temperatures because of overcurrent. Overcurrent is current in excess of the rated current of equipment or conductors. It may result from a(n) _____.

    (a) overload
    (b) short circuit
    (c) ground fault
    (d) all of these

48. To protect against electric shock or to prevent a fire, a dangerous _____ must quickly be removed by opening the circuit's overcurrent protection device.

    (a) overload
    (b) short circuit
    (c) ground fault
    (d) all of these

49. Inverse time breakers operate on the principle that as the current decreases, the time it takes for the device to open decreases.

    (a) True
    (b) False

50. The _____ sensing element causes the circuit breaker to open when a predetermined calibration temperature is reached.

(a) magnetic
(b) electronic
(c) thermo
(d) none of these

51. The magnetic time-delay circuit breaker operates on the solenoid principle where a movable core, held with a spring, is moved by the magnetic field of a(n) _____.

(a) overload
(b) short circuit
(c) ground fault
(d) b or c

52. Available short-circuit current is the current in amperes available at a given point in the electrical system.

(a) True
(b) False

53. Factors that affect the available short-circuit current include transformer _____.

(a) voltage
(b) kVA rating
(c) impedance
(d) all of these

54. Factors that affect the available short-circuit current include circuit conductor _____.

(a) material
(b) size
(c) length
(d) all of these

55. Circuit breakers and fuses are intended to interrupt the circuit, and they must have an ampere interrupting rating (AIR) sufficient for the available short-circuit current.

(a) True
(b) False

56. If the protection device is not rated to interrupt the current at the available fault values at its listed voltage rating, it can explode while attempting to clear the fault.

(a) True
(b) False

57. Equipment must have a(n) _____ current rating that permits the protection device to clear a short circuit or ground fault without extensive damage to the components of the circuit.

(a) overload
(b) short-circuit
(c) ground-fault
(d) b or c

Part B—Ground-Fault Circuit Interrupters

58. A GFCI is designed to protect persons against electric shock. It operates on the principle of monitoring the imbalance of current between the circuit's _____ conductor.

(a) ungrounded
(b) grounded
(c) equipment
(d) a and b

59. A GFCI-protection device contains an internal monitor that prevents the device from being turned on if there is a neutral-to-case connection downstream of the device, but this only occurs if there is a load on the circuit.

(a) True
(b) False

60. Severe electric shock or death can occur if a person touches the ungrounded and the neutral conductors at the same time, even if the circuit is GFCI-protected.

(a) True
(b) False

61. Typically, when a GFCI-protection device fails, the switching contacts remain closed and the device will continue to provide power without GFCI protection.

(a) True
(b) False

Part C—Arc-Fault Circuit Interrupters

62. Arcing is defined as a luminous discharge of electricity across an insulating medium. Electric arcs operate at temperatures between _____ and expel small particles of very hot molten material.

(a) 1,000 and 5,000°F
(b) 2,000 and 10,000°F
(c) 5,000 and 15,000°F
(d) 10,000 and 25,000°F

63. Unsafe arcing faults can occur in one of two ways, as series arcing faults or as parallel arcing faults. The most dangerous is the parallel arcing fault.

(a) True
(b) False

64. An AFCI-protection device provides protection from an arcing fault by recognizing the characteristics unique to an arcing fault and by functioning to de-energize the circuit when an arc fault is detected.

(a) True
(b) False

CHAPTER 5—ALTERNATING CURRENT

UNIT 16—ALTERNATING CURRENT

65. A nonsinusoidal waveform is created when _____ loads distort the voltage and current sine wave.

(a) linear
(b) resistive
(c) inductive
(d) nonlinear

66. When describing the relationship between voltage and current, the reference waveform is always _____.

(a) current
(b) resistance
(c) voltage
(d) none of these

67. The effective value is equal to the peak value _____.

(a) times 0.707
(b) times 1.41
(c) times 2
(d) times $\sqrt{3}$

UNIT 17—CAPACITANCE

68. Even when power is removed from the circuit, capacitors can store large amounts of energy for a long period of time. They can discharge and arc if inadvertently shorted or grounded out.

(a) True
(b) False

69. The opposition offered to the flow of ac current by a capacitor is called "capacitive reactance," which is expressed in ohms and abbreviated _____.

(a) X_C
(b) X_L
(c) Z
(d) none of these

UNIT 18—INDUCTION

70. The induced voltage in a conductor carrying alternating current opposes the change in current flowing through the conductor. The induced voltage that opposes the current flow is called "_____."

(a) CEMF
(b) counter-electromotive force
(c) back-EMF
(d) all of these

71. For ac circuits, the ac _____ of a conductor must be taken into consideration.

(a) eddy currents
(b) skin effect
(c) resistance
(d) all of these

72. The expanding and collapsing magnetic field within the conductor induces a voltage in the conductors (CEMF) that repels the flowing electrons toward the surface of the conductor. This is called "_____."

(a) eddy currents
(b) induced voltage
(c) impedance
(d) skin effect

73. The total opposition to current flow in ac circuits is called "_____" and measured in ohms.

(a) resistance
(b) reactance
(c) impedance
(d) skin effect

74. The abbreviation for impedance is _____.

(a) X_L
(b) X_C
(c) Z
(d) none of these

75. Self-induced voltage opposes the change in current flowing in the conductor. This is called "inductive reactance" and it is abbreviated _____.

(a) X_L
(b) X_C
(c) Z
(d) none of these

UNIT 19—POWER FACTOR AND EFFICIENCY

Part A—Power Factor

76. AC inductive or capacitive reactive loads cause the voltage and current to be in-phase with each other.

(a) True
(b) False

77. What size transformer is required for a 100A, 240V, single-phase noncontinuous load that has a power factor of 85 percent?

(a) 15 kVA
(b) 25 kVA
(c) 37.50 kVA
(d) 50 kVA

78. How many 20A, 120V circuits are required for forty-two, 300W luminaires (noncontinuous load) that have a power factor of 85 percent?

(a) 4 circuits
(b) 5 circuits
(c) 7 circuits
(d) 8 circuits

Part B—Efficiency

79. If the output is 1,600W and the equipment is 88 percent efficient, what are the input amperes at 120V?

(a) 10A
(b) 15A
(c) 20A
(d) 25A

CHAPTER 6—MOTORS, GENERATORS, AND TRANSFORMERS

UNIT 20—MOTORS

Part A—Motor Basics

80. Dual-voltage ac motors are made with two field windings. The field windings are connected in _____ for low-voltage operation and in _____ for high-voltage operation.

(a) series, parallel
(b) parallel, series
(c) series, series
(d) parallel, parallel

81. The motor FLA rating is used when sizing motor conductor size or circuit protection.

(a) True
(b) False

82. What is the nameplate FLA for a 20 hp, 208V, three-phase motor with 90 percent power factor and 80 percent efficiency?

(a) 51A
(b) 58A
(c) 65A
(d) 80A

83. When a motor starts, the current drawn is approximately _____ times the motor FLA; this is known as "motor locked-rotor amperes" (LRA).

(a) 0.80
(b) 1.25
(c) 3
(d) 6

84. If the rotating part of the motor winding is jammed so that it cannot rotate, no CEMF will be produced in the motor winding. Result—the motor operates at _____ and the windings will be destroyed by excessive heat.

(a) FLA
(b) FLC
(c) LRC
(d) any of these

85. In an ac induction motor, the stator produces a rotating magnetic field that induces current in the rotor windings. The rotor current generates a magnetic field in opposition to the magnetic field of the stator, thereby causing the rotor to turn.

(a) True
(b) False

86. In a(n) _____ motor, the rotor is locked in step with the rotating stator field and is dragged along at the speed of the rotating magnetic field.

(a) wound-rotor
(b) induction
(c) synchronous
(d) squirrel-cage

87. _____ motors are fractional horsepower motors that operate equally well on ac and dc and are used for vacuum cleaners, electric drills, mixers, and light household appliances.

(a) AC
(b) Universal
(c) Wound-rotor
(d) Synchronous

88. Swapping _____ of the line conductors can reverse a three-phase ac motor's rotation.

(a) one
(b) two
(c) three
(d) four

89. The _____ of an ac generator contains the electromagnetic field, which cuts through the stationary conductor coils.

(a) stator
(b) rotor
(c) coil
(d) winding

90. Three-phase ac generators have three equally spaced windings, _____ out-of-phase with each other.

(a) 90°
(b) 120°
(c) 180°
(d) 360°

91. The energy transfer ability of a transformer is accomplished because the primary electromagnetic lines of force induce a voltage in the secondary winding.

(a) True
(b) False

92. Voltage induced in the secondary winding of a transformer is dependent on the number of secondary turns as compared to the number of primary turns.

(a) True
(b) False

93. Wasteful circulating _____ in the iron core cause(s) the core to heat up without any useful purpose.

(a) conductor resistance
(b) flux leakage
(c) eddy currents
(d) hysteresis losses

94. _____ can be reduced by dividing the core into many flat sections or laminations.

(a) Conductor resistance
(b) Flux leakage
(c) Eddy currents
(d) Hysteresis losses

95. As current flows through the transformer, the iron core is temporarily magnetized. The energy required to realign the core molecules to the changing electromagnetic field is called "_____" loss.

(a) conductor resistance
(b) flux leakage
(c) eddy currents
(d) hysteresis

96. Three-phase, _____, wye-connected systems can overheat because of circulating odd triplen harmonic currents.

(a) 2-wire
(b) 3-wire
(c) 4-wire
(d) none of these

97. The heating from harmonic currents is proportional to the square of the harmonic current.

(a) True
(b) False

98. Because of conductor resistance, flux leakage, eddy currents, and hysteresis losses, not all of the input power is transferred to the secondary winding for useful purposes.

(a) True
(b) False

99. If the primary phase voltage is 480V and the secondary phase voltage is 240V, the turns ratio is _____.

(a) 1:2
(b) 1:41
(c) 2:1
(d) 4:1

100. Transformers are rated in _____.

(a) VA
(b) kW
(c) W
(d) kVA

Notes

PART 2 NATIONAL ELECTRICAL CODE EXAM (4 HOURS)

Please use the 2014 Code book to answer the following questions. If you need a copy of the *Code* book, visit www.MikeHolt.com/14Code or call 888.632.2633

1. HDPE conduit shall not be subjected to ambient temperatures in excess of _____, unless listed otherwise.

   (a) 50°C
   (b) 60°C
   (c) 75°C
   (d) 90°C

2. Fixed wiring in an aircraft hangar not in a Class I location shall be _____.

   (a) installed in metal raceways
   (b) Type MI, TC, or MC cable
   (c) installed in nonmetallic raceways
   (d) a or b

3. The fuel cell system shall be evaluated and _____ for its intended application.

   (a) approved
   (b) identified
   (c) listed
   (d) marked

4. Emergency systems are generally installed where artificial illumination is required for safe exiting and for panic control in buildings occupied by large numbers of persons, such as _____ and similar institutions.

   (a) hotels
   (b) theaters and sports arenas
   (c) health care facilities
   (d) all of these

5. Listed fittings and connectors that are intended to be concealed at the time of on-site assembly are permitted for on-site interconnection of PV modules or other array components.

   (a) True
   (b) False

6. Types _____ nonconductive and conductive optical fiber cables shall be listed as being suitable for general-purpose use, with the exception of risers, plenums, and other spaces used for environmental air, and shall also be listed as being resistant to the spread of fire.

   (a) OFNP and OFCP
   (b) OFNR and OFCR
   (c) OFNG and OFCG
   (d) OFN and OFC

7. Where multiple utility-interactive inverters are remotely located from each other, a directory must be provided at each dc PV system disconnecting means, each ac disconnecting means, and at the main service disconnecting means showing the location of all ac and dc PV system disconnecting means in the building/structure.

   (a) True
   (b) False

8. An oil switch can be used as both the motor controller and disconnecting means on a circuit whose rating _____ or 100A.

   (a) does not exceed 240V
   (b) does not exceed 300V
   (c) does not exceed 1,000V
   (d) exceeds 1,000V

9. Electrical equipment that depends on _____ for cooling of exposed surfaces shall be installed so that airflow over such surfaces is not prevented by walls or by adjacent installed equipment.

   (a) outdoor air
   (b) natural circulation of air and convection principles
   (c) artificial cooling and circulation
   (d) magnetic induction

10. _____ must be used to disable a PV array or portions of an array for installation and service.

    (a) Open circuiting
    (b) Short circuiting
    (c) Opaque covering
    (d) Any of these

11. Conductors smaller than 1/0 AWG can be connected in parallel to supply control power, provided _____.

    (a) they are all contained within the same raceway or cable
    (b) each parallel conductor has an ampacity sufficient to carry the entire load
    (c) the circuit overcurrent device rating does not exceed the ampacity of any individual parallel conductor
    (d) all of these

12. Cable trays shall _____.

    (a) include fittings or other suitable means for changes in direction and elevation of runs
    (b) have side rails or equivalent structural members
    (c) be made of corrosion-resistant material or protected from corrosion as required by 300.6
    (d) all of these

13. Each elevator shall have a means for disconnecting all ungrounded main power-supply conductors for each unit _____.

    (a) excluding the emergency power system
    (b) including the emergency or standby power system
    (c) excluding the emergency power system if it is automatic
    (d) and the power supply may not be an emergency power system

14. Communications _____ cables shall be listed as being suitable for use in a vertical run in a shaft, or from floor to floor, and shall also be listed as having fire-resistant characteristics capable of preventing the carrying of fire from floor to floor.

    (a) plenum
    (b) riser
    (c) general-purpose
    (d) none of these

15. For flexible metal conduit, if flexibility is necessary after installation, unsecured lengths from the last point the raceway is securely fastened must not exceed _____

    (a) 3 ft for trade sizes ½ through 1¼
    (b) 4 ft for trade sizes 1½ through 2
    (c) 5 ft for trade sizes 2½ and larger
    (d) all of these

16. When bare conductors are installed with insulated conductors, their ampacities shall be limited to _____.

(a) 60°C
(b) 75°C
(c) 90°C
(d) the lowest temperature rating for any of the insulated conductors

17. Capacitors shall be _____ so that persons cannot come into accidental contact or bring conducting materials into accidental contact with exposed energized parts, terminals, or buses associated with them.

(a) enclosed
(b) located
(c) guarded
(d) any of these

18. When an outlet from an underfloor raceway is discontinued, the circuit conductors supplying the outlet _____.

(a) may be spliced
(b) may be reinsulated
(c) may be cut and capped off
(d) shall be removed from the raceway

19. Tap devices used in Type FC assemblies shall be rated not less than _____ or more than 300 volts-to-ground.

(a) 15A
(b) 20A
(c) 30A
(d) 40A

20. The ampacity of the supply conductors to an individual electric arc welder shall not be less than the effective current value on the rating plate.

(a) True
(b) False

21. When service equipment has ground-fault protection installed, it may be necessary to review the overall wiring system for proper selective overcurrent protection _____.

(a) rating
(b) coordination
(c) devices
(d) none of these

22. Overcurrent devices for PV systems shall be rated to carry not less than _____ percent of the maximum currents calculated in 690.8(A).

(a) 80
(b) 100
(c) 125
(d) 250

23. The essential electrical systems in a health care facility shall be supplied from _____.

(a) a normal source generally supplying the entire electrical system
(b) one or more alternate sources for use when the normal source is interrupted
(c) a or b
(d) a and b

24. The feeder conductor ampacity shall not be less than that of the service conductors where the feeder conductors carry the total load supplied by service conductors with an ampacity of _____ or less.

(a) 30A
(b) 55A
(c) 60A
(d) 100A

25. A unit of an electrical system, other than a conductor, that carries or controls electric energy as its principal function is a(n) "_____."

(a) raceway
(b) fitting
(c) device
(d) enclosure

26. Decorative lighting and similar accessories used for holiday lighting and similar purposes shall be _____.

(a) marked
(b) listed
(c) arc fault protected
(d) GFCI protected

27. For PV systems, a(n) _____ is a device that changes direct-current input to an alternating-current output.

(a) diode
(b) rectifier
(c) transistor
(d) inverter

28. Infrared lamps for commercial and industrial heating appliances shall have overcurrent protection not exceeding _____.

(a) 30A
(b) 40A
(c) 50A
(d) 60A

29. Tap conductors not over 25 ft shall be permitted, providing the _____.

(a) ampacity of the tap conductors is not less than one-third the rating of the overcurrent device protecting the feeder conductors being tapped
(b) tap conductors terminate in a single circuit breaker or set of fuses that limit the load to the ampacity of the tap conductors
(c) tap conductors are suitably protected from physical damage
(d) all of these

30. In aircraft hangars, equipment less than _____ ft above wings and engine enclosures of aircraft and that may produce arcs, sparks, or particles of hot metal shall be of the totally enclosed type or constructed so as to prevent the escape of sparks or hot metal particles.

(a) 2
(b) 3
(c) 10
(d) 20

31. Where the removal of equipment opens the bonding connection between the _____ and exposed conducting surfaces in the PV source or output circuit equipment, a bonding jumper shall be installed while the equipment is removed.

(a) equipment grounding conductor
(b) grounded conductor
(c) grounding electrode conductor
(d) ungrounded conductor

32. Resistance-type heating elements in electric space-heating equipment shall be protected at not more than _____.

(a) 24A
(b) 36A
(c) 48A
(d) 60A

33. For switchboards that are not totally enclosed, a space of _____ or more shall be provided between the top of the switchboard and any combustible ceiling.

(a) 12 in.
(b) 18 in.
(c) 2 ft
(d) 3 ft

34. A generator set for a legally required standby system shall _____.

(a) have means for automatically starting the prime mover
(b) have not less than 2 hours of fuel supply for full-demand operation available on-site if the prime mover is an internal combustion engine
(c) not be solely dependent on a public utility gas system unless acceptable to the AHJ
(d) all of these

35. Where feeder conductors are installed to serve a mobile home, an equipment grounding conductor shall be installed with the conductors, unless the premises wiring system is existing.

(a) True
(b) False

36. The _____ of conductors used in prewired ENT manufactured assemblies shall be identified by means of a printed tag or label attached to each end of the manufactured assembly.

(a) type
(b) size
(c) quantity
(d) all of these

37. An electrically driven or controlled machine with one or more motors which is used primarily to transport and distribute water for agricultural purposes, and is not hand portable is called a(n) "_____."

(a) irrigation machine
(b) electric water distribution system
(c) center pivot irrigation machine
(d) automatic water distribution system

38. Article 647 covers the installation and wiring of separately derived systems that operate at _____ volts-to-ground and _____ volts line-to-line for sensitive electronic equipment.

(a) 30, 60
(b) 60, 120
(c) 120, 120
(d) 120, 240

39. Stockrooms and similar areas adjacent to classified locations of aircraft hangars, but effectively isolated and adequately ventilated, shall be designated as _____ locations.

(a) Class I, Division 2
(b) Class II, Division 1
(c) Class II, Division 2
(d) unclassified

40. For the purposes of conduit fill, a multiconductor cable, optical fiber cable, or flexible cord of two or more conductors is considered _____ conductor(s).

(a) one
(b) two
(c) three
(d) four

41. HDPE conduit shall be permitted only in trade sizes _____.

(a) ¾ to 4
(b) ½ to 6
(c) 1 to 5
(d) 1 to 3

42. Floor-mounted flat conductor cable and fittings shall be covered with carpet squares no larger than _____.

(a) 24 inches square
(b) 30 sq in. area
(c) 36 sq in. area
(d) 39.37 inches square

43. The PV maximum output circuit current is equal to the sum of parallel PV source circuit maximum currents as calculated in _____.

(a) 690.8(A)(1)
(b) 690.8(A)(2)
(c) 690.8(A)(3)
(d) none of these

44. The maximum size conductors permitted in a nonmetallic surface raceway shall not be larger than that for which the wireway is designed.

(a) True
(b) False

45. The maximum PV inverter output circuit current is equal to the _____ output current rating.

(a) average
(b) peak
(c) continuous
(d) intermittent

46. _____ are designed for surface mounting that have swinging doors or covers.

(a) Outlet boxes
(b) Cabinets
(c) Cutout boxes
(d) none of these

47. Plug-in type backfed circuit breakers for a stand-alone or multimode inverter connected to a stand-alone PV system are not required to be secured in place by an additional fastener that requires other than a pull to release the breaker from the panelboard.

(a) True
(b) False

48. The number of nonpower-limited fire alarm conductors in a raceway shall not be required to comply with the fill requirements contained in 300.17.

(a) True
(b) False

49. Underfloor raceways shall be laid so that a straight line from the center of one _____ to the center of the next _____ coincides with the centerline of the raceway system.

(a) termination point, termination point
(b) junction box, junction box
(c) receptacle, receptacle
(d) panelboard, panelboard

50. Overload relays and other devices for motor overload protection that are not capable of _____ shall be protected by fuses, circuit breakers, or motor short-circuit protector.

(a) opening short circuits
(b) clearing overloads
(c) opening ground faults
(d) a or c

51. A heating panel is a complete assembly provided with a junction box or length of flexible conduit for connection to a(n) _____.

(a) wiring system
(b) service
(c) branch circuit
(d) approved conductor

52. A "performance area" includes the stage and audience seating area associated with a _____ stage structure, whether indoors or outdoors.

(a) temporary
(b) permanent
(c) a or b
(d) a and b

53. The walls and roofs of transformer vaults shall be constructed of materials that have approved structural strength for the conditions with a minimum fire-resistance rating of _____ hours.

(a) 2
(b) 3
(c) 4
(d) 6

54. Nonpower-limited fire alarm circuit conductors are permitted to be in the same cable, enclosure, or raceway with power-supply circuits where connected to the same equipment.

(a) True
(b) False

55. Conductors for nonpower-limited fire alarm circuits shall be _____.

(a) solid copper
(b) stranded copper
(c) copper or aluminum
(d) a or b

56. Conductors supplying several motors shall not be sized smaller than _____ percent of the full-load current rating of the highest rated motor, plus the sum of the full-load current ratings of all other motors in the group, plus the ampacity or other loads.

(a) 80
(b) 100
(c) 125
(d) 150

57. Conductors for an appliance circuit supplying more than one appliance or appliance receptacle in an installation operating at less than 50V shall not be smaller than _____ AWG copper or equivalent.

(a) 18
(b) 14
(c) 12
(d) 10

58. The radius of the inner edge of any bend in Type MI cable shall not be less than _____ times the external diameter of the metallic sheath for any cable having an external diameter greater than ¾ in., but not more than 1 in.

(a) three
(b) six
(c) eight
(d) 10

59. Where network-powered broadband communications system aerial cables are installed outside and entering buildings, they shall _____.

(a) be located below the electric light or power conductors, where practicable
(b) not be attached to a cross-arm that carries electric light or power conductors
(c) have a vertical clearance of not less than 8 ft from all points of roofs above which they pass
(d) all of these

60. The header on a cellular concrete floor raceway shall be installed _____ to the cells.

(a) in a straight line
(b) at right angles
(c) a and b
(d) none of these

61. Which of the following wiring methods and enclosures that contain photovoltaic power source conductors must be marked "WARNING PHOTOVOLTAIC POWER SOURCE" by means of permanently affixed labels or other approved permanent marking?

(a) Exposed raceways, cable trays, and other wiring methods.
(b) The covers or enclosures of pull boxes and junction boxes.
(c) Conduit bodies in which any of the available conduit openings are unused.
(d) all of these

62. Where conditions of maintenance and supervision ensure only qualified persons service the installation in _____ buildings, the entire length of the metal water piping system can be used for grounding purposes, provided the entire length, other than short sections passing through walls, floors, or ceilings, is exposed.

(a) industrial
(b) institutional
(c) commercial
(d) all of these

63. HDPE conduit shall be resistant to _____.

(a) moisture
(b) chemical atmospheres
(c) impact and crushing
(d) all of these

64. Fixture wires used as pendant conductors for incandescent luminaires with intermediate or candelabra-base lampholders shall not be smaller than _____ AWG.

(a) 22
(b) 18
(c) 16
(d) 14

65. The PV system disconnecting means must be _____ to identify it as a photovoltaic system disconnect.

(a) listed
(b) approved
(c) permanently marked
(d) temporarily marked

66. A fuel cell is an electrochemical system that consumes _____ to produce an electric current.

(a) power
(b) water
(c) heat
(d) fuel

67. The continuous current-carrying capacity of a 1½ sq in. copper busbar mounted in an unventilated sheet metal auxiliary gutter is _____.

(a) 500A
(b) 650A
(c) 750A
(d) 1,500A

68. Network-powered broadband communications cable not terminated at equipment other than a connector, and not identified for future use with a tag, is considered abandoned.

(a) True
(b) False

69. Type MI cable conductors shall be made of _____, nickel, or nickel-coated copper with a resistance corresponding to standard AWG and kcmil sizes.

(a) solid copper
(b) solid or stranded copper
(c) stranded copper
(d) solid copper or aluminum

70. When conduit nipples having a maximum length not exceeding 24 in. are installed between boxes, the nipple can be filled to 60 percent.

(a) True
(b) False

71. Panelboards equipped with snap switches rated at 30A or less shall have overcurrent protection not exceeding _____.

(a) 30A
(b) 50A
(c) 100A
(d) 200A

72. Junction box covers used in installations for sensitive electronic equipment shall be clearly marked to indicate the _____.

(a) system frequency
(b) system voltage
(c) distribution panel
(d) b and c

73. The minimum size conductor for operating control and signaling circuits in an elevator shall be _____.

(a) 20 AWG
(b) 16 AWG
(c) 14 AWG
(d) 12 AWG

74. Bends in NUCC can be _____ so that the conduit will not be damaged and the internal diameter of the conduit will not be effectively reduced.

(a) manually made
(b) made only with approved benders
(c) made with RMC bending shoes
(d) made using an open flame torch

75. Loop wiring _____ in a cellular metal raceway.

(a) shall not be permitted
(b) shall not be considered a splice or tap
(c) shall be considered a splice or tap when used
(d) none of these

76. Ventilation openings for transformer vaults must be located as far as possible from _____.

(a) doors
(b) windows
(c) combustible material
(d) any of these

77. Receptacles or their cover plates, supplied from the essential electrical system in nursing homes shall have a distinctive color or marking so as to be readily identifiable.

(a) True
(b) False

78. Receptacle outlets over countertops in the kitchen in a mobile home shall _____.

(a) be no more than 2 ft apart
(b) be no more than 4 ft apart
(c) be no more than 6 ft apart
(d) include at least one receptacle outlet on each side of the sink

79. The use of NUCC shall be permitted _____.

(a) for direct burial underground installations
(b) to be encased or embedded in concrete
(c) in cinder fill
(d) all of these

80. Audible and visual signal devices shall be provided on legally required standby systems, where practicable, to indicate _____.

(a) derangement of the standby source
(b) that the standby source is carrying load
(c) that the battery charger is not functioning
(d) all of these

81. A capacitor operating at over 1,000V shall be provided with means to reduce the residual voltage to 50V or less within _____ minute(s) after it is disconnected from the source of supply.

(a) one
(b) three
(c) five
(d) seven

82. For emergency systems, manual switches controlling emergency circuits shall be convenient to authorized persons responsible for their _____.

(a) maintenance
(b) actuation
(c) inspection
(d) evaluation

83. Faulted circuits required to have ground-fault protection in a photovoltaic system shall be isolated by automatically disconnecting the _____, or the inverter charge controller fed by the faulted circuits shall automatically stop supplying power to output circuits.

(a) ungrounded conductors
(b) grounded conductors
(c) equipment grounding conductors
(d) all of these

84. In installations where optical fiber cable is terminated on the outside of the building and is exposed to contact with electrical conductors, the metallic sheath members of the cable shall be _____ in accordance with 770.100, or interrupted by an insulating joint or equivalent device.

(a) bonded
(b) connected
(c) grounded
(d) isolated

85. Where ventilation marking is not required, the electric vehicle supply equipment shall be clearly field marked, that "ventilation is not required."

(a) True
(b) False

86. The phase converter disconnecting means shall be _____ and located in sight from the phase converter.

(a) protected from physical damage
(b) readily accessible
(c) easily visible
(d) clearly identified

87. Where two or more branch circuits supply devices or equipment on the same yoke or mounting strap, a means to disconnect simultaneously all ungrounded conductors that supply those devices or equipment shall be provided at the _____.

(a) point where the branch circuit originates
(b) location of the device or equipment
(c) point where the feeder originates
(d) none of these

88. Soldered splices shall first be spliced or joined so as to be mechanically and electrically secure without solder and then be soldered.

(a) True
(b) False

89. PV system conductors shall be identified by separate color coding, marking tape, tagging, or other approved means.

(a) True
(b) False

90. A blocking _____ is used to block reverse current flow into a PV source circuit.

(a) resistor
(b) potentiometer
(c) diode
(d) all of the above

91. Where exposed and subject to physical damage, PV array equipment grounding conductors smaller than 4 AWG must be protected by raceway or cable armor.

(a) True
(b) False

92. Bends in Type MI cable shall be made so that the cable will not be _____.

(a) damaged
(b) shortened
(c) a and b
(d) none of these

93. Knife switches rated for more than 1,200A at 250V or less _____.

(a) can be used only as isolating switches
(b) shall not be opened under load
(c) shall be placed so that gravity tends to close them
(d) a and b

94. A common dc grounding electrode conductor of a PV system is permitted to serve multiple inverters with the size of the common grounding electrode and the tap conductors in accordance with 250.166. The tap conductors must be connected to the common grounding electrode conductor in such a manner that the common grounding electrode conductor remains _____.

(a) without a splice or joint
(b) inside inverter enclosures
(c) inside a raceway
(d) supported on insulators

95. In grounded PV source circuits, one overcurrent protection device is not permitted to protect the PV modules and the interconnecting conductors.

(a) True
(b) False

96. Transformer vaults containing more than _____ total kVA transformer capacity shall be provided with a drain or other means that will carry off any accumulation of oil or water in the vault, unless impracticable.

(a) 100
(b) 150
(c) 200
(d) 250

97. Switchboards shall be placed so as to reduce to a minimum the probability of communicating _____ to adjacent combustible materials.

(a) sparks
(b) backfed
(c) fire
(d) all of these

98. X-ray equipment mounted on a permanent base equipped with wheels for moving while completely assembled describes "_____."

(a) portable
(b) mobile
(c) movable
(d) room

99. Expansion fittings for nonmetallic wireways shall be provided to compensate for thermal expansion and contraction, where the length change is expected to be _____ in. or greater in a straight run.

(a) 1/16
(b) ¼
(c) ½
(d) 6

100. For interconnected electric power production sources, panelboards containing ac inverter circuit breakers must be field marked to indicate the presence of multiple ac power sources.

(a) True
(b) False

PART 3 ELECTRICAL CALCULATIONS EXAM (5 HOURS)

Questions 1–51 relate directly to *Mike Holt's Illustrated Guide to Electrical Exam Preparation, based on the 2014 NEC* textbook. Questions 52–65 relate to *Mike Holt's Illustrated Guide to Understanding Basic Motor Controls* textbook.

CHAPTER 1—ELECTRICAL THEORY

UNITS 1 THROUGH 4—ELECTRICAL THEORY

1. If the output is 160W and the equipment is 88 percent efficient, what are the input amperes if the voltage is 120V?

   (a) 0.75A
   (b) 1.50A
   (c) 2.275A
   (d) 3.25A

2. A transformer winding that is 97 percent efficient produces _____ output for every 1 kW input.

   (a) 970W
   (b) 1,000W
   (c) 1,030W
   (d) 1,300W

CHAPTER 2—*NEC* CALCULATIONS

UNIT 5—RACEWAY AND BOX CALCULATIONS

3. A 200A feeder installed in Schedule 80 rigid nonmetallic conduit has three 3/0 THHN conductors, one 2 THHN conductor, and one 6 THHN conductor. What trade size raceway is required?

   (a) 2
   (b) 2½
   (c) 3
   (d) 3½

4. What trade size rigid metal nipple is required for three 4/0 THHN conductors, one 1/0 THHN conductor, and one 4 THHN conductor?

   (a) 1½
   (b) 2
   (c) 2½
   (d) 3

UNIT 6—CONDUCTOR SIZING AND PROTECTION

5. What is the ampacity of four current-carrying 1/0 THHN conductors in a raceway?

   (a) 111A
   (b) 136A
   (c) 153A
   (d) 171A

6. A raceway contains eight current-carrying conductors. What size conductor is required to feed a 21A noncontinuous load? The overcurrent device is rated 30A.

(a) 14 THHN
(b) 12 THHN
(c) 10 THHN
(d) any of these

7. What is the ampacity of eight current-carrying 10 THHN conductors installed in an ambient temperature of 100°F?

(a) 21A
(b) 25A
(c) 32A
(d) 40A

UNIT 7—VOLTAGE DROP CALCULATIONS

8. What is the ac ohms-to-neutral resistance for 100 ft of 3 AWG copper conductor?

(a) 0.012 ohms
(b) 0.025 ohms
(c) 0.33 ohms
(d) 0.43 ohms

9. A 2-wire circuit supplies a 36A load that is located 100 ft from the panelboard. The load is wired with 1 AWG aluminum in PVC conduit. What is the total ac ohms-to-neutral resistance of the circuit conductors?

(a) 0.05 ohms
(b) 0.25 ohms
(c) 0.50 ohms
(d) 0.62 ohms

10. What size copper conductors in a steel raceway can be used to replace 1/0 AWG aluminum that supplies a 110A load? Note: We do not want to increase the circuit voltage drop.

(a) 3 AWG
(b) 2 AWG
(c) 1 AWG
(d) 1/0 AWG

11. A 24A, 240V, single-phase load is located 160 ft from the panelboard. The load is wired with 10 AWG conductors. What is the approximate voltage drop of the branch-circuit conductors?

(a) 3.20V
(b) 4.25V
(c) 5.90V
(d) 9.50V

12. A 36 kVA, 208V, 100A, three-phase load is located 100 ft from the panelboard and is wired with 1 AWG aluminum conductors. What is the approximate voltage drop of the circuit conductors?

(a) 3V
(b) 3.50V
(c) 4.40V
(d) 5V

13. A single-phase, 5 hp motor is located 110 ft from a panelboard. The nameplate indicates that the voltage is 115/230V and the FLA is 52/26A. What size conductor is required if the motor windings are connected to operate at 115V? Apply the *NEC* recommended voltage-drop limits.

(a) 10 AWG
(b) 8 AWG
(c) 6 AWG
(d) 3 AWG

14. A single-phase, 5 hp motor is located 110 ft from a panelboard. The nameplate indicates that the voltage is 115/230V and the FLA is 52/26A. What size conductor is required if the motor windings are connected to operate at 230V? Apply the *NEC* recommended voltage-drop limits.

    (a) 10 AWG
    (b) 8 AWG
    (c) 6 AWG
    (d) 4 AWG

UNIT 8—MOTOR AND AIR-CONDITIONING CALCULATIONS

15. The branch-circuit short-circuit protection device for a 10 hp, 230V, single-phase motor shall not exceed _____. Note: Use an inverse time breaker for protection.

    (a) 50A
    (b) 75A
    (c) 80A
    (d) 125A

16. The branch-circuit protection (circuit breaker) for a 125 hp, 240V, dc motor is _____.

    (a) 400A
    (b) 600A
    (c) 700A
    (d) 800A

17. The motor feeder conductor size for three 15 hp, three-phase, 208V motors; three 3 hp, single-phase, 208V motors; and three 1 hp, single-phase, 115V motors will be _____.

    (a) 2/0 AWG
    (b) 3/0 AWG
    (c) 4/0 AWG
    (d) 250 kcmil

18. If an inverse time breaker is used for the feeder short-circuit protection, what size protection is required for the following three-phase motors?

    Motor 1 = 40 hp, 52 FLC
    Motor 2 = 20 hp, 27 FLC
    Motor 3 = 10 hp, 14 FLC
    Motor 4 = 5 hp, 7.60 FLC

    (a) 125A
    (b) 175A
    (c) 200A
    (d) 225A

CHAPTER 3—ADVANCED *NEC* CALCULATIONS

UNIT 10—MULTIFAMILY DWELLING CALCULATIONS

19. What is the calculated load for twelve 3.25 kW ovens?

    (a) 10 kW
    (b) 15 kW
    (c) 18 kW
    (d) 20 kW

20. What is the calculated load for eight 7 kW cooktops?

    (a) 14.70 kW
    (b) 17 kW
    (c) 20 kW
    (d) 48 kW

21. What is the calculated load for five 12.40 kW ranges?

    (a) 9 kW
    (b) 14.70 kW
    (c) 20 kW
    (d) 45 kW

22. Each unit of a 20-unit apartment building is 990 sq ft. What is the calculated load for the general lighting, and small-appliance and laundry loads for the building?

(a) 51,300 VA
(b) 74,700 VA
(c) 105,600 VA
(d) 149,400 VA

23. A 40-unit multifamily building has an air conditioner (3 hp, 230V) and two baseboard heaters (3 kW, 240V) in each unit. What is the calculated load for the air-conditioning and heat?

(a) 50 kW
(b) 60 kW
(c) 160 kW
(d) 240 kW

24. In a 16-unit multifamily building, each unit contains a waste disposal (940 VA), a dishwasher (1,250 VA), and a water heater (4,500 VA). What is the service calculated load for these appliances?

(a) 5 kVA
(b) 80 kVA
(c) 100 kVA
(d) 134 kVA

25. A multifamily dwelling (40-unit) contains a 4.50 kW electric clothes dryer in each unit. What is the feeder and service calculated load for all of the dryers?

(a) 27 kW
(b) 53 kW
(c) 60 kW
(d) 90 kW

26. Each unit of a 60-unit apartment building has a 4 kW dryer. Using the optional method, the calculated load that will be added to the service is _____ kW.

(a) 58
(b) 72
(c) 75
(d) 240

UNIT 11—COMMERCIAL CALCULATIONS

27. How many 2 x 4 fluorescent luminaires, each rated 277V, 0.80A, can be connected to a 20A circuit? The four lamps are rated 40W each and the luminaire is to be on for more than 3 hours.

(a) 5
(b) 7
(c) 9
(d) 20

28. A new restaurant has a total connected load of 400 kVA and is all electric. What is the calculated load for the service?

(a) 210 kVA
(b) 275 kVA
(c) 300 kVA
(d) 325 kVA

29. What is the general lighting and general-use receptacle load for a 30,000 sq ft bank?

(a) 123 kVA
(b) 151 kVA
(c) 162 kVA
(d) 173 kVA

30. A 120/208V, three-phase service has a total connected load of 1,450A:

600A of these are phase-to-phase loads
300A are balanced 120V fluorescent lighting
550A are other 120V loads

The neutral calculated load for this service is _____.

(a) 420A
(b) 650A
(c) 745A
(d) 1,150A

31. A marina shore power facility has twenty 20A, 240V receptacles; seventeen 30A, 240V receptacles; and seven 50A, 240V receptacles. After applying demand factors, the service calculated load for the shore power boxes is _____.

(a) 625A
(b) 630A
(c) 1,160A
(d) 1,260A

32. A 75-site mobile home park is designed for mobile homes that have a 14,000 VA load per site. The service calculated load for the park is _____.

(a) 201 kVA
(b) 222 kVA
(c) 264 kVA
(d) 1,200 kVA

33. A 40-unit motel (300 sq ft in each unit) has 3 kVA of air-conditioning and 4 kW of heat in each unit, and every two units share one 1.50 kW water heater. What is the calculated load for the motel?

(a) 202 kVA
(b) 226 kVA
(c) 251 kVA
(d) 281 kVA

34. A recreational vehicle park has 42 sites; 9 sites rated 50A, 120/240V, 30 sites rated 30/20A, and 3 sites rated 20A. The minimum feeder calculated load for these sites is _____.

(a) 83 kVA
(b) 101 kVA
(c) 139 kVA
(d) 158 kVA

35. Using the optional method, what is the calculated load (kVA) for a 20,000 sq ft school that has a total connected load of 160 kVA?

(a) 106 kVA
(b) 112 kVA
(c) 120 kVA
(d) 135 kVA

36. A nonmotor-generator arc welder has a primary current rating of 40A with a duty cycle of 50 percent. The branch-circuit conductor for the welder must be rated at least _____.

(a) 15A
(b) 20A
(c) 25A
(d) 30A

37. The minimum size for a feeder conductor for five 50A nonmotor-generator welders with a duty cycle of 50 percent is _____.

(a) 4 AWG
(b) 3 AWG
(c) 2 AWG
(d) 1/0 AWG

38. The maximum overcurrent device rating for 10 AWG conductors used for an arc welder branch circuit is _____.

(a) 30A
(b) 40A
(c) 50A
(d) 70A

39. The minimum size branch-circuit conductor required for a 50A resistance welder having a duty cycle of 50 percent is _____.

(a) 8 AWG
(b) 6 AWG
(c) 4 AWG
(d) 2 AWG

40. The minimum size feeder conductor for five 50A resistance welders with a duty cycle of 50 percent is _____.

(a) 4 AWG
(b) 3 AWG
(c) 2 AWG
(d) 1 AWG

41. What is the calculated load for an all-electric restaurant that has a total connected load of 300 kVA paralleled in two raceways?

(a) 300 kVA
(b) 270 kVA
(c) 150 kVA
(d) 170 kVA

42. Balance a 120/208V, three-phase panelboard in kVA for the following loads: one 18 kVA, three-phase heat strip; two 5 kVA, single-phase 208V loads; and three 2 kVA 120V loads.

(a) The largest Line is 12.50 kVA.
(b) The smallest Line is 10.50 kVA.
(c) The total Line load equals 34 kVA.
(d) all of these

UNIT 12—TRANSFORMER CALCULATIONS

43. The maximum primary overcurrent device rating for a 750 VA, single-phase, 480V transformer is _____.

(a) 2A
(b) 4A
(c) 6A
(d) 10A

44. The maximum primary overcurrent device rating for a 2 kVA, single-phase, 240V transformer is _____.

(a) 4A
(b) 5A
(c) 13A
(d) 17A

45. The primary full load current rating for a 75 kVA, three-phase, 480V to 120/208V transformer is _____.

(a) 50A
(b) 90A
(c) 107A
(d) 124A

46. What is the primary line current for a fully loaded 45 kVA, 480V to 120/240V, three-phase transformer?

(a) 43A
(b) 54A
(c) 108A
(d) 124A

47. What is the secondary line current for a fully loaded 45 kVA, 480V to 240V, three-phase transformer?

(a) 43A
(b) 54A
(c) 108A
(d) 124A

48. What is the primary line current for a fully loaded 22 kVA, 480V to 120/208V, three-phase transformer?

(a) 22A
(b) 26A
(c) 54A
(d) 61A

49. What is the secondary line current for a fully loaded 22 kVA, 480V to 120/208V, three-phase transformer?

(a) 22A
(b) 27A
(c) 54A
(d) 61A

50. The maximum primary overcurrent device rating for a 75 kVA, three-phase, 480V transformer when there is no secondary protection is _____.

(a) 70A
(b) 100A
(c) 110A
(d) 125A

51. The minimum size primary conductor that could be used for a 75 kVA, three-phase, 480V transformer, where primary overcurrent is sized at 125A is _____.

(a) 6 AWG
(b) 4 AWG
(c) 3 AWG
(d) 2 AWG

BASIC MOTOR CONTROLS

52. In Figure 1 there is(are) _____ momentary-contact pushbutton(s).

(a) 1
(b) 2
(c) 3
(d) 4

53. In Figure 1, when the start pushbutton is pressed, the _____.

(a) M coil energizes
(b) NO M1 contacts close
(c) NC M2 contacts open
(d) all of these

54. In Figure 1, the letter in the middle of the pilot light symbol represents _____.

(a) the direction the motor turns
(b) the color of the pilot light
(c) which coil activates the pilot light
(d) the terminal number to which the pilot light is connected

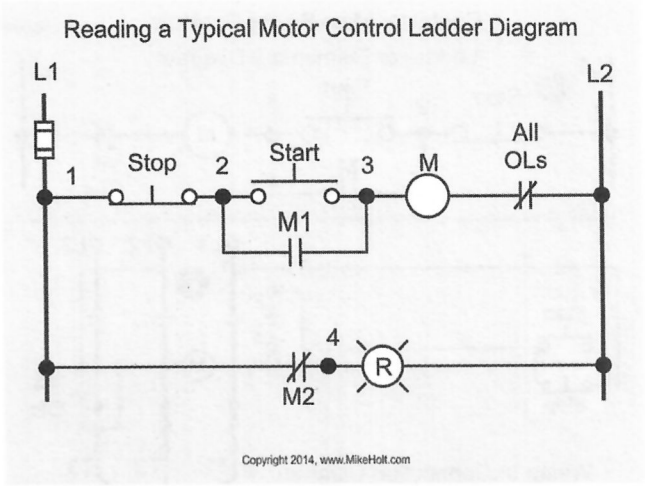

Figure 1

55. In Figure 1, the normally closed auxiliary contacts M2 are connected to points _____.

(a) 1-2
(b) 1-3
(c) 1-4
(d) 3-4

56. In Figure 1, the normally open auxiliary contacts M1 are connected to points _____.

(a) 1-2
(b) 1-3
(c) 1-4
(d) 2-3

57. In Figure 2, the main power contacts are _____.

(a) not shown in the ladder diagram A
(b) shown in the wiring (connection) diagram B
(c) not shown in either diagram
(d) a and b

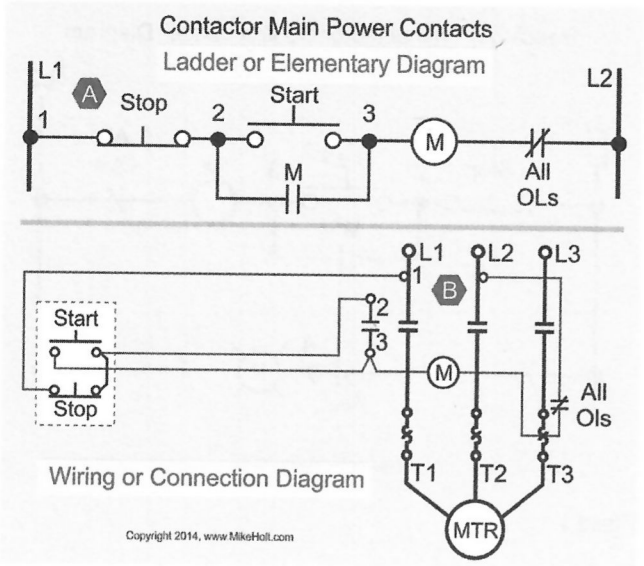

Figure 2

58. In Figure 2, the power for the control circuit is taken from _____.

(a) L1 and L2 for both the ladder and wiring diagrams
(b) L1 and L2 for the ladder diagram and from L1 and L3 for the wiring diagram
(c) L1 and L3 for both diagrams
(d) L2 and L3 for both diagrams

59. In Figure 2 when the start PB is pushed, the M coil _____.

(a) closes the power contacts
(b) closes the auxiliary contacts 2-3
(c) energizes
(d) all of these

60. In Figure 3, the magnetic motor starter is designated by the letter _____.

(a) A
(b) B
(c) C
(d) D

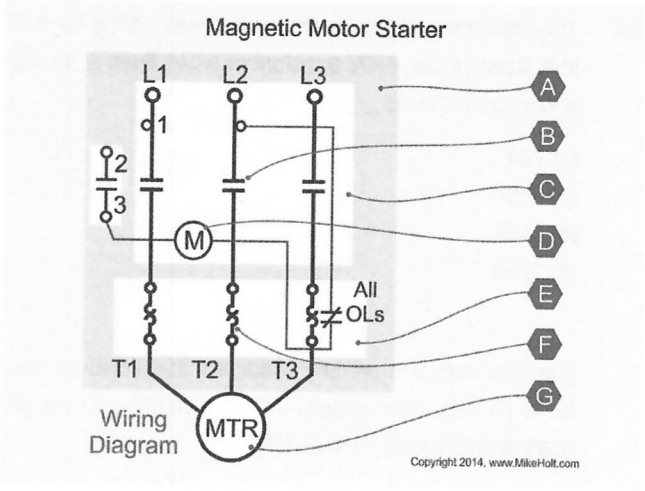

Figure 3

61. In Figure 3, the power contacts for the magnetic motor starter are designated by the letter _____.

(a) A
(b) B
(c) C
(d) D

62. In Figure 3, the coil for the magnetic motor starter is designated by the letter _____.

(a) C
(b) D
(c) E
(d) F

63. In Figure 3, the overload relay assembly for the magnetic motor starter is designated by the letter _____.

(a) C
(b) D
(c) E
(d) F

64. In Figure 3, the motor that's supplied by the magnetic motor starter is designated by the letter _____.

(a) D
(b) E
(c) F
(d) G

65. In Figure 3, the thermal overload (heater) is designated by the letter _____.

(a) C
(b) D
(c) E
(d) F

Notes

PART 1 ELECTRICAL THEORY ANSWER KEY

1. (a) True
2. (a) True
3. (b) False
4. (b) False
5. (b) False
6. (b) False
7. (a) True
8. (a) True
9. (a) True
10. (d) 30,000° F
11. (a) True
12. (d) magnetic
13. (d) resistance
14. (d) resistance
15. (d) magnetic
16. (b) rotor
17. (b) False
18. (a) True
19. (a) True
20. (a) True
21. (b) False
22. (b) False
23. (c) 6.40V

    $E = I \times R$

    E = 16A x 0.40 ohms

    E = 6.40V
24. (a) 0.14 ohms

    $R = E/I$

    R = 7.20V/50A

    R = 0.14 ohms
25. (a) 175W

    $P = I \times E$

    P = 24A x 7.20V

    P = 172.80W
26. (a) 8.20 kW

    The power of the heat strip will be less because the applied voltage (208V) is less than the equipment voltage rating (230V). To calculate this, we must determine the heat strip resistance rating at 230V, and then determine the power rating at 208V based on the heat strip resistance rating.

    $P = E^2/R$

    E =Applied Voltage = 208V

    R = Resistance of Heat Strip = E^2/P

    Heat Strip Voltage Rating = 230V

    Power Rating of Heat Strip = 10,000W

    Resistance of Heat Strip = $230V^2/10,000W$

    Resistance of Heat Strip = 5.29 ohms

    $P = E^2/R$

    P = (208V x 208V)/5.29 ohms

    P = 43,624/5.29 ohms

    P = 8,178W/1,000

    P = 8.20 kW
27. (d) a and b
28. (b) 100W

    $P = I^2 \times R$

    I = 16A

    R = 0.40 ohms

    P = (16A x 16A) x 0.40 ohms

    P = 102.40W

29. (a) 43W

P = I x E
I = 12A
E = 120V x 3%
E = 3.60V
P = 12A x 3.60V
P = 43.20W

30. (c) $70

Cost per Year = Power for the Year in kWh x $0.08
Power per Hour = I^2 x R
I = 16A
R = 0.40 ohms

Power per Hour = (16A x 16A) x 0.40 ohms
Power per Hour = 102.40W
Power for the Year in kWh = (102.40W x 24 hours x 365 days)/1,000
Power for the Year in kWh = 897 kWh

Cost per Year = 897 kWh x $0.08
Cost per Year = $71.76

31. (a) 2.50 kW

The power of the heat strip will be less because the applied voltage (115V) is less than the equipment voltage rating (230V). To calculate this, we must determine the heat strip resistance rating at 230V, and then determine the power rating at 115V based on the heat strip resistance rating.

$P = E^2/R$
E = Applied Voltage = 115V
R = Resistance of Heat Strip = E^2/P
Heat Strip Voltage Rating = 230V

Power Rating of Heat Strip = 10,000W
Resistance of Heat Strip = $230V^2/10,000W$
Resistance of Heat Strip = 5.29 ohms

$P = E^2/R$
P = 13,225/5.29 ohms
P = 2,500W/1,000 = 2.50 kW

Note: Power changes with the square of the voltage. If the voltage is reduced to 50%, then the power consumed will be equal to the new voltage percent² or 50%², or 10,000 x (0.50 x 0.50 = 0.25 = 25%) = 2,500W = 2.50 kW.

32. (a) True
33. (a) True
34. (d) the same
35. (a) True
36. (d) any of these
37. (a) True
38. (a) 0
39. (a) True
40. (a) True
41. (d) b and c
42. (b) grounded
43. (a) True
44. (b) False
45. (a) True
46. (b) premises
47. (d) all of these
48. (d) all of these
49. (b) False
50. (c) thermo
51. (d) b or c
52. (a) True
53. (d) all of these
54. (d) all of these
55. (a) True
56. (a) True
57. (b) short-circuit
58. (d) a and b
59. (b) False
60. (a) True
61. (a) True
62. (c) 5,000 and 15,000° F
63. (a) True
64. (a) True
65. (d) nonlinear
66. (c) voltage
67. (a) times 0.707
68. (a) True
69. (a) X_C
70. (d) all of these

71. (d) all of these
72. (d) skin effect
73. (c) impedance
74. (c) Z
75. (a) X_L
76. (b) False
77. (b) 25 kVA

    Transformer kVA = (Volts x Amperes)/1,000
    Transformer kVA = (240V x 100A)/1,000
    Transformer kVA = 24

    Note: The power factor value given in the question has nothing to do with determining the kVA of a load.

78. (c) 7 circuits

    VA per Circuit = Volts x Amperes
    VA per Circuit = 120V x 20A
    VA per Circuit = 2,400 VA

    VA per Luminaire = Watts/Power Factor
    VA per Luminaire = 300W/0.85 PF
    VA per Luminaire = 353 VA

    Lights per Circuit = 2,400 VA/353 VA = 6.80
    Lights per Circuit = 6
    Circuits = 42 luminaires/6 per circuit
    Circuits = 7

79. (b) 15A

    Input Watts = Output Watts/Efficiency
    Input = 1,600W/0.88 Eff
    Input = 1,818W
    Input Amperes = Watts/Volts
    Input Amperes = 1,818W/120V
    Input Amperes = 15.167A

80. (b) parallel, series
81. (b) False
82. (b) 58A

    FLA = (Motor hp x 746W)/(E x 1.732 x PF x Eff)
    FLA = (20 hp x 746W)/(208V x 1.732 x 0.9 PF x 0.80 Eff)
    FLA = 58A

83. (d) 6
84. (c) LRC
85. (a) True
86. (c) synchronous
87. (b) Universal
88. (b) two
89. (b) rotor
90. (b) 120°
91. (a) True
92. (a) True
93. (c) eddy currents
94. (c) Eddy currents
95. (d) hysteresis
96. (c) 4-wire
97. (a) True
98. (a) True
99. (c) 2:1
100. (d) kVA

Notes

PART 2

NATIONAL ELECTRICAL CODE ANSWER KEY

Question	Answer	*NEC* Section #
1.	(a)	353.12(4)
2.	(d)	513.7(A)
3.	(c)	692.6
4.	(d)	700.2 Emergency Systems Note
5.	(a)	690.32
6.	(d)	770.179(D)
7.	(a)	690.4(D)
8.	(c)	430.111(B)(3)
9.	(b)	110.13(B)
10.	(d)	690.18
11.	(d)	310.10(H)(1) Ex 1(a), (b), and (c)
12.	(d)	392.100(C), (D), and (E)
13.	(b)	620.91(C) and 620.51
14.	(b)	800.179(B)
15.	(d)	348.30(A) Ex 2
16.	(d)	310.15(B)(4)
17.	(d)	460.2(B)
18.	(d)	390.8
19.	(a)	322.56(B)
20.	(a)	630.11(A)
21.	(b)	230.95(C) Note 2
22.	(c)	690.9(B)
23.	(d)	517.35(A)
24.	(b)	215.2(A)(3)
25.	(c)	100 Device
26.	(b)	410.160.
27.	(d)	690.2 Inverter
28.	(c)	422.11(C)
29.	(d)	240.21(B)(2)(1), (2), and (3)
30.	(c)	513.7(C)
31.	(c)	690.48
32.	(d)	424.22(B)
33.	(d)	408.18(A)
34.	(d)	701.12(B)(1), (2), (3), and (3) Ex
35.	(a)	550.33(A)(2) EX
36.	(d)	362.120.
37.	(a)	675.2 Irrigation Machine
38.	(b)	647.1
39.	(d)	513.3(D)
40.	(a)	Chapter 9, Notes to Tables, Note 9
41.	(b)	353.20(A) and (B)
42.	(d)	324.41
43.	(a)	690.8(A)(2)
44.	(a)	388.21
45.	(c)	690.8(A)(3)
46.	(c)	100 Cutout Box
47.	(b)	690.10(E)
48.	(b)	760.51(A)
49.	(b)	390.9
50.	(d)	430.40.
51.	(c)	424.91 Heating Panel
52.	(a)	520.2 Performance Area
53.	(b)	450.42
54.	(a)	760.48(B)
55.	(d)	760.49(C)
56.	(c)	430.24(1), (2), (3), and (4)
57.	(d)	720.4
58.	(d)	332.24(2)

Question	Answer	*NEC* Section #
59.	(d)	830.44(A)(1) and (2), and 830.44(B)
60.	(c)	372.5
61.	(d)	690.31(G)(3)(1),(2), and (3)
62.	(d)	250.68(C)(1) Ex
63.	(d)	353.100.
64.	(b)	410.54(B); See 402.6
65.	(c)	690.13(B)
66.	(d)	692.2 Fuel Cell
67.	(d)	366.23(A), 1,000A per sq in x 1½ inch = 1,500A
68.	(a)	830.2 Abandoned Network-Powered Broadband Communications Cable
69.	(a)	332.104
70.	(a)	Chapter 9, Notes to Tables, Note 4
71.	(d)	408.36(A)
72.	(d)	647.4(B)
73.	(a)	620.12(A)(2)
74.	(a)	354.24
75.	(b)	374.6
76.	(d)	450.45(A)
77.	(a)	517.41(E)
78.	(d)	550.13(D)(1)
79.	(d)	354.10(1), (2), and (3)
80.	(d)	701.6(A), (B), and (C)
81.	(c)	460.28(A)
82.	(b)	700.21
83.	(a)	690.5(B)(1) and (2)
84.	(c)	770.93(B)
85.	(b)	625.15(B)
86.	(b)	455.8(A)
87.	(a)	210.7
88.	(a)	110.14(B)
89.	(a)	690.31(B)
90.	(c)	690.2 Blocking Diode
91.	(b)	690.46
92.	(a)	332.24
93.	(d)	404.13(A)
94.	(a)	690.47(B)
95.	(b)	690.9(E)
96.	(a)	450.46
97.	(c)	408.17
98.	(b)	660.2 Mobile
99.	(b)	378.44
100.	(a)	705.12(D)(3)

PART 3 ELECTRICAL CALCULATIONS ANSWER KEY

Note: The calculations are shown immediately following the answers. Methods other than the ones we used may be correct in some cases. If you used a different method of calculation to come up with the same answer, it's probably okay.

1. (b) 1.50A

   Input Watts = Output Watts/Efficiency
   Input Watts = 160W/0.88 efficiency = 182W

   Input Amperes = Watts/Volts
   Input Amperes = 182W/120V = 1.50A

2. (a) 970W

   Output Watts = Input Watts x Efficiency
   Output Watts = 1,000W x 0.97 Eff = 970W

3. (a) 2

   Step 1: Area of the conductors [Chapter 9, Table 5]

   3 – 3/0 THHN: 0.2679 sq in. x 3 = 0.8037 sq in.
   1 – 2 THHN: 0.1158 sq in. x 1 = 0.1158 sq in.
   1 – 6 THHN: 0.0507 sq in. x 1 = 0.0507 sq in.

   Step 2: Total square inch area of the conductors: 0.9702 sq in.

   Step 3: Permitted conductor fill at 40% fill

   [Chapter 9, Table 1 and Chapter 9, Table 4]
   Trade size 2 Schedule 40 PVC area = 1.15 sq in.

4. (a) 1½

   Step 1: Find the square inch area of the conductors, Chapter 9, Table 5.

   3 – 4/0 THHN: 0.3237 sq in. x 3 = 0.9711 sq in.
   1 – 1/0 THHN: 0.1855 sq in. x 1 = 0.1855 sq in.
   1 – 4 THHN: 0.0824 sq in. x 1 = 0.0824 sq in.

   Step 2: Total square inch area of the conductors: 1.239 sq in.

   Step 3: Size the conduit at 60% fill [Chapter 9, Table 4, Note 3]

   Trade size 1¼: 0.916 sq in.—Too Small
   Trade size 1½: 1.243 sq in.—Just Right
   Trade size 2: 2.045 sq in.—Larger than needed

5. (b) 136A

   1/0 THHN is rated 170A at 90°C

   Ampacity = Table Ampacity x Adjustment Factor of 80% [Table 310.15(B)(3)(a)]

   Ampacity = 170A x 0.80 = 136A

6. (c) 10 THHN

   The conductors must have an ampacity of 21A and must be protected by the 30A overcurrent device. 240.4(D) requires a 10 AWG wire for a 30A overcurrent device. The adjustment factor is 70% [Table 310.15(B)(3)(a)].

   Ampacity = Table Ampacity x Adjustment Factor

   14 THHN – 25A x 0.70 = 17.50A
   12 THHN – 30A x 0.70 = 21A
   10 THHN – 40A x 0.70 = 28A

7. (b) 25A

10 THHN is rated 40A at 90°C

Ampacity = Ampacity x Temperature x Bundle Adjustment

Temperature Adjustment = 0.91 [Table 310.15(B)(2)(a)]
Bundle Adjustment = 0.70 [Table 310.15(B)(3)(a)]
Ampacity = 40A x 0.91x 0.70 = 25.48A

8. (b) 0.025 ohms, [Chapter 9, Table 9]

0.25 ohms/1,000 ft x 100 ft = 0.025 ohms

9. (a) 0.05 ohms, [Chapter 9, Table 9]

1 AWG ohms-to-neutral resistance per 1,000 ft = 0.25 ohms
0.25/1,000 ft x 200 ft = 0.05 ohms

Note: You must double the distance to include the resistance in both conductors.

10. (b) 2 AWG, [Chapter 9, Table 9]

1/0 AWG aluminum in a steel raceway has a resistance of 0.20 ohms; a 2 AWG copper conductor can be used because its ohms-to-neutral resistance is also 0.20 ohms. The ampacity of 2 THHN copper is 130A at 75°C, Table 310.15(B)(16).

11. (d) 9.50V

VD = (2 x K x I x D)/Cmil
K = 12.90 ohms, copper
I = 24A
D = 160 ft
Cmil = 10,380 [Chapter 9, Table 8]
VD = 2 x 12.90 ohms x 24A x 160 ft/10,380 Cmil
VD = 9.50V

12. (c) 4.40V

VD = (1.732 x K x I x D)/Cmil
K = 21.20 ohms, aluminum
I = P/(E x 1.732)
I = 36,000 VA/(208V x 1.732) = 100A
D = 100 ft
Cmil = 83,690 [Chapter 9, Table 8]
VD = (1.732 x 21.20 ohms x 100A x 100 ft)/83,690 Cmil
VD = 4.39V

13. (d) 3 AWG

Cmil = (2 x K x I x D)/VD
K = 12.90 ohms, copper
I = 52A, use the nameplate FLA, not FLC
D = 110 ft
VD = (115V x 0.03) [210.19(A)(1) Note 4]
VD = 3.45V
Cmil = (2 x 12.90 ohms x 52A x 110 ft)/3.45V
Cmil = 42,776
Chapter 9, Table 8 = 3 AWG

14. (b) 8 AWG

Cmil = (2 x K x I x D)/VD
K = 12.90 ohms, copper
I = 26A at 230V
D = 110 ft
VD = 230V x 0.03 [210.19(A)(1) Note 4]
VD = 6.90V
Cmil = (2 x 12.90 ohms x 26A x 110 ft)/6.90V
Cmil = 10,694
Chapter 9, Table 8 = 8 AWG

15. (d) 125A

10 hp, 230V single-phase motor FLC = 50A [Table 430.248]
The motor branch-circuit protection device must not be greater than 250% of the motor FLC. [430.52(C)(1) Ex 1, Table 430.52]
Branch protection must not exceed: 50A x 2.50 = 125A

16. (c) 700A

FLC = 425A [Table 430.247]

The branch-circuit protection device must not be greater than 150% of the motor FLC [Table 430.52].

Branch protection must not exceed: 425A x 1.50 = 637.50A, but 430.52(C)(1) Ex 1 permits the next size up, 700A.

17. (c) 4/0 AWG
[430.24(A) and Table 310.15(B)(16)]

The feeder conductor must be sized not less than 125% of the largest motor FLC, plus 100% of the FLCs of all other motors on the same line.

Motor FLCs—Tables 430.248 and 430.250
15 hp, 208V, three-phase = 46.20A
3 hp, 208V, single-phase = 18.70A
1 hp, 115V = 16A

	L1	L2	L3
3 – 15 hp, three-phase	46.20	46.20	46.20
	46.20	46.20	46.20
	46.20	46.20	46.20
3 – 3 hp, 208V	18.70	18.70	
		18.70	18.70
	18.70		18.70
3 – 1 hp, 115V	16.00	16.00	16.00
	192.00	192.00	192.00

Feeder conductors must not be less than:
(46.20A x 1.25) + 46.20A + 46.20A + 18.70A + 18.70A + 16A = 203.55A

4/0 THHN is rated 230A at 75°C

Note: 3/0 THHN is only rated for 200A at 75°C

18. (b) 175A, [240.6(A), 430.62, and Table 430.52]

Feeder protection must be sized not greater than the largest branch-circuit protection device plus the FLCs of all other motors on the same line. Branch-circuit protection devices must not be greater than the values of Table 430.52, except as permitted by 430.52(C)(1) Ex 1.
Motor 1 = 40 hp, 52A x 250% = 130A, Next size up, 150A (Largest Motor Protection)
Motor 2 = 20 hp, 27A
Motor 3 = 10 hp, 14A
Motor 4 = 5 hp, 7.60A
The feeder-protection device must not be greater than:
150A branch overcurrent device + 27A + 14A + 7.60A = 199A; the next size down is 175A

19. (c) 18 kW, [Table 220.55]

Column A: 3.25 kW x 12 units x 0.45 = 17.55 kW

20. (c) 20 kW, [Table 220.55]

Column B: 7 kW x 8 units x 0.36 = 20.16 kW

21. (c) 20 kW, [Table 220.55, Column C]

22. (a) 51,300 VA, [Table 220.12(A) and Table 220.42]

General Lighting		
990 sq ft x 3 VA	2,970 VA	
Small Appliance		
1,500 VA x 2	3,000 VA	
Laundry Circuit		
1,500 VA x 1	+1,500 VA	
Total Connected Load	7,470 VA x 20 =	149,400 VA
Demand Factor, Table 220.42		
Total Connected Load	149,400 VA	
First 3,000 VA at 100%	– 3,000 VA at 100%	3,000 VA
	146,400 VA	
Next 117,000 VA		
at 35% =	– 117,000 VA at 35%	40,950 VA
Remainder VA at 25%	29,400 VA at 25%	+ 7,350 VA
Total Calculated Load		51,300 VA

23. (d) 240 kW

A/C FLC = 17A [Table 430.248]
A/C: 230V x 17A = 3,910 VA x 40 units = 156,400 VA, Omit [220.60]
Heat [220.15], 3,000 VA x 2 units = 6,000 x 40 units = 240,000W

24. (b) 80 kVA

Disposal	940 VA
Dishwasher	1,250 VA
Water heater	+ 4,500 VA
Calculated Load	6,690 VA

6,690 VA x 16 units = 107,040 VA x 0.75 = 80,280 VA [220.53]

25. (b) 53 kW

Calculated Load = 5 kW* x 40 units x [35% – [0.50 x (40 units – 23)]
Calculated Load = 5 kW x 40 units x [35% – 8.50%]
Calculated Load = 5 kW x 40 units x 26.50%
Calculated Load = 53 kW [Table 220.54]
*The minimum load is 5 kW for standard calculations.

26. (a) 58, [220.84]

Note: Use the nameplate rating.

4 kW x 60 units x 0.24 = 57.60 kW

When using the optional method, all loads are at the nameplate rating.

27. (d) 20, [210.20(A)]

The maximum load on an overcurrent device is limited to 80% of the overcurrent device rating [210.20(A)] 20A x 0.80 = 16A maximum load.

The maximum number of 0.80A continuous load luminaires permitted on a 20A circuit is:
20A x 0.80 (continuous load) = 16A/0.80A
= 20 luminaires per circuit.

20 x 0.80 (continuous load) = 16A
16A/0.80 = 20 luminaires per circuit

Note: 220.18(B) requires that we use the total ampere rating of the unit (0.80A), not the wattage of the lamps.

28. (a) 210 kVA, [220.88]

Table 220.88 permitted load calculation is 50%
(amount of kVA over 325) + 172.5 kVA

400 kVA
–325 kVA
75 kVA x 0.50 + 172.50 kVA = 210 kVA

29. (c) 162 kVA

General Lighting	
(30,000 sq ft x 3.50 VA x 1.25)	131,250 VA
General-Use Receptacles:	
30,000 VA x 1 VA per sq ft	+30,000 VA
[220.14(K) and Table 220.12]	161,250 VA

161,250 VA/1,000 = 161.25 kVA [Table 220.42]

30. (c) 745A, [220.61]

Total feeder load is 1,450A	
Phase-to-phase loads 600A at 0%:	0A
Discharge lighting 300A at 100%: 300A x 1.00 =	300A
First 200A of the 550A at 100%: 200A x 1.00 =	200A
Remainder of the 550A at 70%: 350A x 0.70 =	245A
Total Neutral Calculated Load	745A

31. (b) 630A, [555.12 and Table 555.12]

Step 1: Determine the total connected receptacle ratings.

20 receptacles rated 20A (20 x 20A)	400A
17 receptacles rated 30A (17 x 30A)	510A
7 receptacles rated 50A (7 x 50A)	+ 350A
Total connected receptacle rating	1,260A

Step 2: Determine the demand factor from Table 555.12, which is 50% for 44 receptacles.

Step 3: Determine the calculated load.
1,260A x 0.50 = 630A

32. (c) 264 kVA, [550.31 and Table 550.31]

The calculation is based on 16,000 VA

Step 1: Determine the total connected load.
75 sites x 16,000 VA = 1,200,000 VA

Step 2: Determine the demand factor [Table 550.31].
22%

Step 3: Determine the total calculated load.
1,200,000 VA x 0.22 = 264,000 VA
264,000 VA/1,000 = 264 kVA

33. (a) 202 kVA

Step 1: Determine the general lighting calculated load.

[220.12 and 220.42]

40 units x 300 sq ft			
x 2 VA =	24,000 VA		
First 20,000 VA			
at 50%:	– 20,000 VA	x 0.50	10,000 VA
Remainder			
at 40%:	4,000 VA	x 0.40	1,600 VA
Total general lighting calculated load			

Step 2: Determine the A/C vs. Heat load [220.60]

Air-conditioning, 3 kW, omit it because it's smaller than the heat
Heat, 4 kVA
x 40 units = 160 kVA x 1,000 = 160,000 VA

Step 3: One water heater per 2 units.

40 units/2 = 20 water heaters
20 water heaters x 1,500 VA = + 30,000 VA
Total Calculated Load 201,600 VA

34. (a) 83 kVA, [551.71, 551.73(A), and Table 551.73]

Note: A minimum of 70% of the sites must have a 30/20A facility (3,600 VA per site).

Note: A minimum of 20% of the sites must be equipped with a 50A facility.

Step 1: Determine the total connected load:

9 sites at 50A (9 sites x 9,600 VA)	86,400 VA
30 sites at 30A (20 sites x 3,600 VA)	108,000 VA
3 sites at 20A (3 sites x 2,400 VA)	+ 7,200 VA
Total Connected Load	201,600 VA

Step 2: Determine demand factor [Table 551.73].\
41%

Step 3: Determine calculated load.
201,600 VA x 0.41 = 82,656 VA/1,000
82,656 VA/1,000 = 83 kVA

35. (d) 135 kVA, [220.86 and Table 220.86]

Step 1: Determine the average VA per sq ft.
160,000 VA/20,000 sq ft = 8 VA

Step 2: Determine the calculated VA per sq ft.

Total VA per sq ft	8.00 VA		
First 3 VA at 100%	–3.00 VA	x 1.00 =	3.00 VA
Next 17 VA at 75%	5.00 VA	x 0.75 =	+3.75 VA
Net computed VA per sq ft			6.75 VA

Step 3: Determine the total calculated load.

6.75 VA x 20,000 sq ft = 135,000 VA
135,000 VA/1,000 = 135 kVA

36. (d) 30A

40A x 0.71 = 28.40A, 10 AWG is rated 30A at 60°C [630.11(A), Table 310.15(B)(16) and Table 630.11(A)]

37. (d) 1/0 AWG

Welder 1: 50A x 0.71 = 35.50A x 100% =	35.50A
Welder 2: 50A x 0.71 = 35.50A x 100% =	35.50A
Welder 3: 50A x 0.71 = 35.50A x 85% =	30.18A
Welder 4: 50A x 0.71 = 35.50A x 70% =	24.85A
Welder 5: 50A x 0.71 = 35.50A x 60% =	21.30A
Total Calculated Load	147.33A

[630.11(A) and 630.11(B)]
Conductor size from Table 310.15(B)(16) is 1/0 AWG, rated 150A at 75°C

38. (d) 70A

10 AWG at 75°C is rated 35A [Table 310.15(B)(16)]
35A x 2 = 70A maximum overcurrent device size [630.12(B)]

39. (a) 8 AWG

50A x 0.71 = 25.50A [630.31(A)(2) and Table 630.31(A)(2)]
8 AWG is rated 50A at 75°C [Table 310.15(B)(16)]

40. (d) 1 AWG

Conductor size from Table 310.15(B)(16) is 1 AWG, rated 130A at 75°C

Welder 1: 50A x 0.71 = 35.50A x 100% =	35.50A
Welder 2: 50A x 0.71 = 35.50A x 60% =	21.30A
Welder 3: 50A x 0.71 = 35.50A x 60% =	21.30A
Welder 4: 50A x 0.71 = 35.50A x 60% =	21.30A
Welder 5: 50A x 0.71 = 35.50A x 60% =	21.30A
Total Calculated Load	120.70A

[630.31(B)]

1 AWG is rated at 75°C 130A [Table 310.15(B)(16)]

41. (d) 170 kVA

Connected Load	300 kVA
First 200 kVA at 80%	160 kVA
201-325 kVA at 10%	+ 10 kVA
Total Calculated Load	170 kVA

42. (d) all of these

	Line 1	Line 2	Line 3	Load
18 kVA, 208V, three-phase	6.00 kVA	6.00 kVA	6.00 kVA	18 kVA
5 kVA, 208V, single-phase	2.50 kVA	2.50 kVA		5 kVA
5 kVA, 208V, single-phase		2.50 kVA	2.50 kVA	5 kVA
(3) 2 kVA, 120V, single-phase	4.00 kVA*		2.00 kVA*	6 kVA
	12.50 kVA	11.00 kVA	10.50 kVA	34 kVA

**Indicates neutral load*

43. (b) 4A

I Line = 750 VA/480V = 1.56A
1.56A x 3.00 = 4.68A, use 4A, [240.6(A) and Table 450.3(B)]

(The Note 1 provision for rounding only applies for primary currents over 9A)

44. (c) 13A

I Line= 2,000 VA/240V = 8.33A
8.33 x 1.67 = 13.92A, use 13A, [240.6(A) and Table 450.3(B)]

(The Note 1 provision for rounding only applies for primary currents over 9A)

45. (b) 90A

Primary Current

I = VA/(E x 1.732)
I = 75,000 VA/(480V x 1.732)
I = 90A

46. (b) 54A

$I_{Line} = VA_{Line}/(E_{Line} \times 1.732)$
I = 45,000 VA/(480V x 1.732)
I = 54A

47. (c) 108A

$I_{Line} = VA_{Line}/(E_{Line} \times 1.732)$
I = 45,000 VA/(240V x 1.732)
I = 108A

48. (b) 26A

$I_{Line} = VA_{Line}/(E_{Line} \times 1.732)$
I = 22,000 VA/(480V x 1.732) = 26A

49. (d) 61A

$I_{Line} = VA_{Line}/(E_{Line} \times 1.732)$
I = 22,000 VA/(208V x 1.732) = 61A

50. (d) 125A

I_{Line} =75,000 VA/(480V x 1.732) = 90A

90A x 1.25 = 113A, next size up 125A, [240.6(A) and Table 450.3(B), Note 1]

51. (d) 2 AWG

Step 1: Size the primary conductor at 125% of the primary current rating.

I Line =75,000 VA/(480V x 1.732) = 90A

90A x 1.25 = 113A, 2 AWG has an ampacity of 115A at 75°C [110.14(C)(1) and Table 310.15(B)(16)]

Step 2: Verify that the conductors are protected in accordance with their ampacities [240.4].

2 AWG has an ampacity of 115A at 75°C, and it's permitted to be protected by the 125A primary overcurrent device [240.4(B)].

BASIC MOTOR CONTROLS

52. (b) 2
53. (d) all of these
54. (b) the color of the pilot light
55. (c) 1-4
56. (d) 2-3
57. (d) a and b
58. (a) L1 and L2 for both the ladder and wiring diagrams
59. (d) all of these
60. (a) A
61. (b) B
62. (b) D
63. (c) E
64. (d) G
65. (d) F