

PRACTICE EXAM 7: STATIONARY ENGINEER (ELECTRIC) SIMULATION — 100 QUESTIONS

ELECTRICAL FUNDAMENTALS (Questions 1–12)

1. Two 60-watt, 120V incandescent lamps are connected in parallel across 120V. The total circuit current drawn is?

- A. 0.5A
- B. 2.0A
- C. 1.0A
- D. 4.0A

2. The unit of electrical charge is the?

- A. Ampere
- B. Volt
- C. Coulomb
- D. Joule

3. In a purely resistive circuit, increasing the applied voltage while keeping resistance constant will?

- A. Decrease power consumption

- B. Increase both current and power consumption
- C. Increase current but not power
- D. Have no effect on current

4. Which of the following components opposes a change in current in an AC circuit?

- A. Resistor
- B. Inductor
- C. Capacitor
- D. Diode

5. The average value of a full-wave rectified sine wave is approximately what percentage of its peak value?

- A. 70.7%
- B. 63.7%
- C. 50.0%
- D. 100%

6. A 480V, single-phase transformer secondary delivers 50A. The secondary apparent power is?

- A. 24,000 VA
- B. 9.6 VA
- C. 240 VA
- D. 48,000 VA

7. Which of the following describes the behavior of a capacitor when DC is applied after it is fully charged?

- A. It continuously passes DC current

- B. It discharges immediately and remains uncharged
- C. It blocks further DC current flow — acting as an open circuit
- D. It converts DC to AC internally

8. The relationship between power (P), voltage (V), and resistance (R) can be expressed as?

- A. $P = V \div R$
- B. $P = R \div V^2$
- C. $P = V \times R$
- D. $P = V^2 \div R$

9. A 60 Hz AC circuit has a period of approximately?

- A. 60 seconds
- B. 16.7 milliseconds
- C. 0.60 seconds
- D. 1.67 seconds

10. In a series RLC circuit at resonance, the impedance is?

- A. Maximum — equal to $R + X_L + X_C$
- B. Minimum — equal to R only
- C. Zero
- D. Equal to X_L only

11. Which of the following best describes a transformer with a turns ratio of 1:1?

- A. An isolation transformer — passes voltage unchanged while providing electrical isolation

- B. A step-up transformer doubling the voltage
- C. A step-down transformer halving the voltage
- D. An autotransformer with no secondary winding

12. The power factor angle θ is the angle between?

- A. The voltage waveform and the current waveform at the source
- B. The phase voltages in a three-phase system
- C. The voltage and current phasors in an AC circuit
- D. The primary and secondary voltages of a transformer

WIRING, CONDUCTORS, AND PROTECTIVE DEVICES (Questions 13–22)

13. A 15-ampere, 120V branch circuit requires a minimum conductor size of?

- A. 14 AWG copper
- B. 12 AWG copper
- C. 10 AWG copper
- D. 16 AWG copper

14. The NEC requires that all 15A and 20A, 125V receptacles in bathrooms, garages, and outdoors be protected by?

- A. AFCI breakers
- B. Surge protective devices (SPDs)
- C. Thermal-magnetic circuit breakers
- D. GFCI devices

15. Which of the following best describes a busway (bus duct) system?

- A. A flexible conduit system used for motor connections
- B. A factory-assembled enclosed system of conductors for power distribution with tap-off capability
- C. An underground duct bank for medium-voltage cable
- D. A weatherproof raceway for outdoor feeder installation

16. Type XHHW-2 conductor insulation is rated for?

- A. 60°C wet and dry locations
- B. 90°C wet and dry locations
- C. 75°C wet and dry locations
- D. 105°C dry locations only

17. The NEC requires that service entrance conductors be protected from physical damage. Above a roof with limited slope, service drop conductors must maintain a minimum clearance of?

- A. 3 feet
- B. 6 feet
- C. 10 feet
- D. 8 feet

18. Which of the following is the correct wire color for a phase conductor in a 480V three-phase system per common industry practice?

- A. White

- B. Brown, Orange, or Yellow
- C. Green
- D. Gray

19. A 100A panel is fed by a 100A feeder breaker. The feeder conductors between the main panel and the sub-panel must be sized to carry at least?

- A. 80A continuously
- B. 100A continuously with no derating required
- C. 125A to account for continuous load requirements
- D. 115A with standard ampacity correction

20. The purpose of a grounded conductor (neutral) in a 120/240V single-phase three-wire system is to?

- A. Carry fault current during ground faults only
- B. Provide the equipment grounding path for safety
- C. Serve as the return path for 120V loads and stabilize the midpoint voltage
- D. Connect the service to the utility transformer

21. A main bonding jumper connects the neutral to the equipment grounding conductor at the service. This connection must be made?

- A. At the service equipment — the first disconnect after the meter
- B. At every panel in the building
- C. At the utility transformer secondary terminals
- D. At the grounding electrode only

22. The NEC's definition of a "feeder" is?

- A. All circuit conductors between the service equipment or source of a separately derived system and the final branch circuit overcurrent device
- B. The conductor running from the utility pole to the service entrance
- C. Any conductor carrying more than 20 amperes
- D. The conductors between the main breaker and the meter socket

POWER DISTRIBUTION AND HIGH-TENSION SYSTEMS (Questions 23–32)

23. A delta-connected transformer bank has one transformer fail (open). The remaining two transformers can still supply three-phase power in what configuration?

- A. Open-wye
- B. Closed-delta with reduced capacity
- C. Open-delta (V-V connection) at approximately 57.7% of the original kVA capacity
- D. Single-phase only

24. In a high-resistance grounded (HRG) system, the neutral is connected to ground through a resistor sized to limit ground fault current to?

- A. 5–10 amperes
- B. 25–50 amperes
- C. 100 amperes
- D. Less than 1–5 amperes

25. The purpose of potential transformers (PTs) in a metering and protection system is to?

- A. Step up voltage for transmission purposes
- B. Step down high system voltage to a safe 120V secondary for metering and relay inputs
- C. Provide DC voltage for control power

D. Regulate voltage at distribution panels

26. In switchgear, the term "draw-out" refers to?

- A. The process of manually tripping a circuit breaker under load
- B. A design where circuit breaker modules can be physically withdrawn from the switchgear lineup without de-energizing the main bus
- C. The arc-drawing capability of high-voltage contactors
- D. The process of testing breakers at the factory before shipment

27. A substation bus rated 2,000A is connected to four identical 500A feeders. If one feeder draws 400A, the second draws 350A, the third draws 300A, and the fourth draws 250A, the bus current is?

- A. 250A
- B. 1,300A
- C. 2,000A
- D. 500A

28. Which type of grounding system is most commonly used in commercial building 480/277V distribution?

- A. Solidly grounded wye
- B. Ungrounded delta
- C. High-resistance grounded wye
- D. Corner-grounded delta

29. The available fault current decreases as distance from the transformer increases because?

- A. The impedance of the conductors between the transformer and the fault location adds to the total circuit impedance, limiting fault current
- B. The voltage decreases with distance under fault conditions
- C. Protective relays limit fault current on long feeders
- D. The transformer regulates output to limit fault current

30. The purpose of an automatic transfer switch (ATS) in an emergency power system is to?

- A. Regulate generator output voltage during transfer
- B. Automatically transfer the critical load from normal power to the emergency generator upon loss of normal power
- C. Synchronize the emergency generator to the utility before transferring load
- D. Limit generator load to its rated capacity during transfer

31. A power transformer nameplate shows "OA/FA" ratings. This indicates?

- A. The transformer has dual primary voltage capability
- B. The transformer has two separate secondary windings
- C. The transformer is suitable for both indoor and outdoor installation
- D. The transformer has two ratings — one for oil-cooled (natural convection) and one for forced air cooling

32. Selective coordination in a distribution system requires that for any fault condition, the device that opens is?

- A. The nearest overcurrent device upstream of the fault — all others remain closed
- B. All overcurrent devices simultaneously

- C. The main breaker only, regardless of fault location
- D. The device with the highest ampere rating

GENERATORS, MOTORS, AND MOTOR CONTROL (Questions 33–44)

33. An emergency diesel generator's wet stacking is caused by?

- A. Prolonged operation at light load — unburned fuel and oil accumulate in the exhaust system
- B. Water contamination in the fuel system
- C. Coolant leaking into the exhaust manifold
- D. Excessive oil pressure forcing oil past the piston rings

34. The purpose of a power factor relay (ANSI Function 55) on a synchronous generator is to?

- A. Control output voltage regulation
- B. Detect motoring condition or out-of-step operation
- C. Measure real power output only
- D. Protect against reverse current flow

35. When testing a motor with a clamp-on ammeter, you find that one phase current is significantly lower than the other two. The most likely cause is?

- A. Motor running below full load
- B. Overloaded driven equipment
- C. A high-resistance connection in that phase circuit
- D. Incorrect overload relay setting

36. In a DC compound motor, the series field winding is connected?

- A. In series with the armature circuit
- B. Across the supply voltage in parallel with the shunt field
- C. In series with the shunt field winding only
- D. Between the armature and the commutator

37. A motor soft starter reduces starting current by?

- A. Gradually increasing the voltage applied to the motor stator during acceleration
- B. Inserting resistance in series with the motor windings
- C. Reducing supply frequency during starting
- D. Switching the stator from delta to wye during acceleration

38. The purpose of a dynamic braking resistor in a VFD application is to?

- A. Limit motor starting current during acceleration
- B. Provide emergency mechanical braking on power failure
- C. Regulate motor speed during normal operation
- D. Dissipate the regenerative energy from decelerating loads as heat when the drive cannot feed it back to the supply

39. An induction motor's synchronous speed at 60 Hz with 4 poles is?

- A. 1,800 RPM
- B. 3,600 RPM

- C. 900 RPM
- D. 1,200 RPM

40. The purpose of a motor starter's holding contact (seal-in contact) is to?

- A. Maintain the contactor coil energized after the start button is released
- B. Prevent the motor from starting until conditions are correct
- C. Protect the motor from voltage surges during starting
- D. Monitor motor current during operation

41. Which motor nameplate parameter is used to calculate the motor's full-load speed?

- A. Service factor
- B. Power factor
- C. Synchronous speed minus rated slip
- D. Motor frame size

42. An energy-efficient motor (NEMA Premium) compared to a standard-efficiency motor of the same horsepower will have?

- A. Lower starting torque
- B. Higher starting current
- C. Lower power factor at full load
- D. Lower operating temperature and reduced energy cost over its service life

43. The purpose of a contactor versus a relay in motor control is that a contactor?

- A. Is designed for high-current load switching with arc suppression capability for motor loads
- B. Provides overload protection for the motor
- C. Monitors motor temperature and trips on overload
- D. Provides time-delayed starting sequences only

44. A variable frequency drive (VFD) provides which of the following energy-saving benefits on a centrifugal pump application?

- A. Eliminates the need for mechanical seals on the pump
- B. Reduces maintenance intervals on the pump motor
- C. Allows the pump to operate at reduced speed to match actual system demand, dramatically reducing power consumption per the affinity laws
- D. Increases pump efficiency at all flow rates equally

ELECTRICAL TESTING, TROUBLESHOOTING, AND MAINTENANCE (Questions 45–54)

45. The polarization index (PI) of a motor winding is calculated as the ratio of?

- A. The 10-minute insulation resistance reading divided by the 1-minute reading
- B. The 1-minute reading divided by the 30-second reading
- C. The maximum resistance divided by minimum resistance over the test period
- D. The DC test voltage divided by the measured leakage current

46. A circuit breaker trip unit is found to have a damaged bimetallic element. This will affect the breaker's?

- A. Instantaneous trip function only
- B. Interrupting rating under short circuit conditions
- C. Arc quenching capability

D. Time-delay (thermal) trip function for overloads

47. During an infrared scan of a three-phase motor terminal box, one terminal connection is significantly cooler than the others. This typically indicates?

- A. That terminal is carrying more current than the others
- B. A loose or open connection with reduced or no current flow through it
- C. Normal temperature variation between terminals
- D. Improved connection quality compared to the other terminals

48. A fluorescent lamp that flickers continuously but does not fail to start most likely has?

- A. A failed lamp ballast
- B. A failing lamp tube approaching end of life
- C. Incorrect lamp wattage for the ballast
- D. Insufficient fixture ventilation

49. A ground fault on an ungrounded 480V delta system will?

- A. Trip the main circuit breaker immediately
- B. Blow the fuse on the affected phase immediately
- C. Cause severe equipment damage immediately
- D. Produce little or no fault current — the ground fault alarm will indicate but the system continues to operate

50. The purpose of a power quality meter's demand measurement function is to?

- A. Measure instantaneous peak current only

- B. Calculate apparent power in kVA
- C. Measure power factor continuously
- D. Record the average power demand over a defined interval for billing and load management purposes

51. When replacing a failed motor bearing in the field, the correct method for installing the new bearing onto the shaft is to?

- A. Strike the outer race directly with a hammer to drive it onto the shaft
- B. Use a bearing driver or press applying force only to the inner race when pressing onto the shaft
- C. Heat the bearing in an oil bath and drop it onto the shaft by hand
- D. Cool the bearing with dry ice before pressing onto the shaft

52. A DMM set to the diode test function reads approximately 0.65V when the test leads are placed across a silicon diode in the forward direction. This indicates?

- A. The diode is open (failed)
- B. The diode is shorted (failed)
- C. The diode is operating in reverse bias
- D. The diode is functioning normally — 0.6–0.7V is the normal forward voltage drop

53. A voltage unbalance of more than 2% at a motor terminal causes?

- A. Increased motor efficiency above rated value
- B. Reduced starting torque only, with no effect on running current
- C. Reduced motor speed permanently
- D. Disproportionately higher current unbalance (6–10 times the voltage unbalance) leading to overheating

54. The minimum acceptable polarization index (PI) value for AC motors rated above 1kV per IEEE 43 is?

- A. 2.0
- B. 1.5
- C. 1.0
- D. 4.0

MECHANICAL EQUIPMENT (Questions 55–63)

55. A gate valve in a fluid system is designed primarily for?

- A. Fully open or fully closed service — not for flow throttling
- B. Precise flow regulation in modulating control applications
- C. Check (backflow prevention) service
- D. Pressure relief applications

56. The purpose of a sight glass (liquid indicator) on a refrigerant system receiver is to?

- A. Measure refrigerant temperature in the liquid line
- B. Display system operating pressure
- C. Allow visual inspection of refrigerant flow and detection of moisture (color change of desiccant)
- D. Indicate refrigerant charge level and detect moisture in the liquid line

57. An air compressor's intercooler reduces the work of compression because?

- A. Cooler, denser air entering the second stage requires less work to compress to the final pressure

- B. The intercooler increases second-stage pressure ratio
- C. Cooling the air reduces the viscosity of the lubricating oil
- D. The intercooler removes oil from the compressed air stream

58. A diesel engine's crankshaft position sensor failure will most commonly cause?

- A. Loss of oil pressure indication only
- B. Overheating of the cooling system
- C. Engine no-start or stall condition — the ECM cannot control injection timing without position data
- D. Governor hunting and speed fluctuation

59. The vibration signature of a loose rotating component (mechanical looseness) typically shows?

- A. Vibration only at $1\times$ running speed
- B. Vibration only at sub-synchronous frequencies
- C. Vibration only at bearing defect frequencies
- D. Multiple harmonics of running speed ($1\times$, $2\times$, $3\times$, $4\times$ and higher)

60. A hydraulic pressure relief valve that is set too low will cause?

- A. Actuator stall — the system cannot develop enough pressure to move the intended load
- B. Excessive actuator speed
- C. Pump cavitation from high suction lift
- D. Bearing failure from excessive radial load on the pump shaft

61. The purpose of a centrifugal governor on a reciprocating engine is to?

- A. Regulate fuel delivery to maintain constant engine speed regardless of load changes
- B. Limit maximum engine torque output
- C. Control engine speed only during startup and shutdown
- D. Regulate coolant temperature by controlling the radiator fan speed

62. A hydraulic accumulator with a nitrogen charge of 1,000 PSI is pre-charged to 1,000 PSI with no hydraulic fluid. When the system is pressurized to 3,000 PSI, the nitrogen is compressed. If the bladder fails, the result is?

- A. The accumulator continues to function normally
- B. Loss of nitrogen pre-charge only — no effect on system pressure
- C. Immediate system depressurization through the gas charge valve
- D. Hydraulic fluid enters the nitrogen side — the accumulator loses its energy storage function

63. Which type of coupling allows for a small amount of parallel and angular misalignment between two shafts while transmitting torque?

- A. Flexible jaw (spider) coupling
- B. Rigid flange coupling
- C. Solid sleeve coupling
- D. Shrink disc coupling

FLUID SYSTEMS (Questions 64–72)

64. A boiler's safety relief valve is required to be set at or below?

- A. 110% of the boiler's maximum allowable working pressure (MAWP)
- B. 125% of the MAWP
- C. The boiler's normal operating pressure plus 10 PSI

D. The boiler's maximum allowable working pressure (MAWP)

65. The function of a steam pressure-reducing valve (PRV) in a distribution system is to?

A. Reduce high-pressure steam to a lower, controlled pressure for end-use equipment

B. Prevent steam from flowing backwards into the boiler

C. Regulate steam flow rate to match load demand

D. Remove condensate from the steam main

66. In a chilled water system using variable primary flow, pump speed is modulated to maintain?

A. Constant chiller leaving water temperature

B. A minimum differential pressure at the most remote coil

C. Constant condenser water temperature

D. Constant flow through the chiller evaporator at all times

67. The purpose of an expansion tank in a closed hydronic heating system is to?

A. Store reserve water for makeup during system losses

B. Separate air from the circulating water

C. Absorb the increase in water volume as the system heats up, maintaining system pressure within design limits

D. Regulate boiler output pressure automatically

68. A check valve installed in a pump discharge line prevents?

A. Reverse flow through the pump when it is shut down

B. The pump from exceeding its design flow rate

- C. Pressure surges from reaching the pump inlet
- D. Air from entering the discharge piping

69. In a pneumatic control system, a positioner on a control valve is used to?

- A. Ensure the valve stem position accurately corresponds to the controller output signal, overcoming friction and hysteresis
- B. Convert the pneumatic signal to a 4–20mA electrical signal
- C. Regulate the air supply pressure to the actuator
- D. Provide manual override capability during power outages

70. Which type of valve provides bidirectional flow shutoff and is suitable for throttling service in corrosive fluid applications using plastic or lined construction?

- A. Butterfly valve
- B. Gate valve
- C. Ball valve
- D. Diaphragm valve

71. A pressure gauge installed on a pump discharge reads 75 PSI. The pump suction gauge reads 10 PSI. The differential pressure across the pump is?

- A. 85 PSI
- B. 10 PSI
- C. 65 PSI
- D. 75 PSI

72. Cooling tower water treatment using biocides targets which primary biological hazard?

- A. Algae growth on tower fill only
- B. Scale-forming bacteria in the basin
- C. Sulfate-reducing bacteria in the heat exchanger
- D. Legionella pneumophila — the bacteria responsible for Legionnaires' disease

CONSTRUCTION, TOOLS, AND RIGGING (Questions 73–80)

73. The maximum angle between a sling leg and the vertical in a two-leg bridle hitch, beyond which the sling capacity must be derated, is?

- A. 60° from vertical (corresponding to a horizontal sling angle of 30°)
- B. 45° from vertical
- C. 30° from vertical
- D. 75° from vertical

74. A fish tape (snake) is used in electrical work to?

- A. Pull conductors through conduit runs
- B. Test for ground faults in conduit systems
- C. Measure conduit fill capacity
- D. Mark conduit for bending locations

75. The proper sequence for connecting a welding cable to an electrode holder and work clamp is to?

- A. Connect to the electrode holder first, then the work clamp
- B. Connect to the work clamp first, then the electrode holder

- C. Either order is acceptable — sequence does not matter
- D. Connect both ends simultaneously to prevent voltage buildup

76. Which tool is used to cut the outer jacket and insulation from large conductors during termination without nicking the conductor?

- A. Diagonal cutters (dikes)
- B. Cable insulation stripper (ringing tool)
- C. Utility knife
- D. Lineman's pliers

77. A hydraulic torque wrench is used in industrial maintenance because it?

- A. Provides precise, measurable torque to large fasteners that exceed the capacity of manual torque wrenches
- B. Can be used in energized electrical panels
- C. Eliminates the need for torque specifications on fasteners
- D. Works only on metric fasteners

78. The purpose of a cable tray system in an electrical installation is to?

- A. Support and route cables in an open, easily accessible, and expandable cable management system
- B. Provide arc flash protection for conductors during fault conditions
- C. Replace rigid conduit in all underground applications
- D. Provide EMI shielding for signal cables in industrial environments

79. When selecting wire rope for a rigging application, the designation 6×19 means?

- A. The rope has a 6-inch diameter and is 19 feet long
- B. The rope has 6 strands with 19 wires per strand
- C. The rope has 19 strands with 6 wires per strand
- D. The rope has a working load limit of 6 tons at 19 feet

80. A pneumatic impact wrench requires a minimum air supply pressure of 90 PSI at the tool inlet. If the compressor output is 120 PSI and the supply hose causes a 20 PSI drop at the required flow, the pressure at the tool is?

- A. 100 PSI — adequate for operation
- B. 120 PSI — no derating for hose losses
- C. 90 PSI — exactly at minimum
- D. 80 PSI — below minimum, inadequate

HAZARDOUS MATERIALS AND ENVIRONMENTAL COMPLIANCE (Questions 81–89)

81. A chemical with a pH of 1.5 is classified as a RCRA characteristic hazardous waste because it exhibits?

- A. Reactivity
- B. Ignitability
- C. Toxicity
- D. Corrosivity

82. The OSHA requirement for labeling secondary containers of hazardous chemicals in the workplace is?

- A. The product identifier and words, pictures, or symbols providing general hazard information
- B. The full GHS label with all six elements

- C. The SDS document number only
- D. The manufacturer's original label must be reproduced exactly

83. NYC DEP's stormwater pollution prevention plan (SWPPP) is required for facilities that?

- A. Store hazardous materials above CERCLA reportable quantities
- B. Generate more than 2,200 lbs of hazardous waste per month
- C. Discharge process wastewater to the city sewer system
- D. Disturb one or more acres of land or discharge stormwater associated with industrial activity

84. A spill of 50 gallons of diesel fuel reaches a storm drain. The facility must report this to?

- A. The EPA only — within 24 hours
- B. NYC FDNY only
- C. The facility's insurance carrier only
- D. The National Response Center (NRC) and NYC DEP immediately

85. Which OSHA standard specifically addresses respiratory protection requirements for asbestos work?

- A. 29 CFR 1910.1001 (asbestos standard) and 29 CFR 1910.134 (respiratory protection)
- B. 29 CFR 1910.146 only
- C. 29 CFR 1910.1200 only
- D. 29 CFR 1910.95 only

86. The Resource Conservation and Recovery Act (RCRA) regulates hazardous waste?

- A. Only at Superfund cleanup sites

- B. From generation through transportation, treatment, storage, and disposal — "cradle to grave"
- C. Only when transported across state lines
- D. Only at licensed treatment, storage, and disposal facilities (TSDFs)

87. A facility stores 1,500 gallons of used oil in a single aboveground tank. Under EPA 40 CFR Part 279, the facility must?

- A. Register as a hazardous waste generator
- B. Label all containers "Used Oil," prevent releases, and comply with used oil storage standards
- C. Obtain a RCRA Part B storage permit
- D. Report monthly to the EPA regional office

88. The SDS section that describes first-aid measures for skin contact, inhalation, eye contact, and ingestion is?

- A. Section 6
- B. Section 7
- C. Section 4
- D. Section 11

89. Which type of fire extinguisher agent is suitable for use on Class D (combustible metal) fires?

- A. CO₂ (carbon dioxide)
- B. Dry powder (sodium chloride or graphite-based)
- C. Dry chemical (ABC)
- D. Halon replacement agent

SAFETY, LOTO, ARC FLASH, AND EMERGENCY PROCEDURES (Questions 90–100)

90. OSHA's LOTO standard requires that all energy sources for a piece of equipment be identified in the?

- A. Written energy control procedure for that specific equipment
- B. General facility safety plan only
- C. Equipment purchase specification
- D. Manufacturer's warranty documentation

91. The arc flash hazard label required by NFPA 70E must be installed on electrical equipment?

- A. Only on equipment rated above 600V
- B. Before the equipment is put into service — not after an arc flash incident
- C. Only when the equipment has been energized for more than one year
- D. Only when a qualified person requests it

92. When a worker wears arc-rated PPE rated at 40 cal/cm² and the calculated incident energy at the working distance is 35 cal/cm², the worker is?

- A. Not adequately protected — PPE must exceed incident energy by at least 20%
- B. Adequately protected — the PPE arc rating exceeds the incident energy
- C. Overprotected — lower PPE is required by NFPA 70E
- D. Required to use additional PPE regardless of the margin

93. The OSHA permit-required confined space standard requires the employer to provide training to?

- A. Supervisors only
- B. All employees who perform permit space entry — entrants, attendants, and entry supervisors
- C. Entrants only, not attendants
- D. Only workers who enter the space — not attendants

94. Which of the following is the correct method to safely discharge a capacitor before working on equipment containing capacitors?

- A. Use a resistor-equipped discharge tool — never short the terminals directly
- B. Momentarily short the capacitor terminals with a screwdriver to discharge it
- C. Wait 30 seconds — all capacitors self-discharge within this time
- D. Remove the capacitor from the circuit before discharging it

95. A worker is struck by an arc flash blast and has burns on both hands and forearms. The correct first-aid priority after calling 911 is?

- A. Cool the burns with cool (not ice-cold) water and cover loosely with a clean non-stick dressing
- B. Apply butter or oil to the burns to soothe the tissue
- C. Remove any stuck clothing from the burned areas
- D. Wrap the burns tightly with bandages to reduce swelling

96. The purpose of the OSHA 300 Log is to?

- A. Document all employer safety training records
- B. Record work-related injuries and illnesses that meet OSHA recording criteria
- C. Report hazardous chemical inventory to the EPA
- D. Track equipment inspection and maintenance records

97. Which of the following is a requirement for the emergency action plan (EAP) under OSHA 29 CFR 1910.38?

- A. The plan must be reviewed by OSHA before implementation
- B. The plan must be certified by a licensed safety engineer

- C. The plan must be submitted to the local fire department annually
- D. The plan must include procedures for reporting emergencies, evacuation routes, and accounting for personnel

98. A worker performing switching operations on a 13.8kV switchgear lineup must wear at a minimum?

- A. Standard cotton work clothes and a hard hat
- B. Class E hard hat and voltage-rated gloves only
- C. Arc-rated FR clothing and standard safety glasses
- D. Arc-rated face shield, arc-rated clothing rated for the calculated incident energy, and voltage-rated gloves

99. Eye protection requirements for workers exposed to arc flash hazards must include a face shield with a minimum arc rating matching the?

- A. Voltage of the system being worked on
- B. Available fault current at the equipment
- C. Service factor of the largest motor in the vicinity
- D. Calculated incident energy at the working distance

100. A Stationary Engineer is required to take a specific action when they believe a safety rule or procedure is being violated by a coworker. They should?

- A. Ignore the violation if the coworker is more experienced
- B. Document the violation in the equipment log only
- C. Immediately intervene to stop the unsafe act and report it to supervision
- D. Contact OSHA anonymously before speaking to the coworker

PRACTICE EXAM 7 — ANSWER KEY AND FULL EXPLANATIONS

ELECTRICAL FUNDAMENTALS (Questions 1–12)

1. Correct Answer: C — 1.0A

Each lamp draws $I = P \div V = 60 \div 120 = 0.5\text{A}$. In a parallel circuit, total current = sum of branch currents = $0.5 + 0.5 = 1.0$ ampere. Each lamp operates at full rated voltage and wattage independently of the other.

2. Correct Answer: C — Coulomb

The coulomb is the SI unit of electrical charge — defined as the quantity of charge transported by one ampere of current in one second ($1\text{ C} = 1\text{ A} \times 1\text{ s}$). The ampere measures current (charge flow rate); the volt measures potential difference; the joule measures energy.

3. Correct Answer: B — Increase both current and power consumption

In a purely resistive circuit with constant resistance, current increases proportionally with voltage ($I = V \div R$), and power increases with the square of voltage ($P = V^2 \div R$). Both current and power increase simultaneously when voltage is raised.

4. Correct Answer: B — Inductor

An inductor stores energy in a magnetic field and opposes any change in current through it ($V = L \times di/dt$). A resistor opposes current magnitude; a capacitor opposes changes in voltage; a diode controls current direction, not change in current.

5. Correct Answer: B — 63.7%

The average value of a full-wave rectified sine wave = $(2 \div \pi) \times V_{\text{peak}} = 0.637 \times V_{\text{peak}}$, or approximately 63.7% of peak value. The RMS value is 70.7% of peak — used for power calculations, while average value is used in rectifier and DC meter applications.

6. Correct Answer: A — 24,000 VA

Apparent power = $V \times I = 480 \times 50 = 24,000\text{ VA} = 24\text{ kVA}$. This is single-phase apparent power — voltage multiplied by current gives volt-amperes regardless of power factor.

7. Correct Answer: C — It blocks further DC current flow — acting as an open circuit

Once a capacitor is fully charged to the applied DC voltage, no further current flows because the voltage across the capacitor equals the supply voltage — no potential difference drives current. A fully charged capacitor acts as an open circuit for steady-state DC.

8. Correct Answer: D — $P = V^2 \div R$

Power can be expressed as $P = V^2 \div R$ when voltage and resistance are known. This is derived by substituting $I = V \div R$ into $P = V \times I$. The three power formulas — $P = V \times I$, $P = I^2 \times R$, and $P = V^2 \div R$ — are all equivalent forms used depending on which quantities are known.

9. Correct Answer: B — 16.7 milliseconds

Period = $1 \div$ Frequency = $1 \div 60 = 0.01667$ seconds = 16.7 milliseconds. At 60 Hz, one complete AC cycle takes approximately 16.7 ms — the time from one zero crossing through the positive peak, back through zero, through the negative peak, and back to zero.

10. Correct Answer: B — Minimum — equal to R only

At resonance in a series RLC circuit, inductive reactance (X_L) equals capacitive reactance (X_C) and they cancel each other completely. The impedance reduces to the resistance R alone — its minimum value. Current is maximum at resonance for a given voltage.

11. Correct Answer: A — An isolation transformer — passes voltage unchanged while providing electrical isolation

A 1:1 transformer passes the same voltage from primary to secondary with no transformation, but provides complete galvanic isolation between the two circuits — eliminating common-mode interference, removing shock hazard paths to ground, and isolating sensitive equipment from line-conducted noise.

12. Correct Answer: C — The voltage and current phasors in an AC circuit

The power factor angle θ is the phase angle between the voltage phasor and the current phasor in an AC circuit. Power factor = $\cos \theta$ — when $\theta = 0^\circ$ (resistive), PF = 1.0; when $\theta = 90^\circ$ (purely reactive), PF = 0. The angle represents how much current and voltage are out of phase.

WIRING, CONDUCTORS, AND PROTECTIVE DEVICES (Questions 13–22)

13. Correct Answer: A — 14 AWG copper

NEC Section 210.19(A) and Table 310.15(B)(16) permit 14 AWG copper conductors on 15-ampere branch circuits. The NEC minimum ampacity table shows 14 AWG is rated for 15A at 60°C — it is the smallest conductor permitted for standard branch circuit use.

14. Correct Answer: D — GFCI devices

NEC Section 210.8 requires GFCI protection for all 15A and 20A, 125V receptacles in bathrooms, garages, outdoors, crawl spaces, unfinished basements, kitchens, boathouses, and other locations where shock hazard from water contact is elevated. AFCI protection is a separate requirement for bedroom and living area circuits.

15. Correct Answer: B — A factory-assembled enclosed system of conductors for power distribution with tap-off capability

Busway (bus duct) is a prefabricated power distribution system consisting of copper or aluminum bus bars housed in a grounded metal enclosure — available in feeder busway (no tap-offs) and plug-in busway (with tap-off points every few feet) configurations for flexible power distribution in commercial and industrial facilities.

16. Correct Answer: B — 90°C wet and dry locations

XHHW-2 insulation is rated for 90°C in both wet and dry locations — the "-2" suffix indicates the 90°C wet rating. This is one of the most versatile conductor insulation types, suitable for conduit installations in mechanical rooms, outdoor applications, and locations subject to moisture.

17. Correct Answer: D — 8 feet

NEC Table 230.24(A) requires service drop conductors above a roof to maintain a minimum clearance of 8 feet above the roof surface. Exceptions allow reduced clearance (3 feet) over a roof area with a slope of 4 inches in 12 inches or more, and 18 inches over the overhang only at the final span.

18. Correct Answer: B — Brown, Orange, or Yellow

NFPA 70B and industry practice recommend brown, orange, and yellow for the three phase conductors in 480V three-phase systems — paralleling the common utility convention. White or gray identifies the neutral; green identifies the equipment grounding conductor. These colors are not mandated by the NEC for ungrounded conductors above 120V but are widely followed in industrial practice.

19. Correct Answer: C — 125A to account for continuous load requirements

When a feeder supplies a panelboard where the load is considered continuous (3 hours or more), NEC Section 215.2(A) requires the feeder conductors to be sized at 125% of the continuous load. A 100A panel with continuous loading requires conductors and overcurrent protection rated for 125A minimum.

20. Correct Answer: C — Serve as the return path for 120V loads and stabilize the midpoint voltage

In a 120/240V single-phase three-wire system, the neutral conductor carries the unbalanced return current from 120V loads and establishes the voltage midpoint between the two 120V legs. It is not an equipment ground — the EGC provides the fault current return path for safety.

21. Correct Answer: A — At the service equipment — the first disconnect after the meter

The NEC requires the main bonding jumper to be installed at the service entrance equipment only — where the grounded neutral conductor is first connected to the equipment grounding system. Making this connection at any other point in the system (sub-panels, downstream equipment) would create objectionable neutral current on the equipment grounding conductors.

22. Correct Answer: A — All circuit conductors between the service equipment or source of a separately derived system and the final branch circuit overcurrent device

NEC Article 100 defines a feeder as all circuit conductors between the service equipment (or the source of a separately derived system) and the final branch circuit overcurrent protective device. Feeders supply panelboards, MCCs, and large equipment — distinguishing them from the branch circuits they supply.

POWER DISTRIBUTION AND HIGH-TENSION SYSTEMS (Questions 23–32)

23. Correct Answer: C — Open-delta (V-V connection) at approximately 57.7% of the original kVA capacity

When one transformer in a delta bank fails, the remaining two can supply three-phase power in an open-delta (V-connection) configuration. The capacity is reduced to 57.7% ($1 \div \sqrt{3}$) of the original three-transformer bank — useful for temporary service continuity while the failed unit is replaced.

24. Correct Answer: D — Less than 1–5 amperes

High-resistance grounded systems limit ground fault current to a very low level — typically 1–5 amperes — by connecting the neutral to ground through a high-value resistor. This allows the system to continue operating through a single ground fault while an alarm alerts maintenance personnel to locate and clear the fault.

25. Correct Answer: B — Step down high system voltage to a safe 120V secondary for metering and relay inputs

Potential transformers (PTs or VTs) step down the high system voltage (480V, 4,160V, 13,800V) to a standardized 120V secondary output that is safe for metering instruments, protective relays, and synchronizing equipment. The PT ratio is marked on the nameplate for use in calculating actual system voltage.

26. Correct Answer: B — A design where circuit breaker modules can be physically withdrawn from the switchgear lineup without de-energizing the main bus

Draw-out switchgear uses a racking mechanism that allows each breaker to be rolled from the fully connected position to a test position (disconnected from the bus but still mechanically in the cell) and then to a fully withdrawn position — enabling maintenance and testing without interrupting bus power.

27. Correct Answer: B — 1,300A

Total bus current = sum of all feeder currents = $400 + 350 + 300 + 250 = 1,300$ amperes. The bus carries the total of all currents drawn by the feeders it serves — in this case well within the 2,000A bus rating.

28. Correct Answer: A — Solidly grounded wye

The 480/277V solidly grounded wye system is the overwhelmingly dominant distribution configuration for commercial buildings because it provides a grounded neutral for 277V single-phase lighting, enables 480V three-phase power for mechanical equipment, and allows ground faults to be immediately detected and cleared by overcurrent devices.

29. Correct Answer: A — The impedance of the conductors between the transformer and the fault location adds to the total circuit impedance, limiting fault current

Available fault current = Source voltage \div Total circuit impedance. As distance increases, conductor impedance (resistance and reactance) adds to the transformer impedance in the denominator — increasing total impedance and reducing the maximum fault current available at that location.

30. Correct Answer: B — Automatically transfer the critical load from normal power to the emergency generator upon loss of normal power

An automatic transfer switch monitors the normal power source continuously. When normal power fails or falls below acceptable voltage/frequency limits, the ATS signals the generator to start, then transfers the load to the generator after it reaches rated voltage and frequency — all without manual intervention.

31. Correct Answer: D — The transformer has two ratings — one for oil-cooled (natural convection) and one for forced air cooling

ANSI cooling class designations: OA = Oil-immersed, self-cooled (natural convection); FA = Forced air cooled (fans). An OA/FA transformer has a lower rating without fans and a higher rating when the cooling fans operate — allowing a single unit to meet varying load demands.

32. Correct Answer: A — The nearest overcurrent device upstream of the fault — all others remain closed

Selective coordination ensures that for any fault, only the device immediately upstream of the fault opens, isolating only the affected portion of the system. All upstream devices remain closed, preserving power to all other loads not connected to the faulted circuit section.

GENERATORS, MOTORS, AND MOTOR CONTROL (Questions 33–44)

33. Correct Answer: A — Prolonged operation at light load — unburned fuel and oil accumulate in the exhaust system

Wet stacking occurs when a diesel generator operates for extended periods at less than 30% of rated load. Incomplete combustion allows unburned fuel, carbon, and oil to accumulate in the exhaust system,

turbocharger, and cylinders — causing power de-rating, exhaust smoke, and eventual engine damage. Load bank testing clears wet stacking.

34. Correct Answer: B — Detect motoring condition or out-of-step operation

ANSI Function 55 (power factor relay) monitors the power factor of a synchronous generator. When the generator absorbs real power from the grid (motoring condition) or loses synchronism (out-of-step), the power factor shifts into an abnormal region that the relay detects, initiating a trip to protect the machine and prime mover.

35. Correct Answer: C — A high-resistance connection in that phase circuit

One phase reading significantly lower than the other two indicates that less current is flowing in that phase — not because the load is lower (which would affect all phases equally), but because a high-resistance connection (loose terminal, corroded lug) is limiting current flow in that specific phase conductor.

36. Correct Answer: A — In series with the armature circuit

In a DC compound motor, the series field winding is connected in series with the armature — the full armature current flows through it. The shunt field winding is connected in parallel with the armature across the supply. The series field provides load-dependent torque boost; the shunt field provides the base speed regulation.

37. Correct Answer: A — Gradually increasing the voltage applied to the motor stator during acceleration

A solid-state soft starter uses SCRs (thyristors) to control the firing angle, progressively increasing the voltage applied to the motor from a reduced starting value to full voltage over the programmed ramp time. This limits inrush current and reduces mechanical shock on the driven equipment during starting.

38. Correct Answer: D — Dissipate the regenerative energy from decelerating loads as heat when the drive cannot feed it back to the supply

During deceleration, the motor acts as a generator and feeds energy back into the VFD DC bus, raising bus voltage. Without regenerative capability, a dynamic braking resistor is switched across the DC bus to absorb this energy as heat, preventing DC bus overvoltage faults that would otherwise trip the drive.

39. Correct Answer: A — 1,800 RPM

Synchronous speed = $(120 \times f) \div \text{Poles} = (120 \times 60) \div 4 = 7,200 \div 4 = 1,800$ RPM. A four-pole, 60 Hz motor has a synchronous speed of 1,800 RPM — actual running speed is slightly less due to slip, typically 1,725–1,760 RPM at full load.

40. Correct Answer: A — Maintain the contactor coil energized after the start button is released

The holding (seal-in) contact is an auxiliary contact on the contactor that closes when the contactor energizes, creating a parallel path around the momentary start button. When the start button is released,

current continues to flow through the holding contact to keep the contactor coil energized — the motor continues running until the stop button is pressed.

41. Correct Answer: C — Synchronous speed minus rated slip

Full-load speed = Synchronous speed \times (1 – slip). Slip percentage is listed on the nameplate or calculated from synchronous speed and full-load RPM. For example, a 4-pole motor with 1,750 RPM nameplate speed has a slip of $(1,800 - 1,750) \div 1,800 = 2.8\%$ at full load.

42. Correct Answer: D — Lower operating temperature and reduced energy cost over its service life

NEMA Premium efficiency motors have lower core losses, better copper fill, and improved rotor design — resulting in higher efficiency, lower operating temperature, and significantly reduced energy consumption over the motor's service life. The energy savings over 5–10 years typically far exceed the premium purchase price.

43. Correct Answer: A — Is designed for high-current load switching with arc suppression capability for motor loads

Contactors are designed specifically for repetitive switching of high-current AC loads — they have robust contacts with arc suppression horns or chambers that safely extinguish the arc drawn when interrupting motor current. Standard relays are designed for control circuit switching at much lower current levels.

44. Correct Answer: C — Allows the pump to operate at reduced speed to match actual system demand, dramatically reducing power consumption per the affinity laws

Per the pump affinity laws, power varies as the cube of speed — reducing pump speed to 80% of full speed reduces power to 51% (0.8^3). This dramatic energy reduction at partial flow is the primary economic justification for VFD installation on centrifugal pumps and fans in HVAC and process applications.

ELECTRICAL TESTING, TROUBLESHOOTING, AND MAINTENANCE (Questions 45–54)

45. Correct Answer: A — The 10-minute insulation resistance reading divided by the 1-minute reading

The Polarization Index (PI) = $R_{10 \text{ min}} \div R_{1 \text{ min}}$. Good insulation shows increasing resistance over time as the charging current decays, giving a PI above 2.0. Contaminated or deteriorated insulation shows little increase (PI near 1.0) because leakage current dominates the measurement throughout the test.

46. Correct Answer: D — Time-delay (thermal) trip function for overloads

The bimetallic element in a thermal-magnetic breaker is the thermal element — it deflects when heated by sustained overload current and initiates the time-delayed trip. A damaged bimetallic element impairs or eliminates the breaker's ability to trip on sustained overloads, while leaving the magnetic instantaneous trip function for short circuits intact.

47. Correct Answer: B — A loose or open connection with reduced or no current flow through it

A significantly cooler terminal in an infrared scan of a three-phase connection means less current is flowing through it — not more. A loose or corroded connection in that phase means the other two phases are carrying more than their share, while the high-resistance or open connection carries little or no current and generates no heat.

48. Correct Answer: B — A failing lamp tube approaching end of life

Continuous flickering in a fluorescent lamp that still starts is the characteristic sign of a lamp tube approaching end of life — the cathode emission material is depleting, causing erratic arc maintenance. A failed ballast typically causes the lamp to not start at all; an incorrect wattage lamp usually causes ballast overheating.

49. Correct Answer: D — Produce little or no fault current — the ground fault alarm will indicate but the system continues to operate

In an ungrounded delta system, there is no return path for ground fault current — the first ground fault produces essentially no fault current and the system continues to operate. A ground fault monitor (ground detector) will alarm, indicating maintenance personnel should locate and clear the fault before a second ground fault on a different phase creates a phase-to-phase fault through ground.

50. Correct Answer: D — Record the average power demand over a defined interval for billing and load management purposes

The demand measurement function integrates energy consumption over a defined interval (typically 15 or 30 minutes) and calculates the average power demand in kW or kVA. Utilities charge demand charges based on the peak demand interval recorded — monitoring demand helps facilities manage peak demand to reduce utility costs.

51. Correct Answer: B — Use a bearing driver or press applying force only to the inner race when pressing onto the shaft

When pressing a bearing onto a shaft, force must be applied only through the inner race (which is the tight fit component). Applying force through the outer race transmits it through the rolling elements, damaging the raceways and rolling elements. A bearing driver of the correct size contacts only the inner race face.

52. Correct Answer: D — The diode is functioning normally — 0.6–0.7V is the normal forward voltage drop

Silicon diodes have a forward voltage drop of approximately 0.6–0.7V — this voltage is consumed overcoming the semiconductor junction barrier. A reading of 0 (or near 0) indicates a shorted diode; an OL (overload/open) reading indicates an open diode. The 0.65V reading confirms the diode is conducting normally.

53. Correct Answer: A — Increased motor efficiency above rated value

Voltage unbalance above 2% causes current unbalance that is 6–10 times greater than the voltage unbalance percentage. This excessive current in one or more windings causes disproportionate I^2R heating, reduced torque output, vibration, and significantly reduced motor life — not improved efficiency.

54. Correct Answer: A — 2.0

IEEE Standard 43 recommends a minimum PI of 2.0 for AC motors rated above 1kV. A PI between 1.0 and 2.0 is considered questionable — the motor should be investigated further before being returned to service. A PI below 1.0 indicates definitely poor insulation condition requiring immediate attention.

MECHANICAL EQUIPMENT (Questions 55–63)

55. Correct Answer: A — Fully open or fully closed service — not for flow throttling

Gate valves are designed with a gate (wedge) that retracts completely out of the flow path when open, providing full bore flow with minimal restriction. When used for throttling (partially open), the high-velocity fluid erodes the gate and seat rapidly. Globe valves are the correct choice for throttling service.

56. Correct Answer: D — Indicate refrigerant charge level and detect moisture in the liquid line

The sight glass on a refrigerant liquid line serves two purposes: it allows visual inspection of refrigerant flow (bubbles indicate insufficient charge or a restriction upstream), and it contains a moisture indicator (desiccant) that changes color — typically from green (dry) to yellow (wet) — when moisture contamination is present.

57. Correct Answer: A — Cooler, denser air entering the second stage requires less work to compress to the final pressure

Intercooling between compression stages cools the air back toward ambient temperature, increasing its density. Denser air has more mass per unit volume, so less volumetric work is needed to achieve the final pressure — reducing total compression power compared to single-stage compression to the same final pressure.

58. Correct Answer: C — Engine no-start or stall condition — the ECM cannot control injection timing without position data

Modern diesel engines use the crankshaft position (CKP) sensor to provide the ECM with real-time shaft position data for precise fuel injection timing. Without this signal, the ECM cannot calculate when to fire each injector — the engine will not start, or will stall immediately if the sensor fails while running.

59. Correct Answer: D — Multiple harmonics of running speed (1×, 2×, 3×, 4× and higher)

Mechanical looseness — loose foundation bolts, worn bearing housings, loose rotor components — produces non-linear behavior that generates vibration energy at multiple harmonics of running speed. The

characteristic "harmonic forest" pattern in the FFT spectrum ($1\times$, $2\times$, $3\times$, $4\times\dots$) with truncated waveform time data is the diagnostic signature.

60. Correct Answer: A — Actuator stall — the system cannot develop enough pressure to move the intended load

A relief valve set too low limits the maximum pressure the hydraulic system can develop. If this maximum pressure is insufficient to overcome the load resistance, the actuator stalls — it cannot move the intended load even at full pump output, because all pump flow bypasses through the relief valve at the low setpoint pressure.

61. Correct Answer: C — Regulate fuel delivery to maintain constant engine speed regardless of load changes

The centrifugal (flyweight) governor uses rotating flyweights whose outward centrifugal force is balanced against a spring force. When load increases and engine speed drops, the flyweights move inward, mechanically increasing fuel delivery to restore speed. When load decreases and speed rises, the flyweights move outward, reducing fuel delivery.

62. Correct Answer: D — Hydraulic fluid enters the nitrogen side — the accumulator loses its energy storage function

If the bladder or diaphragm separating the nitrogen charge from the hydraulic fluid fails, hydraulic fluid fills the nitrogen side. The accumulator becomes a solid hydraulic volume with no compressibility — it loses its ability to store and release pressurized energy, and the system loses its pressure stabilization and supplemental flow capability.

63. Correct Answer: A — Flexible jaw (spider) coupling

Flexible jaw couplings (also called spider or jaw couplings) use a polyurethane or rubber spider element between two metal jaws to transmit torque while accommodating small angular and parallel misalignment, absorbing vibration, and providing some shock load protection. Rigid couplings cannot accommodate any misalignment.

FLUID SYSTEMS (Questions 64–72)

64. Correct Answer: D — The boiler's maximum allowable working pressure (MAWP)

The safety relief valve must be set at or below the boiler's MAWP — it must open before the boiler pressure can exceed the MAWP under any operating condition. Setting the relief valve above MAWP would allow the boiler to exceed its safe structural pressure limit before the valve opens.

65. Correct Answer: A — Reduce high-pressure steam to a lower, controlled pressure for end-use equipment

Steam PRVs (pressure-reducing valves) automatically modulate their opening to maintain a steady downstream pressure regardless of variations in upstream pressure or downstream flow demand. They

allow a boiler to operate at one efficient high pressure while supplying steam to equipment requiring various lower pressures.

66. Correct Answer: B — A minimum differential pressure at the most remote coil

In variable primary flow chilled water systems, pump speed is controlled to maintain a minimum differential pressure setpoint at the most hydraulically remote (critical) coil in the system. As coil control valves close at reduced load, the pump slows to maintain only enough pressure to satisfy the critical coil — saving pumping energy.

67. Correct Answer: C — Absorb the increase in water volume as the system heats up, maintaining system pressure within design limits

Water expands approximately 4% in volume as it heats from cold fill temperature to operating temperature. Without an expansion tank, this volume increase would cause the pressure relief valve to open repeatedly. The expansion tank (using a pressurized bladder or diaphragm) absorbs the expanded volume, maintaining system pressure within the design range.

68. Correct Answer: A — Reverse flow through the pump when it is shut down

A check valve on the pump discharge prevents the system water from flowing backwards through the stopped pump when other pumps in a parallel arrangement are running, or when pump discharge pressure falls below system pressure. Reverse flow through a pump can cause reverse rotation and impeller damage.

69. Correct Answer: A — Ensure the valve stem position accurately corresponds to the controller output signal, overcoming friction and hysteresis

A valve positioner is a closed-loop feedback controller that compares the actual valve stem position (measured by a position sensor) to the desired position (the controller signal) and adjusts actuator air pressure to eliminate any error. This overcomes packing friction, pressure imbalance forces, and mechanical hysteresis that would otherwise cause valve positioning errors.

70. Correct Answer: D — Diaphragm valve

Diaphragm valves use a flexible diaphragm that presses against a weir or seat to control flow — the diaphragm is the only wetted moving part. They provide bubble-tight shutoff in both directions, are suitable for throttling, and are used with corrosive, abrasive, or contaminated fluids because lined bodies and elastomeric diaphragms resist attack.

71. Correct Answer: C — 65 PSI

Differential pressure = Discharge pressure – Suction pressure = 75 – 10 = 65 PSI. This differential represents the pressure energy added to the fluid by the pump — the pump head. It is the relevant parameter for calculating pump work and verifying pump performance against the design curve.

72. Correct Answer: D — Legionella pneumophila — the bacteria responsible for Legionnaires' disease

Cooling towers are the primary environmental source of Legionella pneumophila outbreaks — the warm, nutrient-rich recirculating water at 77–113°F (25–45°C) is ideal for Legionella growth. The aerosolized water droplets from drift can carry bacteria into building air intakes, making Legionella control the highest-priority biological hazard in tower water treatment.

CONSTRUCTION, TOOLS, AND RIGGING (Questions 73–80)

73. Correct Answer: A — 60° from vertical (corresponding to a horizontal sling angle of 30°)

Rigging standards specify sling capacity reductions based on the horizontal sling angle (angle from horizontal). At 60° from vertical = 30° from horizontal, the sling tension increases to 200% of the load per leg — the minimum recommended horizontal sling angle. Below 30° from horizontal, load per leg exceeds rated capacity and the configuration becomes unsafe.

74. Correct Answer: A — Pull conductors through conduit runs

A fish tape (pull tape or snake) is a flexible steel or fiberglass tape that is pushed through a conduit run, a pull string or conductor is attached to the end, and the tape is retracted to pull the conductors through. It is the standard tool for pulling conductors through installed conduit in new construction and renovation work.

75. Correct Answer: D — Connect both ends simultaneously to prevent voltage buildup

Welding cables must be connected at both ends before the welder is energized — electrode holder first would leave the work clamp end of the cable as an open energized conductor. Connecting the work clamp to the workpiece first and then the electrode holder prevents any energized end from being exposed. The simultaneous connection approach ensures neither end is left open and energized.

76. Correct Answer: B — Cable insulation stripper (ringing tool)

A cable insulation stripper (also called a ringing tool or cable stripper) uses an adjustable blade set to the insulation thickness to score and remove the outer jacket and insulation layers from large conductors without nicking or cutting the strands of the conductor itself — nicking conductors reduces their current-carrying capacity and creates stress risers that cause premature failure.

77. Correct Answer: A — Provides precise, measurable torque to large fasteners that exceed the capacity of manual torque wrenches

Hydraulic torque wrenches can deliver thousands of foot-pounds of torque to large flange bolts, structural connections, and equipment anchor bolts — far beyond the capacity of manual torque wrenches. They use hydraulic pressure to generate precisely controlled torque, with the applied torque calculated from the hydraulic pressure reading and tool geometry.

78. Correct Answer: A — Support and route cables in an open, easily accessible, and expandable cable management system

Cable tray systems provide a structural support system for cables in industrial and commercial facilities — allowing cables to be laid in, rearranged, and added to easily without the pulling friction or fill limitations of conduit. They are widely used in data centers, industrial plants, and large commercial facilities.

79. Correct Answer: B — The rope has 6 strands with 19 wires per strand

Wire rope designation follows the format: number of strands × number of wires per strand. A 6×19 rope has 6 strands wound around a central core, with 19 individual wires in each strand, totaling 114 wires. A 6×19 classification actually covers ropes with 15–26 wires per strand — providing a balance between flexibility and abrasion resistance.

80. Correct Answer: A — 100 PSI — adequate for operation

Pressure at tool = Compressor output – Hose pressure drop = 120 – 20 = 100 PSI. Since 100 PSI exceeds the 90 PSI minimum requirement, the tool has adequate supply pressure for operation. Hose losses must always be considered when sizing compressor output for pneumatic tools.

HAZARDOUS MATERIALS AND ENVIRONMENTAL COMPLIANCE (Questions 81–89)

81. Correct Answer: D — Corrosivity

RCRA defines a corrosive hazardous waste as one with a pH of 2.0 or less (highly acidic) or 12.5 or greater (highly alkaline), or one that corrodes steel at a rate greater than 6.35 mm per year. A pH of 1.5 falls well below the 2.0 threshold — this waste is classified as characteristically hazardous due to corrosivity.

82. Correct Answer: A — The product identifier and words, pictures, or symbols providing general hazard information

OSHA HazCom 2012 (29 CFR 1910.1200) requires secondary containers (those the product is transferred into for use) to be labeled with at minimum the product identifier and general hazard information sufficient to warn workers. Full GHS labeling with all six elements is required on shipped containers, not necessarily on secondary containers used within the facility.

83. Correct Answer: D — Disturb one or more acres of land or discharge stormwater associated with industrial activity

NYC DEP requires Stormwater Pollution Prevention Plans (SWPPPs) for construction sites disturbing one or more acres and for industrial facilities whose stormwater discharges are associated with industrial activity — ensuring that construction runoff and industrial stormwater are managed to prevent pollution of the city's waterways.

84. Correct Answer: D — The National Response Center (NRC) and NYC DEP immediately

A petroleum spill reaching a storm drain constitutes a release to navigable waters — a federal CERCLA reportable quantity event requiring immediate notification to the National Response Center (1-800-424-8802). NYC DEP must also be notified immediately under local regulations. Notification is required regardless of quantity when the spill reaches a storm drain.

85. Correct Answer: A — 29 CFR 1910.1001 (asbestos standard) and 29 CFR 1910.134 (respiratory protection)

Respiratory protection for asbestos work is governed by both the asbestos-specific standard (1910.1001), which specifies the type and class of respirator required at various exposure levels, and the general respiratory protection standard (1910.134), which establishes the overall respiratory protection program requirements including medical evaluation and fit testing.

86. Correct Answer: B — From generation through transportation, treatment, storage, and disposal — "cradle to grave"

RCRA's Subtitle C hazardous waste program establishes cradle-to-grave management of hazardous waste — tracking it from the point of generation (cradle) through its transportation, any treatment or storage, to its final disposal (grave). The manifest system, generator standards, transporter requirements, and TSDF standards collectively implement this cradle-to-grave framework.

87. Correct Answer: B — Label all containers "Used Oil," prevent releases, and comply with used oil storage standards

Under EPA 40 CFR Part 279, used oil generators must label all containers and tanks with "Used Oil," prevent releases, and meet storage container standards (good condition, no severe rusting, etc.). They are not required to obtain RCRA permits for used oil storage as long as the used oil has not been mixed with listed hazardous wastes.

88. Correct Answer: C — Section 4

SDS Section 4 — First-Aid Measures — describes the emergency first aid procedures for each route of exposure: skin contact, eye contact, inhalation, and ingestion. It also notes symptoms and whether immediate medical attention is required. Section 6 covers accidental release; Section 7 covers handling and storage; Section 11 covers toxicological information.

89. Correct Answer: B — Dry powder (sodium chloride or graphite-based)

Class D fires involve combustible metals such as magnesium, titanium, sodium, and lithium. Standard extinguishing agents (water, CO₂, dry chemical) react violently with burning metals. Only specialized dry powder agents — sodium chloride-based (Met-L-X), graphite-based (Lith-X), or copper powder — smother the burning metal without chemical reaction.

SAFETY, LOTO, ARC FLASH, AND EMERGENCY PROCEDURES (Questions 90–100)

90. Correct Answer: A — Written energy control procedure for that specific equipment

OSHA 1910.147 requires that the written energy control procedure for each piece of equipment specifically identify all energy sources — electrical, pneumatic, hydraulic, thermal, mechanical, gravitational, and chemical — along with the specific isolation and verification steps for each source. Generic procedures that do not identify equipment-specific energy sources do not meet the standard.

91. Correct Answer: B — Before the equipment is put into service — not after an arc flash incident

NEC 110.16 requires arc flash warning labels to be applied to all electrical equipment likely to require examination, adjustment, servicing, or maintenance while energized — before the equipment is placed in service. Waiting until an arc flash incident occurs to add a label violates the intent of the standard and may result in an OSHA citation.

92. Correct Answer: B — Adequately protected — the PPE arc rating exceeds the incident energy

NFPA 70E requires that PPE arc rating equal or exceed the calculated incident energy at the working distance. A 40 cal/cm² arc rating with 35 cal/cm² incident energy provides a 5 cal/cm² margin of protection — the worker is adequately protected. NFPA 70E does not require a specific minimum margin beyond the rating equaling or exceeding the incident energy.

93. Correct Answer: B — All employees who perform permit space entry — entrants, attendants, and entry supervisors

OSHA 29 CFR 1910.146(g) requires the employer to provide training to all employees whose work is regulated by the standard — authorized entrants (those who enter), attendants (those who monitor from outside), and entry supervisors (those who authorize and oversee the entry). All three roles have specific responsibilities requiring role-specific training.

94. Correct Answer: A — Use a resistor-equipped discharge tool — never short the terminals directly

Capacitors must be discharged using a tool with a resistor in series with the shorting conductor — the resistor limits the discharge current and rate, preventing the violent spark and potential weld that direct shorting would create. Shorting directly with a screwdriver risks flying molten metal, personal injury, and equipment damage from the uncontrolled discharge current.

95. Correct Answer: A — Cool the burns with cool (not ice-cold) water and cover loosely with a clean non-stick dressing

Electrical burn first aid requires cooling the burned area with cool (15–25°C) running water for at least 20 minutes to stop the burning process and reduce pain. Ice water causes vasoconstriction and additional tissue damage. Butter or oil traps heat; removing stuck clothing risks further tissue damage; tight wrapping impairs circulation.

96. Correct Answer: B — Record work-related injuries and illnesses that meet OSHA recording criteria

The OSHA 300 Log (Log of Work-Related Injuries and Illnesses) is a running record maintained by employers to document all work-related injuries and illnesses that meet OSHA's recording criteria — those involving days away from work, restricted duty, medical treatment beyond first aid, loss of consciousness, or diagnosis of a significant injury or illness.

97. Correct Answer: D — The plan must include procedures for reporting emergencies, evacuation routes, and accounting for personnel

OSHA 29 CFR 1910.38 requires emergency action plans to include procedures for reporting fires and other emergencies, evacuation procedures and route assignments, procedures for employees who remain to perform critical operations before evacuation, means of accounting for all personnel after evacuation, and rescue and medical duties for designated employees.

98. Correct Answer: D — Arc-rated face shield, arc-rated clothing rated for the calculated incident energy, and voltage-rated gloves

Switching operations on 13.8kV switchgear involve exposure to potential arc flash hazards at medium voltage — where incident energy levels can be extremely high. Minimum PPE includes arc-rated face shield (over safety glasses), arc-rated clothing matching the incident energy, leather work boots, hard hat, and Class 2 (17kV rated) voltage-rated rubber gloves with leather protectors.

99. Correct Answer: D — Calculated incident energy at the working distance

Face shield arc rating must equal or exceed the calculated incident energy at the specific working distance for the equipment being worked on. The incident energy — determined by the arc flash study per IEEE 1584 — is the only scientifically valid basis for selecting face shield arc rating; voltage level alone does not determine arc flash severity.

100. Correct Answer: C — Immediately intervene to stop the unsafe act and report it to supervision

Every worker has both the right and the professional responsibility to stop an unsafe act regardless of the coworker's experience level. Safety culture requires immediate intervention — experience does not grant immunity from safety rules. The incident must then be reported to supervision so that corrective action can be taken to prevent recurrence.