1. Which drawing type shows physical details as seen by the eye? **Pictorial Drawing**

2. Which drawing is similar to a pictorial drawing but has circles or rectangles for components? **Wiring Diagram**

3. Which drawing type shows the circuitry necessary for operation but not the physical components or their location? **Schematic Diagram**

4. Which diagram shows the most direct path and logical sequence of operation? **Line Diagram**

5. What is necessary in an electrical circuit before current can flow? **Complete path or closed circuit**

6. What are the main parts of an electrical circuit? **Source, load, control device, and conductors. (protection device)**

7. What is the term used to describe a circuit where a person is required to initiate and action? **Manual control circuit**

8. What is indicated when two wires cross with a dark black node on the point? **They are connected**

9. How is a start pushbutton indicated on a line diagram? **Set of NO contacts**

10. What are three actions that will stop the motor in Diagram 4-10 once it has started? **Loss of power, switch turned off, or motor overloads**

11. What type of contact is required on a float switch to maintain a water level in a tank? **NC contact**

12. What is the term used to describe an electrical device that converts electrical energy into linear mechanical force? **Solenoid**

13. Which device is constructed similar to a solenoid but is designed to operate a set of contacts with the linear movement? **Contactor**

14. What is the difference between a Contactor and a Magnetic Starter? **Starter has overloads**
15. What is the proper procedure when an overload condition occurs in a motor starter? Remove the overload condition, reset the device, and push the start button

16. Which components are typically located inside a control panel? Transformers, starters, relays, timers, fuses

17. Which components for motor control circuit may be located outside the control panel? Pushbuttons, motors, solenoids, limit switches, pressure switches, pushbuttons

18. What is the most common tester for troubleshooting a control circuit? DMM

Chapter 8 (Page 207-210 Motor Control Centers)

1. What are three things that are made easier by a motor control center? Wiring, control, and troubleshooting of circuits

2. What is the backbone of most all production and industrial applications? Electric motor

3. How does a motor control center differ from a switchboard containing motor panels? Designed for plug-in control units and motor control

4. What are some control inputs that are typically wired into the motor control panel? Pushbuttons, level switches, and limit switches

5. What is the output connected to a motor control center? Motor

6. What percentage of the power load in industrial plants is typically motors? 60-80%

7. Where is a two-wire level switch connected on a motor control center? Terminals 1 & 3

8. What wire reference numbers are typically used for wires installed by the manufacturer in a motor control center? None

Chapter 9

1. Why were knife switches discontinued as a means of controlling motors? Exposed live parts, speed of operation determined by operator (arching), not reliable. (frequent replacement)

2. What improvements were made to the knife switch? Steel enclosure, insulated handle, and spring loaded action

3. What is the purpose of a knife switch in relation to motors? Disconnecting means
4. What is the purpose of double-break contacts? **Higher contact rating in smaller space**

5. What is the purpose of the springs on the moveable contact of a starter? **Soften impact**

6. What is silver mixed with to produce a low resistance silver alloy? **Cadmium or cadmium oxide**

7. What should be done with silver-oxide contacts that appear tarnished? **Nothing**

8. What is indicated by heavy dark lines, thin lines, and dashed lines on a wiring diagram? **Power circuit, control circuit, and user connections**

9. What is a mechanical interlock for a manual starter? **Contacts arranged so both sets of contacts cannot be energized at the same time**

10. What is a locked rotor condition for a motor? **Motor loaded so heavy the shaft cannot turn**

11. What are the three stages of a motor operation? **Resting, starting, operating under load**

12. What percentage of the FLA for a motor is typically drawn during startup? **6 to 8 times**

13. What is ambient temperature? **Temperature of the surrounding air**

14. Will fuses blow if a motor is slightly overloaded and heating up? **No**

15. What is the purpose of the fuses in a motor circuit? **Protect the conductors**

16. What is the purpose of the overloads in a motor circuit? **Protect the motor**

17. What is the most popular method of providing overload protection? **Melting alloy overload relay**

18. What is a eutectic alloy? **Metal with a fixed temperature where it changes from a solid to a liquid**

19. What actually opens when a melting alloy overload relay trips? **Not the heater circuit but the NC overload contact**

20. What provides the mechanical force to open the overload contact when a melting-alloy overload trips? **Compressed spring**

21. What happens if you reset the motor after an overload condition without removing the overload condition? **Trips again**

22. How is the overload relay changed for different sized motors? **Heater coil size**
23. What are some considerations when selecting a motor starter? Phases/poles, voltage, starter size, and enclosure type

24. Which conductors must be disconnected when controlling a device according to the CEC and NEC? NEC says each ungrounded CEC says not necessarily if there is a separate disconnecting means (I would always break each ungrounded conductor)

25. What type of motor protection is not provided with manual motor starters and contactors? Low-voltage (Under-voltage)

26. What are some limitations of three-phase manual motor starters? Only available up to 7.5 HP, no low voltage protection, not for frequent operation, can’t be operated remotely, can’t use with limit switches, etc.

27. Which loads are typically controlled by a contactor? Lights, heaters, transformers, and capacitors

28. What are the two main advantages of a contactor over a manual motor starter? Remote operation and automation

29. What is low-voltage release? Circuit will de-energize in the event of a loss of power but restart on a return to power (Definitions in CEC)

30. What is low-voltage protection? Circuit will de-energize in the event of a loss of power but will not restart on a return to power (Has to be restarted) (Definitions in CEC)

31. How many wires are required to a starter from an input that provides low-voltage release as well as low-voltage protection? 3

32. What is typically the maximum control circuit voltage for motor starters? 120 V

33. Why are DC coils not laminated like the AC coils? No eddy currents as the polarity is not changing constantly

34. What is the term used to describe the device that dissipates the energy present across opening contacts? Arc Suppressor

35. What two values increase as contacts start to open? Resistance and temperature

36. What two characteristics differ for DC contactors over AC? Larger air gaps and faster action

37. What makes AC arcs self extinguishing? Sine wave

38. What are the three components of the de-ion principle? Confine, divide, and extinguish
39. What is another name for a DC magnetic blowout coil? **Puffer**

40. Why are single-break contacts in large contactors typically made of copper? **Cost**

41. How is resistance reduced in copper contacts that are seldom opened or closes? **Cleaning**

42. What are the three considerations when selecting a starter? **Type, Size, and Voltage**

43. What type of contacts are typically used for closing short-circuit currents? **Molybdenum or Tungsten**

44. What does the overload open on a manual starter? **Power circuit**

45. What does the overload open on a magnetic starter? **Contacts to the coil**

46. Which type of overload relay has an adjustment for trip time and current? **Magnetic Overload Relay**

47. Which overload relay resets quicker? **Magnetic**

48. What is the main advantage of a bi-metallic overload relay? **Automatic reset**

49. What is the advantage of using overload current transformers? **Save space**

50. What are the three considerations when selecting overload heaters for a motor? **FLA (FLC), Service Factor, and Ambient temperature**

51. What is the term used to describe the percentage of extra demand that can be placed on a motor for a short period of time without damage? **Service Factor**

52. According to the CEC what is the rule around overload size and service factor? If the SF is 1.15 or greater go 125% but if less than 1.15 or not marked then 115% (28-306)

53. What information is found on the faceplate of a magnetic starter? **Class, type, and size**

54. Where is the heater selection chart for a starter typically found? **Inside the enclosure**

55. What are two types of inherent motor protectors? **Bimetallic thermodiscs and thermistor overload devices**

56. What type of motor typically incorporates a bimetallic thermodisc? **Small horsepower**

57. What are the three parts of a thermistor overload device? **Thermistor, solid-state relay, and contactor**

58. What is unique about a thermistor? **Resistance decreases as temperature increases**

59. What is the principle of operation of an electronic overload? **Magnetic field strength**
60. What are the two methods of setting programmed overloads? Setting a dial or programming with a keypad

61. What is the motor nameplate current? Current it draws operating at rated HP or kW

62. What is the result of allowing a motor to operate above rated HP for an extended period of time? Heating damage to motor and drive

63. What is one feature of advanced parameter programming for motor drives? Automatic restart

64. What are some devices that may be added to magnetic motor starters? Additional contacts, power poles, pneumatic timers, transient suppression modules, and fuse holders

65. What is a power pole? Contacts capable of carrying a load

66. Where are pneumatic timers typically mounted? Side of the contactor

67. What type of circuit is typically used for transient suppression modules? RC (Resistance/capacitance)

68. What are the differences between IEC devices and NEMA devices? IEC smaller and cheaper (for specific known applications) NEMA larger and more expensive (machine requirements and specifications may vary)

69. What is the first step in troubleshooting a contactor or starter? Visual inspection

70. What percentage of the rated motor voltage should be present? Within 10%

71. What is the result of a broken or missing shading coil in a starter? Loud buzzing

72. What are three causes of nuisance tripping? Overload wrong size, no temperature compensation, loose connections

Chapter 12

1. How many sets of overload heaters are required for a manual reversing starter? 1

2. What is a mechanical interlock? Physical restriction to keep both forward and reverse contacts from energizing at the same time

3. What would be the result of no mechanical or electric interlock on a reversing starter? Dead short if both contacts energized at same time

4. Which two leads should be changed for reversing a motor with a reversing starter? 1 and 3
5. How is the direction of rotation changed in a single-phase (split-phase) motor? Reverse the current through the start or run winding (Not both)

6. How is the start winding identified if it is not marked? Higher resistance

7. How is the direction of rotation typically changed for a DC motor? Reverse the direction of the current through the armature

8. How many leads are available on a DC permanent-magnet motor? 2

9. What type of switch is typically used to reverse (raise and lower) a crane when the operator must keep his eyes on the load being lifted? Drum switch

10. Does a drum switch contain overloads? No

11. Are interpoles (commutating windings) considered part of the armature circuit or part of the field circuit when reversing a DC motor? Armature

12. What are the three types of interlocking for motor starters? Mechanical, Auxiliary Contact, and Pushbutton

13. How is electrical interlocking provided for magnetic reversing motor starters? Auxiliary NC contacts or pushbutton

14. How are Power and control circuits isolated from each other in a motor starter? Control transformer

15. Where is a pilot light connected to indicate a motor is running? Parallel with the coil

16. How is overtravel protection provided in motor control circuits? Limit switches

17. In diagram 12-24 what is removed from the circuit by setting the selector switch to jog? Memory or hold circuit

18. What are some advantages of a PLC reversing circuit? Changes and modifications are easily made using programming. Don’t need auxiliary contacts or additional wiring (they can be programmed in and exist only in the PLC)

19. Where are forward and reverse coils connected to a PLC? Outputs


21. What are the main disadvantages of direct hard wired circuits? Troubleshooting and modifications are time consuming
22. Which two tasks are made easier with the direct wired using terminal strips method? 
   Troubleshooting and modifications

23. Which motor control method provides metering and display of voltage, amperage, etc? 
   Electric motor drive

24. Which motor control method provides the best overall performance and monitoring of a 
   motor? Electric motor drive

25. Where does troubleshooting start when a reversing motor controller is not working? 
   Inside the control cabinet

26. Where are the leads of a DMM placed to check the voltage of a reversing control circuit? 
   L1 and L2

27. Where is the first check made for voltage in the power circuit of a reversing starter? 
   Incoming power leads

28. What precaution must be taken when manually operating starter contacts? Loads may 
   start or stop without warning

Chapter 15 Pages 453-460

1. What are some features of solid-state motor starters not found on electromagnetic motor 
   starters? Control the amount of voltage and current applied to the motor, and torque 
   produced by the motor during starting and stopping

2. What are some components found on solid-state motor starters not found on 
   electromagnetic motor starters? Terminal strip, DIP Switchboard, Potentiometers, and 
   LEDs

3. What are three different types of connections on the control terminal strip? External 
   control voltage, external control switches, and output contacts

4. What is the “trip class” setting on a solid-state overload? Length of time it takes for an 
   overload relay to trip and remove power from the motor

5. What is the trip class setting based on? Type of load placed on a motor

6. How is a solid-state motor starter programmed for proper operation? DIP Switch

7. What precaution must be taken when setting the overload reset function? Workers must 
   be aware the motor may start unexpectedly after an overload

8. What are the three common motor starting modes with solid-state starters? Soft start, soft 
   start with start boost, and current limit start
9. Which of the three methods listed above is most common? Soft start

10. What are the three common stop modes with solid-state starters? Soft stop, pump control, and brake stop

Chapter 18

1. What are some of the advantages of reduced-voltage starting? Reduced interference in the power source, the load, and the electrical environment around the motor

2. What percentage of the FLA of a motor is drawn at startup? 200 to 600%

3. What is the term used to describe the amount of current permitted by the utility in each step of startup? Increment current

4. What are two advantages of reduced-voltage starting for the paper industry? Gentle start and smooth acceleration

5. Which loads are not well suited to reduced-voltage starting? Loads that are difficult to start at full voltage

6. What is the result of high starting currents in large DC motors? Damage to motor

7. Why does the starting current decrease as a motor gets up to speed? Induced EMF

8. Which two reduced-voltage starting methods place a large resistance in series with the motor? Rheostat and Primary Resistor

9. When is the current highest in an AC motor? Rotor is at standstill

10. What is the term used to describe the current taken from the power line with the rotor stopped? Locked rotor current

11. Briefly describe open and closed circuit transition for motor starting. Open circuit transition is when the motor is momentarily disconnected from the supply voltage when switching from start to run. Closed circuit transition is when the voltage is not removed during the transition.

12. What happens to the resistors as the motor accelerates to the set point with primary resistor starting? Shorted out
13. What are the two additional requirements for multiple-step primary resistor starting? Contactors and resistors

14. Which reduced-voltage starting method produces more motor torque with less line disturbance, autotransformer or primary resistor? Autotransformer

15. What is the requirement of a motor for part-winding starting? Stator winding must have at least two equal parts and terminals available for each part

16. What is one advantage of part-winding starting circuits? Economical

17. What is one disadvantage of part-winding starting circuits? Poor torque

18. What is the minimum number of overloads for a part-winding starting circuit? 2 sets

19. How much of the full motor torque is available at startup with a Wye/Delta starting circuit? 33%

20. How many leads are required for a motor to be wired wye-delta? 6

21. What are the main advantages of Solid-state switches? Fast switching, no moving parts, long life, and the ability to interface with electronic circuits (PLC, etc)

22. How is a transistor protected from high-voltage spikes when used as a switch? Diode connected across the transistor

23. How many SCRs are required to switch high-level DC current? 1

24. How many SCRs are required to switch high-level AC current? 2

25. What is the advantage of using two SCRs to switch high-level AC current instead of a triac? Better heat dissipation

26. How is a triac turned on and off? On when a voltage is applied to the gate and off when the voltage is removed

27. What is the main advantage of an alternistor over a triac? Better cooling

28. What three functions of acceleration are controlled by an SCR in a Solid-state starting circuit? Voltage, current and torque

29. What are some advantages of SCRs? Small in size, rugged, no contacts

30. What is the life expectancy of SCRs when operated within specifications? Unlimited

31. What is the result of a signal being applied to the gate of an SCR? Anode resistance decreases sharply
32. How are SCRs wired to control AC line current in both directions? Reverse parallel

33. Which reduced-voltage starting method uses several potentiometers to set timers? Soft start

34. What are some of the considerations when selecting reduced-voltage starting method? Amount of reduced current, amount of reduced torque, and the cost

35. Which reduced-voltage starting methods are not adjustable? Part-winding and wye-delta

36. Which method of reduced-voltage starting is most expensive? Solid-state

37. Which method of reduced-voltage starting is least expensive? Part-winding

38. Which method of reduced-voltage starting provides the most torque per amp? Autotransformer

39. How many leads are required for a motor to be started using the part-winding starting method? 9

40. Which method of reduced-voltage starting is reasonably inexpensive and well suited to long acceleration times or frequent starts? Wye-delta

41. Which method of reduced-voltage starting offers the most control? Solid-state

42. What are the main parts of the power circuit for a reduced-voltage starting circuit? Main switching contacts, overload detection device, starting resistors, and autotransformer

43. What are the main parts of the control circuit for a reduced-voltage starting circuit? Motor starter, overload contacts, and timing circuit

44. What are the first two steps in troubleshooting a reduced-voltage power circuit? 1. Visually inspect the starter 2. Measure the incoming voltage

Chapter 19

1. How does a regular motor stop without any interference? Coast to stop

2. What is the oldest braking method? Friction Braking

3. How are friction brakes typically held open? Solenoid

4. How is a friction brake typically closed? Spring
5. What is the advantage of using a rotor fastened to the shaft rather than using the shaft of a motor for braking? More surface area for braking (Less pressure needed)

6. How is braking pressure measured? Lb-ft of torque

7. What are two advantages of friction brakes? Low initial cost and simplified maintenance

8. What is the main disadvantage of friction brakes? More maintenance than other methods

9. What is the principle of plugging? Reversing the motor connections so the motor develops countertorque that acts as a brake

10. What is the function of a plugging switch on a motor braking system? Prevent reversal of the load once it comes to a standstill

11. How is a plugging switch connected to a motor? Mechanically to the shaft

12. What are the two functions of the emergency stop button when using plugging for emergency stops? De-energize the forward starter and energize the reversing starter

13. Why are most split-phase and capacitor start motors not capable of being stopped by plugging? Centrifugal switch removes the start winding from the circuit. It will not start without the start winding.

14. What is the recommended Service Factor for a motor in plugging applications? 1.35 or more

15. What are two advantages of using timing relays for plugging? Cheap and no mechanical connection required to shaft

16. What is one disadvantage of using timing relays for plugging? No compensation for changing load conditions once set up

17. What is another name for electric braking? DC injection braking

18. Why is maintenance minimal with electric braking? No physical contact during braking

19. What force will keep a motor from coming to a complete stop during the first alignment of poles when the DC voltage is applied to the stator windings? Inertia of the load

20. Where does the DC voltage come from in an electric braking circuit? Rectified AC

21. How is the amount of braking torque adjusted with electric braking? Transformer with tapped windings

22. What does “total interlocking” include? Mechanical, electrical, and pushbutton interlocks
23. What type of motor is typically used with dynamic braking? DC

24. What happens to the energy of a rotating motor with dynamic braking? It is changed to electrical energy then dissipated as heat (resistors)

25. How does the size of the resistor affect the stop time for a motor using dynamic braking? Smaller resistor means faster stop time

26. What are two limitations of dynamic braking? Cannot completely stop a motor and cannot hold a load once stopped

27. How are the limitations (above) overcome? Adding electromechanical brakes

28. What is added to a dynamic braking motor drive when stopping high inertia loads quickly? Resistor

SKIP TO END OF CHAPTER