1. What are the two main parts of a three-phase motor? **Stator and Rotor**

2. Which part of a three-phase squirrel-cage induction motor is a hollow core? **Stator**

3. What are two purposes of the stator core? **Support for stator field windings and provide a low reluctance path for the magnetic circuit**

4. How many degrees apart are the stator windings in a three-phase squirrel-cage induction motor? **120**

5. Where does the term “squirrel-cage” come from? **Looks like an exerciser for a squirrel or hamster**

6. Why are the bars in a squirrel-cage not run parallel to the slots cut in the stator core? **Smother and quieter operation**

7. What materials are typically used for the bars in a squirrel-cage? **Copper or aluminum**

8. What is the purpose of the fan blades molded into a rotor for a three-phase squirrel-cage induction motor? **Circulate air to cool the core and windings**

9. What is the main purpose of the end bells in a three-phase squirrel-cage induction motor? **House the bearings**

10. What determines the type of enclosure a motor will have? **Environment where it will be used**


12. What are some of the more common classifications of motor enclosures? **Open, Drip proof, Totally enclosed fan cooled**
13. What are the enclosure classifications for severe environmental conditions?  
   Encapsulated winding and sealed winding

14. What information can be obtained from the frame designation? Shaft height from 
   bottom mounting bracket, distance between mounting holes, etc.

15. What is the horsepower rating of a motor used for? Match the motor to the load, 
   size the starter and disconnect, determine the FLA of motor if not given

16. What is the service factor of a motor? Multiply by HP to determine the maximum 
   HP at rated frequency and voltage the motor can supply continuously without 
   damage to the motor

17. What does “short-time” mean in the time rating of a motor? 5 – 60 minute rating 
   (Not continuous)

18. Is the ambient temperature of a motor always the temperature of the surrounding 
   air? It is the cooling medium typically air but not always

19. How are insulation systems classified? Class A (105), Class B (130), Class F 
   (155), and Class H (180)

20. What value is rpm inversely proportional to? Number of poles

21. Frequency should not be varied more than what percentage of the rated frequency 
   of a motor? 5%

22. Can a 240 V motor be operated at full load, at rated frequency, on a 208 V 
   system? No, it is not within the 10%

23. What value of a motor is used to determine overload size and conductor size? 
   FLA
24. Is the locked-rotor amperage rating typically shown on the nameplate of a motor?
   No

25. What is the design letter shown on a motor nameplate? Can be looked up to find the locked-rotor KVA

26. What is considered “evidence of approval” for electrical equipment installed in accordance to the CEC? Approval from a certified agency such as CSA or UL

27. How are secondary currents induced in the rotor of a three-phase induction motor? Induced by the flux from the stator field

28. How many poles does a three-phase, two-pole stator have? 6

29. What is the value of the current in the B and C phases of a stator when phase A is at maximum? Half value in the negative direction

30. Skip to page 20

31. What is the speed of a four-pole motor on a 60-cycle supply? 1800 RPM

32. What is the speed of a six-pole motor on a 50-cycle supply? 1000 RPM

33. What is the relationship between speed of a motor and frequency of the supply? Directly proportional

34. What is the synchronous speed of a motor? Speed of the rotating stator field

35. Describe the rotor windings in a squirrel-cage motor. Rotor bars and end rings form the windings which are short-circuited coils

36. What happens when the stator field rotates past a stopped rotor at synchronous speed? Voltage is induced in the rotor bars

37. What is the direction of rotation for a rotor in a three-phase squirrel-cage motor? Same as the rotor field
38. What is the result of a rotor traveling at the synchronous speed of the stator? No current would flow in the rotor and no torque would be developed.


40. Is slip consistent regardless of speed? Slip decreases as the rotor speed increases.

41. What is the rotor speed of a squirrel-cage motor with 4 poles and a 4% slip operated on a 60 Hz source? 1728 RPM.

42. What is the percent speed regulation for a motor with a no-load speed of 1750 RPM and a full-load speed of 1690 RPM? 3.5%.

43. How is a three-phase motor reversed? Interchange any two leads.

44. When is rotor current and stator current at their maximum value? Power is on but the rotor is at a standstill.

45. When is rotor and stator current at their minimum value? Rotor is up to speed.

46. What percent slip for a motor will produce the most torque? 25%.

47. Rated horsepower of a motor is typically at what % slip? 2-5%.

48. What is breakdown torque and when does it occur? Maximum torque the motor will produce or “stalling torque”.

49. What is starting torque? Maximum torque the motor will develop at rest with rated voltage and frequency applied.

50. What is the slip speed and % slip for a 4-pole motor with a rotor speed of 1690 rpm at 60 hz? 110 RPM and 6.1% slip.

51. What is the slip speed and % slip for a 2-pole motor with a rotor speed of 3350 rpm at 60 hz? 250 RPM and 6.9%.
52. Why does torque stop increasing as slip is increased beyond 25% in a three-phase motor? Power factor decreases faster than the increase in current.

53. How are motors rated to indicate the torque and speed characteristics? NEMA standards A-D.

54. What is the designation of a motor with the most torque? D.

55. What is the efficiency of a 2 HP, 3 PH, 208 V motor that draws 7 amps at a power factor of 80%? 74%.

56. What is a linear-induction motor? Moves in a line instead of rotating.

57. What is the main difference between a standard three-phase induction motor and a linear-induction motor? Stator coil is flat instead of round.

58. Why does the aluminum core in a linear-induction motor have an iron backing? Reduce the reluctance of the magnetic path.

59. How is the synchronous speed of a linear-induction motor measured? (units) m/sec.

60. How is numbering of terminal leads for windings done on phasor diagrams of three-phase motors? Starting with $T_1$ at the outside top of the diagram and going counter-clockwise on a spiral towards the center.

61. What are the three winding terminals that are connected together in the diagram in figure 2 on page 35? $T_{10}$, $T_{11}$, and $T_{12}$.

62. Which three terminals would connect to the lines in figure 2 on page 35? $T_1$, $T_2$, and $T_3$.

63. What happens to terminal designations when connections are made internally in wiring diagrams for three-phase motors? Highest number is dropped.
64. How is a three-phase motor connected internally when terminals are T1, T2, and T3? Either wye or delta

65. How many leads are required on a motor to allow either wye or delta connections? 6

66. If a delta run motor is connected wye for start, what percentage of the delta start current is then utilized? 33%

67. Can a nine-lead, dual-voltage, three-phase motor be connected either wye or delta? No, they are internally connected one or the other

68. How many leads are required for a dual-voltage, three-phase motor that can be connected either wye or delta? 12

69. What are the two pieces of equipment required to determine the rotation of a three-phase motor without actually starting it? Connection diagram and continuity tester

70. Why are squirrel-cage induction motors so popular? They require less maintenance than other types

71. What are two methods for checking bearing condition in a motor? Stethoscope or ear to a screw driver

72. How is insulation tested on low-voltage motors? Megger

73. What is considered an acceptable resistance to ground for a low-voltage motor winding? 1 Megohm or larger

74. What is one possible cause of a motor overheating? Overload, improper ventilation

75. What is one possible result of a belt being too tight? Heating in the bearings
Unit 2

1. What is the difference between the stator of a three-phase, squirrel-cage, induction motor and a three-phase, wound-rotor motor? **Same**

2. How many poles will a rotor have in a three-phase, wound-rotor motor? **Same**

3. What term is used to describe the rotor circuit in a wound-rotor motor? **Secondary circuit**

4. How are the connections made between the rotor circuit and the external resistance grid in a three-phase, wound-rotor, motor? **Slip rings and brushes**

5. What is the relationship between the slip rings and the rotor shaft in a three-phase, wound-rotor motor? **Insulated from**

6. How are the brushes connected to the external circuit in a three-phase, wound-rotor motor? **Flexible conductor (pigtail or shunt)**

7. What information is included on the nameplate for a three-phase, wound-rotor, motor that would not be included on a nameplate for a three-phase, squirrel-cage, induction motor? **Maximum rotor voltage and current**

8. How can the speed at which breakdown torque occurs be changed in motor? **Changing the resistance of the rotor circuit**

9. What are two results of adding resistance in the secondary circuit of a three-phase, wound-rotor, motor? **Lowers rotor current and improves power factor**

10. What is the result of leaving the starting resistance in the circuit of a three-phase, wound-rotor, motor? **Torque of the motor immediately starts to decrease**

11. What is done with the leads of the secondary circuit in a three-phase, wound-rotor, motor after the resistance is removed? **Short circuited**
12. Is a three-phase, wound-rotor, motor as efficient as a three-phase, squirrel-cage, induction motor? Yes, about the same

13. How is the speed of a three-phase, wound-rotor, motor controlled? Up to what point? Adding resistance to the rotor circuit. Up to about 50% slip

14. Basically, how does a regenerative electronic speed controller operate? They change electrical energy into three-phase energy which is fed back into the supply side of the motor (regeneration)

15. What is the difference between resistors for starting and resistors for speed control? Resistors used for speed control must be able to dissipate heat continually but starting resistors require long cooling off periods between starts

16. A three-phase, wound-rotor motor is reversed by reversing any two leads to the rotor. True or False?

17. How many resistors are required in each phase for four-step resistance starting of a three-phase, wound-rotor motor? 3

18. How is acceleration made smoother in a three-phase, wound-rotor motor? Adding resistance in the rotor circuit then removing it in steps

19. What is the relationship between current in the rotor and motor speed in a three-phase, squirrel-cage, induction motor? Inversely proportional

20. Why is a three-phase, wound-rotor motor better suited to prolonged high-inertia starts than a three-phase, squirrel-cage, induction motor? Not as likely to overheat as rotor current is kept lower

21. What is the typical % slip for a three-phase, wound-rotor motor? Less than 5%
22. What are the main disadvantages of a three-phase, wound-rotor motor? Physical size, higher cost and maintenance, more complicated control, and poor speed regulation if resistance is left in the circuit.

23. What are the typical applications for a three-phase, wound-rotor motor? Driving overhead cranes, starting ball mills, driving loaded conveyors.

24. What type of three-phase motor is best suited to starting a conveyor loaded with heavy material? Wound rotor.

25. What is the main difference in maintenance for a three-phase, wound-rotor motor compared to maintenance for a three-phase, squirrel-cage, induction motor? Maintenance of the brushes and slip rings and external circuit.

26. At what point should brushes be replaced on a three-phase, wound-rotor motor? ¾ worn out.

27. Which is worse for brushes, too much tension or too little? Too little.

28. How can you check to see if an “open” is in the rotor or the external circuit? Short circuit the slip rings and try the motor.

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Unit 3

1. What speeds are synchronous motors best suited for? Below 500 RPM.

2. What is an extra benefit of using a three-phase, synchronous motor on systems with other types of motors? Improve power factor.

3. What are salient poles? Project out from the rotor.
4. What is the purpose of the amortisseur winding in a three-phase, synchronous motor? Dampen momentary speed fluctuations

5. What is the source for the rotor current in a three-phase, synchronous motor? Separate DC source

6. What are the three most common methods for supplying DC power to the rotor in a three-phase, synchronous motor? External converter, built-in exciter, or brushless exciter

7. Typically, what is an external converter for the rotor circuit in a three-phase, synchronous motor? Rectifier

8. What is a built-in exciter for a three-phase, synchronous motor? Small DC generator mounted on the shaft

9. How is the field excitation controlled when a built-in exciter is used to supply the rotor circuit in a three-phase, synchronous motor? Varying the output voltage of the DC exciter

10. Why are brushes not required on a brushless exciter for a three-phase synchronous motor? Alternator, rectifier, and field all rotate

11. What is the main purpose of the end bells and bearings in a motor? Keep the motor in alignment with the stator

12. What is the result of applying power to both the stator and rotor in a three-phase synchronous motor? Applies torque in one direction then the other with the net torque being 0 and the rotor remaining still
13. How is a three-phase, synchronous motor brought up to speed? Same as a squirrel-cage motor up to about 95% then DC is applied to the rotor circuit which pulls it into synchronism with the stator speed.

14. At what percent of full-load speed is the DC power applied to the rotor of a three-phase synchronous motor? 95-97%.

15. What happens if the DC current is applied to the rotor when the poles of the rotor and stator are not in alignment? May stall.

16. What is a “pony motor”? Wound rotor motor coupled to the same shaft to start heavy loads.

17. How are field windings protected from induced voltage during acceleration in a three-phase synchronous motor? Short circuited or connected to a field discharge resistor during acceleration.

18. How is a three-phase synchronous motor reversed? Reverse any two leads to the stator.

19. What is “pull-in-torque” for a synchronous motor? The torque required to pull the rotor into synchronism.

20. If the rotor of a synchronous motor is nearly up to the speed of the rotating field in the stator, what will allow it to synchronize? Pull-in torque.

21. What is the “torque angle” of a synchronous motor? Maximum constant torque under which the motor will pull its connected load into synchronism when the field excitation is applied.
22. What is “pull-out-torque” and what happens if it is exceeded in a synchronous motor? It is the maximum torque the motor will develop without pulling out of synchronism. It will pull out of synchronism, slow down and stall.

23. As load is added to a synchronous motor, what value must increase to input the extra power to the motor? Stator current.

24. What happens to the power factor of a synchronous motor when load is added? Becomes more lagging.


26. Why are synchronous motors deliberately run over-excited? Improve power factor of inductive circuits.

27. What is the difference between a synchronous motor and a synchronous capacitor? Synchronous capacitor is a motor with no shaft.

28. What is the relationship between VA and Watts after unity power factor correction? They are equal.

29. How are the rotor field leads identified on a three-phase synchronous motor? F1 and F2.


31. What are the problems that may cause a synchronous motor to pull out of synchronism or fail to synchronize? Open in field coils, no exciter voltage, open in the field rheostat, rheostat resistance set too high (current too low).
32. What is the result of setting the field current too high or too low on a synchronous motor? Overheating