UNIVERSITY OF MINES AND TECHNOLOGY, TARKWA

FIRST SEMESTER EXAMINATIONS, NOV. / DEC. 2018

COURSE NO: EL 375
COURSE NAME: AC MACHINES
CLASS: EL III **TIME:** 3 HOURS

Name**:** _____Index Number: _____

SECTION A [60 MARKS]

Carefully read each question and then circle the letter that bears the correct answer

1. If the load or torque angle of a 4-pole synchronous motor is 6° electrical, its value in mechanical degrees is 3°
   a. True b. False
2. For a concentrated winding the pitch factor (K_c) is equal to one.
   a. True b. False
3. A synchronous motor is doubly excited which means that the stator must be supplied from an AC source while the rotor is also supplied from an AC source.
   a. True b. False
4. In power systems, frequency is controlled by reactive power control.
   a. True b. False
5. When a squirrel cage induction motor is energized from a 3-phase system and is mechanically driven to synchronous speed it will deliver power to the system.
   a. True b. False
6. As power factor decreases the frequency remains constant and hence the speed of an alternator decreases.
   a. True b. False
7. In static excitation system, a portion of the AC from each phase of synchronous generator output is fed back to the armature windings as DC excitations, through a system of transformers and rectifiers.
   a. True b. False
8. Concentrated winding makes the waveform of the induced emf more sinusoidal in nature.
   a. True b. False
9. In an induction motor, maximum starting torque occurs when rotor resistance is equal to the rotor reactance.
   a. True b. False

10. The unstable region of operation of the induction machine is called hyperbola.

    a. True b. False

11. On no load the rotor speed must be less than the synchronous speed in an induction motor, because a torque must be set up to overcome the friction and iron loss torque.

    a. True b. False

12. In the high slip region of the torque-slip characteristics of the induction motor, torque is directly proportional to slip and hence the motor operates in the stable region.

    a. True b. False

13. As load increases in synchronous machines, load angle remains constant keeping speed constant as synchronous.

    a. True b. False

14. Maximum power that can be supplied by a synchronous generator is called the static stability limit of the generator.

    a. True b. False

15. At standstill, rotor of an induction motor does not rotate, hence $N_r = 0$, so slip =1.

    a. True b. False

16. Laminating the iron core of an AC machine minimise eddy current losses, since by laminating the core, area decreases and hence resistance increases.

    a. True b. False

17. When the slip is greater than 1, the induction motor works in the braking mode and hence the rotor is rotated in the same direction to that of rotating field.

    a. True b. False

18. The number of electrical degrees passed through in one mechanical revolution of a 14-pole synchronous machine is 2510

    a. True b. False

19. The voltage regulation for a lagging power factor is positive because there is a rise in voltage when the load is thrown off.

    a. True b. False

20. Synchronous impedance can be determined from short circuit test only.

    a. True b. False

21. Insulation problems and the difficulty involved in transmitting large currents via the brushes, limit the maximum power output and the generated emf in the rotating field type of synchronous machine.

    a. True b. False

22. The induced or the gross torque in an induction motor differs from the actual torque by an amount equal to the friction and windage torques in the machine.

    a. True b. False

23. In drawing the phasor diagram of the induction motor, the rotor resistive drop is drawn in phase with the rotor current and the reactive drop leading the resistive drop by 90°

a. True
b. False

24. The open circuit test gives information on the current handling capability of the alternator.

a. True
b. False

25. When an alternator is connected with a purely inductive load the current leads the terminal voltage.

a. True
b. False

26. In the synchroscope method of synchronisation, clockwise rotation of the pointer indicates that, the frequency and therefore the speed of the incoming machine is too fast.

a. True
b. False

27. Which of the following type of induction motor can be used to drive high inertia load?

a. Slip ring type
b. Squirrel cage type
c. Single phase induction motor
d. Cylindrical rotor type

28. Which of the following motors will be used in electric clocks?

a. DC shunt motor
b. DC series motor
c. AC induction motor
d. AC synchronous motor

29. Which of the following methods is used to start a synchronous motor?

a. Damper winding
b. Damper winding with star-delta starter
c. Star-delta starter
d. Cylindrical rotor type

30. The power factor of a synchronous motor is better than that of induction motor because___.

a. Synchronous motor has large air gab
b. Mechanical load on the motor can be changed
c. Synchronous motor runs at synchronous speed
d. Stator supply is relieved of the responsibility of producing magnetic field

31. If the slip of a 3-phase induction motor increases, the current in its stator winding ___.

a. increases
b. Remains same
c. Decreases
d. None of the above

32. A 3-phase 450 V, 2-pole, 60 Hz induction motor has 3% slip. The rotor speed will be___.

a. 3600 rpm
b. 3000 rpm
c. 2910 rpm
d. 3492 rpm

33. Which of the following methods is easily applicable to control the speed of the squirrel-cage induction motor?

a. By changing the number of stator poles
b. Rotor rheostat control

c. By operating two motors in cascade
d. By injecting emf in the rotor

34. When rotor resistance of a three-phase induction motor become equal to its rotor reactance, its starting torque will be ____.

a. Zero
b. Maximum
c. Unity
d. Minimum

35. Direct on line starting of induction motors is usually restricted to___.

a. Low horsepower motors
b. Variable speed motors
c. High horsepower motors
d. High speed motors

36. Slip of an induction motor is negative when___.

a. The rotor speed is equal to the synchronous speed
b. Rotor speed is less than the synchronous speed
c. Rotor speed is more than the synchronous speed
d. None of the above

37. It is advisable to avoid line starting of induction motor and use starter because___.

a. It will run in reverse direction
b. It will pick up very high speed and may go out of step
c. Starting torque is very high
d. Motor takes five to seven times its full load current

38. In an induction motor the ratio of the gross mechanical power (P_m) to the electromagnetic power (P_E)is equal to___.

a. $1-\text{slip}$
b. N_s/N_r
c. slip
d. 1/slip

39. What will happen if the relative speed between the rotating flux of stator and rotor of the induction motor is zero?

a. The slip of the motor will be 5%
b. The rotor will run at very high speed
c. The rotor will not run
d. The torque produced will be very large

40. In a star-delta starter of an induction motor_____.

a. Resistance is inserted in the stator
b. Reduced voltage is applied to the stator
c. Resistance is inserted in the rotor
d. Applied voltage per stator phase is 57.7% of the line voltage.

41. The back emf in the stator of the synchronous motor depends on___.

a. Number of poles
b. Flux density
c. Rotor speed
d. Rotor excitation

42. Hunting in synchronous motor cannot be due to ____.

a. Windage friction
b. Variable load
c. Variable frequency
d. Variable supply voltage

43. In a synchronous motor, the maximum power developed depends on all the following except___.
a. Rotor excitation
b. Maximum value of load angle
c. Direction of rotation
d. Supply voltage

44. A synchronous motor can be used as a synchronous capacitor or condenser when it is___.
a. Under-loaded
b. Over-loaded
c. Under-excited
d. Over-excited

45. Power factor of a synchronous motor is unity when___.
a. The armature current is maximum
b. The armature current is zero
c. The armature current is minimum
d. None of the above

46. The maximum constant torque under which a synchronous motor will pull into synchronism at rated rotor supply voltage and frequency is known as___.
a. Pull-up torque
b. Pull-out torque
c. Pull-in torque
d. None of the above

47. For inverted V-curves for a synchronous motor the graph is drawn between___.
a. Armature current and power factor
b. Terminal voltage and load factor
c. Field current and armature current
d. Power factor and field current

48. The induced emf in a synchronous motor working on lagging power factor will be
a. More than the supply voltage
b. Slightly than the supply voltage
c. Equal to the supply voltage
d. Less than the supply voltage

49. A 3-phase synchronous motor is running clockwise. If the direction of the field current is reversed the motor will____.
a. Stop
b. Run in the same direction
c. Run in the reverse direction
d. Burn its windings

<u>Questions 50 to 54 refer to the following data:</u>

A 3-phase, 100 hp, 60 Hz, 480 V, 4-pole, wye-connected, cylindrical rotor synchronous motor has an armature resistance of 0.15 Ω and a synchronous reactance of 2 Ω per phase, respectively. At the rated load and a leading power factor of 0.8, the motor efficiency is 0.95. Determine the following:

50. The motor input power (P_m).
a. 74.60 kW
b. 746 W
c. 78.53 kW
d. 75.00 kW

51. Armature current (I_a).

a. 112 A
b. 195 A
c. 129A
d. 118 A

52. Back emf or the internal generated voltage (E_b).

a. 451 V
b. 516 V
c. 172 V
d. 277 V

53. Maximum power developed (P_{in} max).

a. 187.478 kW
b. 100.688 kW
c. 62.49 kW
d. 108.24 kW

54. Maximum or pull-out torque (T_g max).

a. 994.98 Nm
b. 331.53 Nm
c. 1.24 Nm
d. 994.61 N

Questions 55 to 58 refer to the following data:

A 3-phase, star-connected alternator is rated at 1800 kVA, 14000 V. The armature effective resistance and synchronous reactance are 1.6 Ω and 35 Ω respectively per phase. The alternator was loaded with 1300 kW at power factors of (a) 0.8 leading, (b) 0.7 lagging (c) unity. Determine the following parameters.

55. The armature current or the line current.

a. 132.65 A
b. 76.59 A
c. 53.61 A
d. 67.01 A

56. Voltage regulation for a leading power factor.

a. -12.97 V
b. -10.98 V
c. -17.33 V
d. -14.18 V

57. Voltage regulation for a lagging power factor.

a. 23.16
b. 26.64
c. 18.32
d. 47.89

58. Voltage regulation for a unity power factor.

a. 6.78
b. 5.40
c. 3.69
d. 17.6

59. If an alternator winding has a fractional pitch of 5/6, the angle of short pitch is ____.

a. 180
b. 150
c. 30
d. 60

60. A 500 kW, 3-phase, 440 volts, 50 Hz, A.C. induction motor has a speed of 960 rpm on full load. The machine has 6 poles. The slip of the machine will be___.

a. 0.01
b. 0.03
c. 0.02
d. 0.04

Section B [40 MARKS]

Answer all questions

Q1.

a. A 12 MVA,400V, 50 Hz, 3-phase delta-connected alternator is driven at 50 rps, there are 2 coil sides per slots and 16 turns per coil. The armature has 24 slots on its periphery. The pole pitch is 1 slot less than the full pitch. Calculate:
   i. The winding factor and comment on your answer.
   ii. The flux per pole.
   iii. The full load current per conductor.

b. With the aid of a well labelled diagram, briefly explain the autotransformer starting of the 3-phase induction motor in not more than 6 lines.

c. i. What is synchronous condenser?
   ii. With the aid of a well labelled power flow and phasor diagrams explain the concept or power factor improvement by synchronous condenser method.

d. State four (4) advantages of parallel operation of alternators.

e. Draw the phasor diagram for an alternator whose armature terminals is connected with a capacitive load.

[25 Marks]

Q2.

a. State the main difference between constant losses and variable losses and give two (2) examples each of these losses.

b. The rotor resistance and reactance per phase of a 3-phase, 50 Hz, 440 V induction motor having 2-pole star connected stator winding are 0.2 Ω and 1.5 Ω respectively. If full-load slip is 5% and stator to rotor ratio is 4:1, Calculate:
   i. Total mechanical power developed in kW.
   ii. Total torque developed.
   iii. The speed at maximum torque, and
   iv. Maximum torque.

[15 Marks]

***Examiners*: R. A. OFOSU**/ E. NORMANYO