QUESTION BOOKLET

A

ELECTRICAL ENGINEERING (06)

Time Allowed : 3 Hours
[1 Hour for Objective
2 Hours for Subjective]

Maximum Marks : 200
[100 Marks for Objective
100 Marks for Subjective]

SEAL

INSTRUCTIONS FOR CANDIDATES

1. This Question Booklet consists of **two** Parts (Objective and Subjective). Candidate has to attempt both the Parts.

2. **In Objective Part, there are 50 questions carrying 2 marks each. There is no negative marking for any wrong answer. In Subjective Part, four (4) questions should be answered in which Question No. 1 is compulsory.**

3. Please do not open this Question Booklet until you are told to do so.

4. Candidate must fill up the necessary information in the space provided on the OMR Answer Sheet before commencement of the test.

5. For marking the correct answer, darken one circle by **black or blue** ball-point pen only. Please do not mark on more than one circle. Darkening on more than one circle against an answer will be treated as wrong answer.

6. Do not detach any leaf from this Question Booklet. After the examination, hand over the OMR Answer Sheet to the Room Invigilator.

7. Possession and use of Calculator, Mobile Phone and Pager is prohibited in the Examination Hall.

8. Candidates are informed that evaluation of OMR Sheets will be done by Electronic Machine. So, they should shadow the bubbles of Roll No., Booklet Series and Booklet No. properly, otherwise Machine will not be able to evaluate it. Failure to comply this instruction will be sole responsibility of the candidates.

PART—A

(Objective)

1. Power transfer capability of a HVDC transmission line varies with distance as

   (A) square of the distance

   (B) square root of the distance

   (C) independent of the distance

   (D) directly with the distance

2. The time of operation of distance relay is a function of

   (A) magnitude of fault current

   (B) magnitude of line voltage at the relay

   (C) ratio of the line voltage at the relay to the fault current

   (D) ratio of the fault current to the line voltage at the relay

3. The moderator used in fast breeder reactor is

   (A) graphite

   (B) heavy water

   (C) ordinary water

   (D) None of the above

4. In order to have lower cost of electric energy generation

   (A) the load factor and diversity factor should be low

   (B) the load factor should be low but the diversity factor should be high

   (C) the load factor should be high but the diversity factor should be low

   (D) both the load factor and diversity factor should be high

5. For transient stability of a system, which of the following is correct?

   (A) $\dfrac{d\delta}{dt} > 0, \dfrac{dP}{d\delta} > 0$

   (B) $\dfrac{d\delta}{dt} < 0, \dfrac{dP}{d\delta} < 0$

   (C) $\dfrac{d\delta}{dt} = 0, \dfrac{dP}{d\delta} > 0$

   (D) $\dfrac{d\delta}{dt} < 0, \dfrac{dP}{d\delta} = 0$

6. Which relays are best suited for the detection of the occurrence of severe synchronizing power surges?

   (A) Reactance relays

   (B) Split-phase relays

   (C) mho relays

   (D) Impedance relays

7. Series compensation on EHV lines is resorted to

(A) reduce the fault level

(B) improve the stability

(C) as a substitute for synchronous phase modifier

(D) None of the above

8. The mechanical power developed by the d.c. motor is maximum, when

(A) back e.m.f. is equal to applied voltage

(B) back e.m.f. is equal to zero

(C) back e.m.f. is equal to half of the applied voltage

(D) None of the above

9. In the equivalent circuit of double-cage induction motor, the two rotor cages can be considered

(A) in parallel

(B) in series-parallel

(C) in series

(D) in parallel with stator

10. When a bank of two single-phase transformers in an open delta arrangement is used, each of them supplies

(A) 33·3% of its output rating

(B) 86·6% of its output rating

(C) 76·6% of its output rating

(D) 66·6% of its output rating

11. Under balanced load conditions, main transformer rating in the Scott connection is

(A) 10% greater than teaser transformer

(B) 15% greater than teaser transformer

(C) 20% greater than teaser transformer

(D) 25% greater than teaser transformer

12. The leakage reactance of a 3-phase alternator is determined by performing

(A) open-circuit and zero power factor tests

(B) zero power factor and slip tests

(C) open-circuit and short-circuit tests

(D) short-circuit and slip tests

13. What would happen if the field of d.c. shunt motor is opened?

(A) The speed of the motor will be reduced

(B) It will continue to run at its normal speed

(C) The speed of the motor will be enormously high and might destroy itself

(D) The current in the armature will increase

14. The heating time constant of an electrical machine gives an indication of its

(A) temperature rise

(B) normal rating

(C) overload capacity

(D) short-time rating

15. For the minimum-phase system to be stable

(A) phase margin should be negative and gain margin positive

(B) phase margin should be positive and gain margin negative

(C) both phase margin and gain margin should be positive

(D) both phase margin and gain margin should be negative

16. In control systems excessive bandwidth is not employed, because

(A) noise is proportional to bandwidth

(B) noise is proportional to the square of bandwidth

(C) it leads to low relative stability

(D) it leads to slower response

17. Integral error compensation in a control system

(A) increases steady-state error

(B) minimizes steady-state error

(C) reduces steady-state error to zero

(D) has no effect on steady-state error

18. The damping ratio of the characteristic equation

$$s^2 + 2s + 8 = 0$$

is

(A) 0·353

(B) 0·350

(C) 0·300

(D) 0·333

19. In a nonlinear control system, limit cycle is self-sustained oscillation of

(A) variable amplitude

(B) variable frequency

(C) fixed frequency

(D) fixed frequency and amplitude

20. When a charge is given to a conductor

(A) it distributes uniformly all over the surface

(B) it distributes uniformly all over the volume

(C) it distributes on the surface, inversely proportional to the radius of curvature

(D) it stays where it was placed

21. What is the purpose of impedance matching between the output of previous stage and the input of next stage in cascaded amplifier?

(A) To achieve high efficiency

(B) To achieve maximum power transfer

(C) To achieve reduced distortion

(D) To achieve reduced noise

22. Which one of the following is considered as amplitude-modulated signal?

(A) BPSK

(B) DPSK

(C) PSK

(D) None of the above

23. An amplifier without feedback has a gain of 1000. What is the gain with a negative feedback of 0·009?

(A) 900

(B) 125

(C) 100

(D) 10

24. Which one of the following factors is limited in case of FM?

(A) Maximum frequency

(B) Maximum permissible modulation index

(C) Signal-to-noise voltage ratio

(D) minimum permissible modulation index

25. A modulator is a device to

(A) separate two frequencies

(B) impress the information onto a radio frequency carrier

(C) extract information from the carrier

(D) amplify the audio frequency signal

26. Darlington pair is mainly used for

(A) impedance matching

(B) wide-band voltage amplification

(C) power amplification

(D) reducing distortion

27. What is the main source of distortion in a push-pull amplifier?

(A) Fundamental component

(B) Second harmonic

(C) All even harmonics

(D) Third harmonic

28. In the root locus analysis, the angle between adjacent asymptotes is

(A) $\dfrac{180°}{m+n}$

(B) $\dfrac{360°}{m+n}$

(C) $\dfrac{180°}{m-n}$

(D) $\dfrac{360°}{m-n}$

29. A feedback control system is represented by the equation

$$\frac{d^2e}{dt^2}+6\cdot4\frac{de}{dt}=160\,e$$

where $e=r-0\cdot4c$ and c is the output variable, r is the input variable.

The value of damping ratio is

(A) 0·4

(B) 0·15

(C) 1/6·4

(D) 1·00

30. Human system is

(A) an open-loop control system

(B) a closed-loop control system

(C) a multivariable feedback control system

(D) a complex control system

31. For

$$0 < \xi < \frac{1}{2}$$

ω_r is equal to

(A) 0

(B) $\dfrac{\omega_n}{\sqrt{1-\xi^2}}$

(C) $\omega_n \sqrt{1-\xi^2}$

(D) $\omega_n \sqrt{1-2\xi^2}$

32. The AND function can be realized by using N number of NOR gates. The minimum value of N is

(A) 2

(B) 3

(C) 4

(D) 5

33. A program structure that allows the repeated operation of a particular sequence of instructions until a specified termination is reached is called

(A) subroutine

(B) machine

(C) module

(D) loop

34. The disadvantage of dynamic storage elements is that

(A) storage cells are to be refreshed frequently

(B) information stored previously is lost

(C) power has to be kept on

(D) None of the above

35. Every processor must necessarily have

(A) a data bus

(B) a data bus and an address bus

(C) a control bus

(D) a data bus, a control bus and an address bus

36. Algorithm is used

(A) to bring itself into desired state by its own action

(B) to perform logarithmic operation

(C) to describe a set of procedures by which the given result is obtained

(D) None of the above

37. Programmable logic array (PLA) uses

(A) ROM matrices

(B) PROM matrices

(C) RAM matrices

(D) Silo memory

38. Byte is synonymous with

(A) band

(B) character

(C) bit

(D) word

39. The speed of digital ICs indicates

(A) the rate at which output changes

(B) how fast input triggers the output

(C) how fast a flip-flop can change stages

(D) None of the above

40. In load flow studies a PV bus is treated as a PQ bus, when

(A) voltage at the bus becomes high

(B) reactive power goes beyond limit

(C) phase angle becomes high

(D) None of the above

41. The method of neutral grounding affects the

(A) positive sequence network

(B) negative sequence network

(C) zero sequence network

(D) All of the above

42. A synchronous generator is feeding an infinite bus. A shunt reactor is added at the infinite bus. The stability limit will

(A) increase

(B) decrease

(C) remain the same

(D) Any of the above

43. The insulation strength of EHV lines is mainly governed by

(A) switching over voltages

(B) lightning over voltages

(C) power frequency over voltages

(D) None of the above

44. The reactive power transfer over a line mainly depends on

(A) power angle

(B) V_r

(C) $|V_s| - |V_r|$

(D) V_s

45. The corona loss in a 50-Hz system is 0·2 kW/phase/km. At a frequency of 60 Hz, the corona loss would be

(A) 0·17 kW/phase/km

(B) 0·24 kW/phase/km

(C) 0·22 kW/phase/km

(D) 0·34 kW/phase/km

46. For a transmission line

$V_s = AV_r + BI_r$ and $I_s = CV_r + DI_r$

Then, I_r equals

(A) $CV_s + AI_s$

(B) $DV_s + AI_s$

(C) $DV_s - BI_s$

(D) $AV_s + DI_s$

47. A large number of commutator segments are used in a d.c. machine to

(A) increase the magnitude of the output voltage

(B) increase the output current of the generator

(C) increase the kW power output

(D) make the d.c. output wave smooth

48. If the armature current is increased to double its previous value and the time of commutation is halved, the reactance voltage will

(A) be halved

(B) remain the same

(C) be doubled

(D) become four times

49. If the field current of a shunt motor is changed, then

(A) its torque remains constant but the horsepower will change

(B) the horsepower remains constant but the torque will change

(C) both torque and horsepower will change

(D) both torque and horsepower will remain constant

50. The main purpose of the conservator in a transformer is to

(A) store extra oil to compensate for the loss of oil due to leakage

(B) achieve better cooling of the transformer

(C) take up the expansion of oil due to heating

(D) have the Buchholz relay fitted

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ELECTRICAL ENGINEERING (06)

PART—B

(Subjective)

Full Marks : 100   **Time : 2 hours**

The figures in the margin indicate full marks for the questions

Candidates are required to answer **four** questions of which
Question No. **1** is compulsory

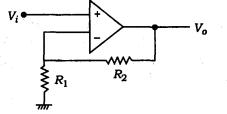1. Answer any *five* of the following questions :   5×5=25

   (a) Indicate the functions of 'compiler' and the steps involved to obtain a
   solution using a digital computer.

   (b) Develop the flowchart to read a 2-digit positive integer number and
   find the sum of the two digits.

   (c) Describe two techniques of braking of d.c. shunt motors. Provide
   necessary circuit diagrams.

   (d) Explain the term short-circuit ratio (SCR) in the context of an
   alternator.

   (e) Explain briefly why an induction motor takes about 6–7 times of its
   rated current during direct on-line starting.

   (f) Describe Ferranti effect in a long EHV transmission line. Also describe
   the steps to be taken to remove its adverse effects.

   (g) The open-loop transfer function of a unity feedback system is given by

   $$G(s) = \frac{k}{s(1+0\cdot 5s)(1+0\cdot 2s)}$$

   Find the gain margin.

(h) Obtain the expression for gain for the circuit given below :

2. *(a)* Describe critical speed and critical field resistances in the context of a d.c. shunt motor. Explain with necessary sketches. **10**

(b) A d.c. series motor with armature resistance of $0.5\,\Omega$ and brush resistance of $0.3\,\Omega$ runs at 1500 r.p.m. at 200 V taking a current of 20 A. Find the new speed of the machine when its armature resistance increases to double its initial value while taking same current from the source. Assume linear magnetic characteristic for the machine. **15**

3. *(a)* A one-phase transformer of 30 kVA, 3000/300 V rating produced the following test results :

(i) Leakage impedance of the high-voltage (HV) winding
$$= (0.5 + j0.8)\,\Omega$$

(ii) Leakage impedance of the low-voltage (LV) winding
$$= (0.005 + j0.008)\,\Omega$$

(iii) Shunt branch admittance as seen from high voltage (HV) winding $= (0.25 - j2.5)\,\mho$

Draw the equivalent circuits of the transformer referred to both high-voltage (HV) and low-voltage (LV) sides. **10**

(b) Define all-day efficiency of a transformer. A 100-kVA single-phase transformer has maximum efficiency of 98% at full load and unity p.f. The load cycle of the transformer is as below :

12 hrs—25 kW at p.f. of 0.6 lag

6 hrs—20 kW at p.f. of 0.8 lag

6 hrs—15 kW at p.f. 0.9 lag

Calculate the 'all-day efficiency' of the transformer. **2+13=15**

4. *(a)* Deduce the expression of torque developed in a three-phase induction machine as a function of slip. Also define 'slip' of the machine. Show the characteristics with the help of neat sketch and comment on the operation of the machine when slip goes to negative value. **6+2+2=10**

(b) Explain the relative merits and demerits of a double-cage induction motor over a single-cage machine.

The standstill impedances of the outer and inner cage of a double-cage induction machine are $(0.3 + j0.5)\,\Omega$ and $(0.1 + j1.5)\,\Omega$ respectively. Calculate the current and torque ratios of the two cages *(i)* at standstill, *(ii)* at a slip of 4%.   5+10=15

5. *(a)* Explain why the cylindrical rotor alternators have lower diameter and larger length compared to a salient pole alternators of equivalent rating.   5

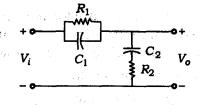*(b)* What is a synchronous condenser? Explain its operation with the help of phasor diagram.   5

(c) What is synchronous impedance? Find the synchronous impedance of a three-phase star-connected alternator which produces a short-circuit armature current of 200 A for a given field current. The same field current produces 2000 V line-to-line on open circuit. Also calculate its per phase synchronous reactance when the measured d.c. resistance between the two terminals is $3.0\,\Omega$. Assume d.c. resistance and a.c. resistance are same for the machine.

What is the terminal voltage of the machine when a load of 250 A at 0.8 lagging p.f. is switched on at same field current mentioned above?
2+8+5=15

6. *(a)* Explain what is transfer function of a system indicating its properties. Find the transfer function of the network shown below :   10
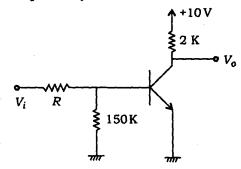

(b) An open-loop transfer function of a unity feedback system is given by

$$G(s) = \frac{20}{s(s+3)} \cdot s$$

Determine damping factor, undamped natural frequency, damped natural frequency and the time response for a unit step input.   10

(c) For a second-order system to a step input, define delay time, peak overshoot, settling time and steady-state error. 5

7. (a) For the circuit given below the transistor has $\beta \approx 30$ and $I_{CBO} \approx 10$ nA. Find—

(i) the minimum value of R for the transistor to remain in the active region for $V_i = 10$ V;

(ii) the value of V_o for $V_i = 1$V and $R = 150\,k\Omega$. 5+5=10

(b) Minimize the four-variable logic function using K-map

$$f(A, B, C, D) = \Sigma m(0, 1, 2, 3, 5, 7, 8, 9, 11, 14)$$ 10

(c) Find the output voltage for the following op-amp circuit : 5

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SPACE FOR ROUGH WORK

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