ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2021
EXAMINATION CATEGORY: TECHNICAL

PAPER III: SUBJECT SPECIALISATION PAPER FOR ELECTRICAL ENGINEERING

Date : October 31, 2021
Total Marks : 100
Writing Time : 150 minutes (2.5 hours)
Reading Time : 15 minutes (prior to writing time)

GENERAL INSTRUCTIONS:

1. Write your Registration Number clearly and correctly on the Answer Booklet.
2. The first 15 minutes is provided to check the number of pages of the Question Paper, printing errors, clarify doubts and to read the instructions. You are NOT permitted to write during this time.
3. This paper consists of **TWO SECTIONS**, namely SECTION A & SECTION B:
   - **SECTION A** has two parts: Part I - 30 Multiple Choice Questions
     Part II - 4 Short Answer Questions

     All questions under SECTION A are COMPULSORY.
   - **SECTION B** consists of two Case Studies. Choose only **ONE** case study and answer the questions of your choice.
4. All answers should be written on the Answer Booklet provided to you. Candidates are not allowed to write anything on the question paper. If required, ask for additional Answer Booklet.
5. All answers should be written with correct numbering of Section, Part and Question Number in the Answer Booklet provided to you. Note that any answer written without indicating the Section, Part and Question Number will NOT be evaluated and no marks will be awarded.
6. Begin each Section and Part on a fresh page of the Answer Booklet.
7. You are not permitted to tear off any sheet(s) of the Answer Booklet as well as the Question Paper.
8. Use of any other paper including paper for rough work is not permitted.
9. **You must hand over the Answer Booklet to the Invigilator before leaving the examination hall.**
10. This paper has **10 printed pages**, including this instruction page.

GOOD LUCK

SECTION A

PART I: Multiple Choice Questions [30 marks]

Choose the correct answer and write down the letter of your chosen answer in the Answer Booklet against the question number e.g. 31 (d). Each question carries ONE mark. Any double writing, smudgy answers or writing more than one choice shall not be evaluated.

1. ACSR conductor implies
   a) All conductors surface treated and realigned.
   b) Aluminum conductor steel reinforced.
   c) Ariel-bundled cable steel reinforced.
   d) Anodized Core smooth run.

2. A 25 kVA, single-phase transformer has 250 turns on the primary and 40 turns on the secondary winding. The primary is connected to 1500V, 50 Hz mains. The maximum flux in the core is
   a) 0.027 Wb
   b) 0.27 Wb
   c) 0.054 Wb
   d) 0.54 Wb

3. In star connected system:
   a) Line Current = $\sqrt{3}$ x Phase current
   b) Phase Current = $\sqrt{3}$ x Line Current
   c) Line Current = Phase Current
   d) Line Voltage = Phase Voltage

4. An electric heater is used for 150 minutes. The electricity bill for 30 days is 75 units. Calculate the power of the electric heater.
   a) 1.875 kW
   b) 1 kW
   c) 3 kW
   d) 187.5 kW

5. Corona effect can be detected by
   a) hissing sound.
   b) faint luminous flow of bluish colour.
   c) presence of ozone detected by odour.
   d) All of the above.

6. Ten discs usually suggest that the transmission line voltage is
   a) 11 kV
   b) 33 kV
   c) 66 kV
   d) 132 kV

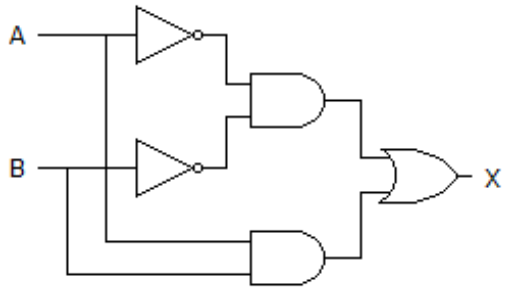
7. A shunt generator running at 1000 rpm has generated emf of 100V. If the speed increases to 1200 rpm, the generated emf will be nearly
   a) 175
   b) 140
   c) 120
   d) 240

8. Hopkinson test is conducted under which of the following condition?
   a) No load
   b) Full load
   c) Half load
   d) All of the above.

9. When Flemings Right Hand rule is used to find the direction of induced emf, the thumb points towards
   a) opposite to the direction of motion of the conductor.
   b) direction of motion of the conductor.
   c) direction of induced emf.
   d) direction of flux.

10. Creeping is the phenomenon which occur in
    a) Voltmeter
    b) Ammeter
    c) Energy meter
    d) Wattmeter

11. The circuit of the given figure realizes which of the following functions?



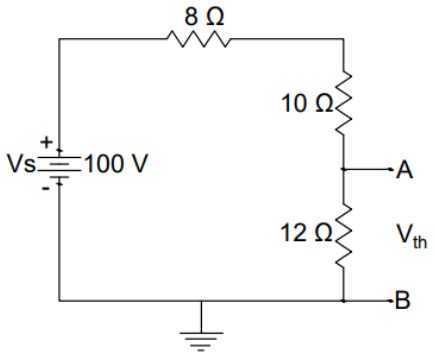
    a) $X = A\bar{B} + \bar{A}B$
    b) $X = \overline{\bar{A}B} + \bar{A}\bar{B}$
    c) $X = \overline{\bar{A}B} + AB$
    d) $X = \bar{A}\bar{B} + AB$

12. The 2's complement of binary number 1010 is
    a) 0101
    b) 1010
    c) 0110
    d) 1110

13. A relay on long transmission line is
    a) Admittance relay
    b) Reactance relay
    c) Impedance relay
    d) Ohm's relay

14. Which distribution system is more reliable?
    a) Ring main system
    b) Tree system
    c) Radial system
    d) All are equally reliable

15. The Thevenin equivalent (V_{th} and R_{th}) between terminals A and B of the circuit given below is



    a) 99.96 V, 12 Ω
    b) 40 V, 7.2 Ω
    c) 66.67 V, 7.2 Ω
    d) 66.67 V, 12 Ω

16. Which of the quantity consists of SI unit as Candela?
    a) Velocity
    b) Impulse
    c) Luminous Intensity
    d) Force

17. Thin laminations are used in a machine in order to reduce
    a) Eddy current losses
    b) Hysteresis losses
    c) Both 1 and 2
    d) Copper losses

18. The emf induced in the DC generator armature winding is
    a) AC
    b) DC
    c) AC and DC
    d) None of the above

19. Series generators are used in which of the following applications?
    a) Air crafts
    b) Arc Welding
    c) Used as boosters in DC distribution or transmission
    d) All of the above

20. When length of the cable is doubled, its capacitance C will be
    a) One-fourth
    b) One-half
    c) Doubled
    d) Unchanged

21. Maximum power transfer capability of transmission line can be increased by
    a) parallel transmission lines.
    b) using series capacitance.
    c) using bundled conductors.
    d) All of the above.

22. Ferranti effect will not occur in which of the following transmission lines?
    a) Long transmission lines
    b) Short transmission lines
    c) Medium transmission lines
    d) All of the above.

23. Which of the following method is used for changing power factor from leading to lagging?
    a) Shunt capacitor
    b) Series capacitor
    c) Shunt reactor
    d) Any of the above

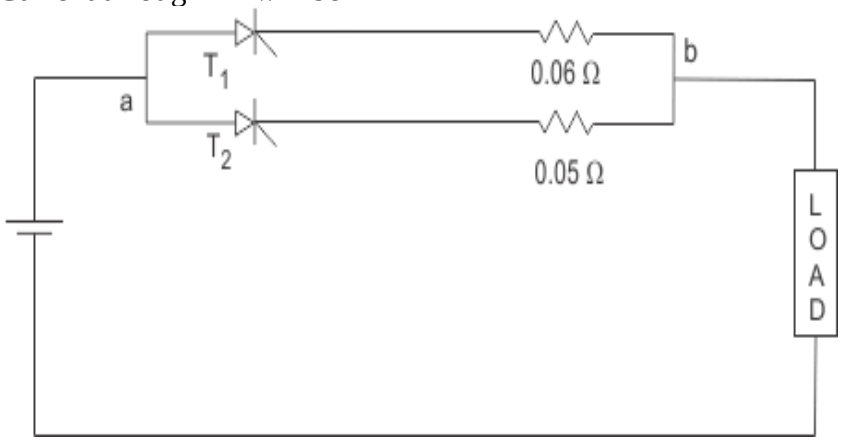
24. Specified quantities of load bus are
    a) P and Q
    b) V and δ
    c) P and δ
    d) Q and V

25. Find the number of strands of ACSR conductor for 4-layer transmission line?
    a) 1
    b) 7
    c) 37
    d) 29

26. The skin effect shows that
    a) the distribution of AC current is uniform through the cross section of the conductor.
    b) turrent density is more at the center of the conductor.
    c) turrent density is lower at the surface of the conductor.
    d) current density is more at the surface of the conductor.

27. Surge impedance loading of a 3-phase, 400 kV transmission line is 400 Ω. The surge impedance loading is
    a) 400 MW
    b) 800 MW
    c) 1600 MW
    d) 200 MW

28. Figure shows two thyristors rated 400 A sharing a load current. Current through T2 is 180A. Current through T1 will be



    a) 100 A
    b) 150 A
    c) 120 A
    d) 110 A

29. Which following is a two terminal three-layer device?
    a) BJT
    b) Power diode
    c) MOSFET
    d) None of above

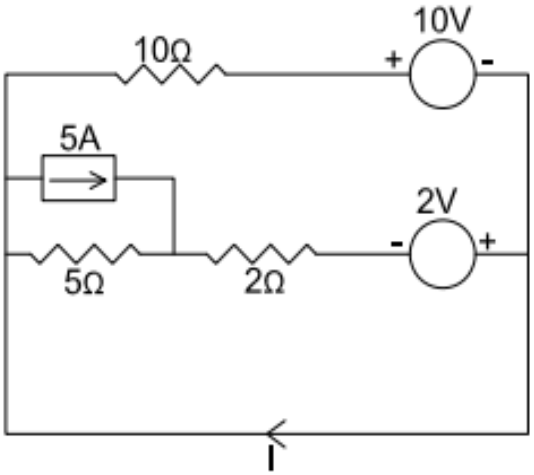
30. A power MOSFET has three terminals called
    a) Collector, emitter and gate
    b) Drain, source and gate
    c) Drain, source and base
    d) Collector, emitter and base

PART II – Short Answer Questions [20 marks]

This part has 4 Short Answer Questions. Answer ALL the questions. Each question carries 5 marks. Mark for each sub-question is indicated in the brackets.

1. What is the difference between DC shunt motor and generator? The 8-pole D.C shunt generator with 778 wave-connected armature conductors and running at 500 r.p.m supplies a load of 12.5Ω resistance at terminal voltage of 250 V. The armature resistance is 0.24Ω and the field resistance is 250Ω. Find the armature current, the induced e.m.f and the flux per pole. Show the circuit diagram. (5 marks)

2. State Superposition Theorem. Find the current "I" for the circuit shown using Superposition theorem. (5 marks)



3. A transformer is rated at 100KVA. At full load, its copper loss is 1200 W and its iron loss is 960 W. Calculate:
   a) The efficiency at full load, unity power factor. (1 mark**)**
   b) The efficiency at half full load, 0.8 power factor. (1 mark)
   c) The load KVA at which maximum efficiency will occur. (1 mark)
   d) The maximum efficiency at 0.85 power factor and iron loss and copper loss in this case. (2 marks)
4. What is Buchholz relay? Which equipment is protected by it? Discuss its working principle. **(**5 marks)

SECTION B: CASE STUDY [50 marks]

Choose either CASE I OR CASE II from this section. Each case study carries 50 marks. Mark for each sub-question is indicated in the brackets.

CASE I

You are a newly selected electrical engineer in the Department of Renewable Energy, Ministry of Economic Affairs. The Department is in the verge of implementing one of the biggest Renewable Energy (RE) projects in the country through installation of 50 kW Solar Photovoltaic (PV) Plant essentially to augment the energy deficit during the lean (winter) seasons and also to diversify the energy at source. Your supervisor entrusted you with the detailed project design works for the implementation of the project due to acute dearth of staff in the office. With this task in your hand, please answer the following questions:

1. What do you understand by the term Renewable Energy? Provide some examples of Renewable Energy in Bhutan (2 marks)
2. What are the basic components required for the solar PV system? (2 marks)
3. What is the principle of solar photovoltaic conversion of solar energy? (1 mark)
4. What is meant by array and string in solar PV system? (2 marks)
5. What is your consideration for the most appropriate site selection? Why? (2 marks)
6. What is the difference between Monocrystalline and Polycrystalline Solar Module? (2 marks)
7. From the above two kind of modules, which one would you prefer? Why? (2 marks)
8. In which direction should the panel be facing for optimum exposure to the sun? (1 mark)
9. What should be the tilt angle of the panel for optimum exposure to the sun in our context? Support your answer with appropriate reason(s). (2 marks)
10. What Solar Module Wattage rating are you going to choose for the above project? Why? (2 marks)
11. With your chosen wattage rating of the solar module, calculate how many numbers of module you would require to achieve 50kW install capacity. Assume 75% module operating factor and no other losses. What will be the energy produced in a day if average sunshine hour is 5 hours a day (3 marks)
12. What do you understand by the term solar irradiance? How it is being measured or what is its unit? (2 marks)
13. Briefly explain how the temperature affects the overall efficiency of solar panel? (2 marks)
14. What device are you going to use to convert DC power into AC power? What should be your device rating for above system? (2 marks)
15. How is DC power different from AC power? (2 marks)

16. What is power factor in AC circuit? What causes poor power factor? How can we improve power factor? (3 marks)
17. What is meant by Capacity Utilization Factor (CUF) of the solar power plant? (1 mark)
18. What is the solar PV fill factor? Demonstrate it with Current (I) and Voltage (V) curve graph (3 marks)
19. Explain and illustrate with the schematic diagram of a typical off-grid solar PV plant system (from source to the load) (5 marks)
20. What is the purpose of battery in solar PV system? What is the most common type of solar PV batteries found in the market today and how are they usually rated in? (2 marks)
21. How will you explain and convince the general public on why we need to switch into the Renewable Energy particularly Solar? (3 marks)
22. Why do you think Renewable Energy in Bhutan has not picked up as it should be? What measures would you propose for smooth and successful transition to the Renewable Energy (especially Solar and Wind) in Bhutan? (4 marks)

CASE II

The School Planning and Building Division under the Ministry of Education has a project to construct schools in various parts of the country. During the initial package, there was no plan to construct Multi-Purpose Halls (MPH) taking into account the budget constraint. However, the Ministry has later on decided to include MPH in the same package only for the selected schools. You have just joined the Division as an Electrical Engineer and entrusted with the responsibilities to prepare electrical designs and estimates for MPH to be added to the project package. You are assigned as a Project Engineer looking after the construction of school at Dotey in Paro. Answer the following questions to determine your competence for the assignment. (Assume that the structure is the same for all the schools). Data for the project is given below:

Sl. No.	LED Fittings & fixtures	Rating	Output (Lumen/Watt)
1	LED Tube light	100 W each	80
2	Exhaust fan (4 Nos.)	80 W each	-
3	Power point (8 Nos.)	2000W each	-

The dimension (LxBxH) in meter of the hall as per Architectural drawing is (20x10x6)
Assume: Lux level required is 400 lux, Maintenance factor (Mf) is 0.6, Utilization factor (Uf) is 0.7, load factor is 60% and power factor is 0.85.
Note: Choose 3-phase if connected load > 12kW if not single phase

1. As an Electrical Engineer, what are the minimum set of requirements you would include in your wiring design to make it an easy reference while executing? (2 marks)
2. What is meant by the distribution board? (1 mark)

3. What is Luminous flux? Mention its SI unit. Calculate the number of luminaires (N) required. (4 marks)
4. What do you understand by connected load and demand load? Calculate the total connected load and the demand load. (3 marks)
5. What is voltage? What are the supply voltages for single and three phase system used in Bhutan? (2 marks)
6. Which phase system is suitable for the load you have calculated? Calculate the rating of the circuit breaker in ampere (supply voltage will depend on phase system you have chosen). (3 marks)
7. Differentiate between single phase and three phase supply system. (2 marks)
8. In earlier design calculation (excluding MPH), the total load was found to be 100kW. What is the total connected load and demand load including MPH? What would be the breaker ampere rating of the main distribution board? Which circuit breaker would you use as per your calculation and why? (3 marks)
9. As per the requirement of a power company, a distribution transformer is required to be installed for the load calculated. Compute the kVA rating of the transformer considering power factor to be 0.85. Why are transformers rated in kVA? Describe the working principle of a transformer. (4 marks)
10. Ten 100 W LED bulbs are used for 8 hours every day for 30 days. Find the cost of electricity to be paid to the power company if the rate is Nu.2.50 per unit and the first 100 units of energy is free. (3 marks)
11. Why are LEDs preferred over ordinary bulbs? Which type of MCB is suitable for LED lighting? (2 marks)
12. What is earthing? Why is it important to have earthing? What are the types of earthing? Draw few differences between earthing and grounding. How is lightning arrester different from surge arrester? (5 marks)
13. What is RCCB and ELCB? Which is better to use in wiring and why? (2 marks)
14. An energy meter is designed to have 80 revolutions of the disc per unit of energy consumed. The load is carrying 30 A at 230 V and 0.85 power factor. Find the percentage error if the meter actually makes 467 revolutions. Also specify whether the meter runs slower or faster. (4 marks)
15. What are some of the commonly used wiring system in Bhutan? Which type of wiring system gives more mechanical and fire protection? (2 marks)
16. The school authority is considering vertical extension of the MPH for hosting a central library. What will be your design considerations? If the connected load for the library is calculated to be 20 kW, what is the new total load of MPH? Is existing transformer rating sufficient to carry the additional load safely? (3 marks)
17. To be able to safely withstand the new load, what must be the circuit breaker rating of the sub-distribution board of MPH? Mention if the existing breaker can withstand the additional load. (2 marks)
18. What is meant by the voltage grading of cables? What is the difference between wire and cable? (2 mark)
19. What is busbar? (1 mark**)**