

**ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2019
EXAMINATION CATEGORY: TECHNICAL**

PAPER III: SUBJECT SPECIALISATION PAPER FOR ELECTRICAL ENGINEERING

Date	: October 13, 2019
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 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 in 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 are required to hand over the Answer Booklet to the Invigilator before leaving the examination hall.**
10. This paper has **11 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. If the field current is decreased in shunt dc motor, the speed of motor will
 - a) decrease.
 - b) remains the same.
 - c) increase.
 - d) None of the above.

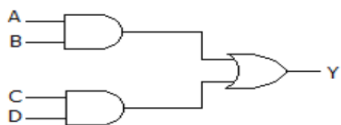
2. Hysteresis current will depend on
 - a) f
 - b) f^2
 - c) $1/f$
 - d) $f^{1.6}$

3. A DC generator without commutator is a
 - a) DC Motor.
 - b) DC Generator.
 - c) AC Generator.
 - d) Induction Motor.

4. A Shunt generator running at 1000 rpm has generated emf of 100 V. If the speed increases to 1200 rpm, the generated emf will be nearly
 - a) 210 V
 - b) 110 V
 - c) 220 V
 - d) 120 V

5. The power-factor of series resonant circuit is
 - a) Unity
 - b) Zero
 - c) 0.8 lagging
 - d) 0.8 leading

6. What is the output from gate below:



- a) $Y = ABC + D$
- b) $Y = ABCD$
- c) $Y = A + BCD$
- d) $Y = AB + CD$

7. For two inputs A and B from the logic gate, the outputs are as below:

A	B	Output
0	0	0
0	1	1
1	0	1
1	1	0

Which logic gate is used?

- a) XOR gates
- b) NOT gates
- c) OR gates
- d) NOR gates

8. Calculate the power across each 20 ohm resistance.

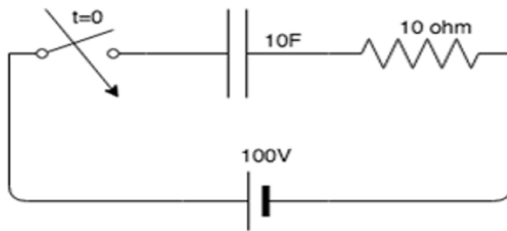


- a) 1000W, 1000W
- b) 500W, 500W
- c) 1000kW, 1000kW
- d) 500kW, 500Kw

9. A 250V bulb passes a current of 0.3A. Calculate the power in the lamp.

- a) 75W
- b) 50W
- c) 25W
- d) 90W

10. If the switch is closed at $t = 0$, what is the current in the circuit below:

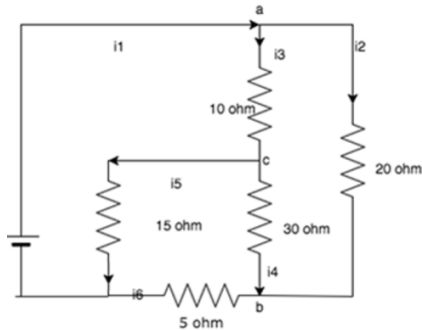


- a) 0 A
- b) 10 A
- c) 20 A
- d) Infinity

11. Magnetic field lines form _____ loops from pole to pole.

- a) open and closed alternately
- b) open
- c) closed
- d) branched

12. In the diagram below, find the current i_2 , i_4 and i_5 if $i_1=3A$, $i_3=1A$ and $i_6=1A$



- a) 2A, -1A and 2A respectively
- b) 4A, -2A and 4A respectively
- c) 2A, 1A and 2A respectively
- d) 4A, 2A and 4A respectively

13. For a purely inductive circuit with sinusoidal steady-state excitation, the voltage and current phasors, the current lags the voltage by

- a) 60°
- b) 90°
- c) 120°
- d) 180°

14. If the Q for generator is negative, then the reactive power is being

- a) generated.
- b) neutralized.
- c) absorbed.
- d) (a) and (b)

15. The transmission line parameters are

- a) resistance.
- b) resistance and capacitance.
- c) resistance and inductance.
- d) resistance, capacitance and inductance.

16. Fixed capacitor banks are used in distribution system in order to

- a) compensate for reactive power requirements at light loads.
- b) compensate for reactive power requirements at heavy loads.
- c) compensate for real power requirements at light loads.
- d) compensate for real power requirements at heavy loads.

17. Relay gets its operating energy from
- Alternator
 - Transformer
 - Overhead line
 - CT and PT
18. An impedance relay is used for
- Earth faults
 - Interphase faults
 - both (a) and (b).
 - None of the above.
19. The “one unit” of the energy measured in AC circuit is equivalent to
- one watt-hour.
 - one kilowatt-hour.
 - one watt.
 - one kilowatt.
20. Which of the following error may arise in wattmeter if it is not compensated for the errors?
- Voltage coil inductance
 - Voltage coil capacitance
 - Eddy Current
 - All of the above.
21. The internal resistance of ammeter and voltmeter will be
- infinity.
 - very high and very small respectively.
 - very small and very high respectively.
 - will be the same for both.
22. Gain margin of a first and second order system is
- zero
 - 100
 - 1
 - infinity
23. Frequency range over which response of the system is within acceptable limits is called system
- modulation frequency.
 - band width.
 - demodulation frequency.
 - carrier frequency.
24. Which of the following are normally used for transmission of power in the intermediate voltage range?
- Single phase system
 - 3 phase, 3 wire system
 - 3 phase, 4 wire system
 - 3 phase, 2 wire system

25. _____ is the greatest root mean square (effective) difference of potential between any two legs of the circuit.
- Phase voltage
 - RMS voltage
 - Line voltage
 - Ground Voltage
26. Which of the following wiring system can be used to attain safest possible multi-purpose distribution system for low voltage?
- Single phase, 2-wire system
 - 3 phase, 4-wire wye system
 - 3 phase, 4-wire delta system
 - 3 phase, 3-wire wye system
27. Which of the following coil will have large resonant frequency?
- A coil with large distributed capacitance.
 - A coil with low distributed capacitance.
 - A coil with large resistance.
 - A coil with low resistance.
28. The Laplace transform of the unit function is given by
- 1
 - 1/s
 - S
 - 1/s²
29. Which of the following statement is TRUE?
- The current in a discharging capacitor grows exponentially.
 - The current in a discharging capacitor decays exponentially.
 - The current in the discharging capacitor grows linearly.
 - The current in the discharging capacitor decreases constantly.
30. Which of the following indicates the units of displacement density?
- Ampere-meter
 - Coulomb-meter
 - Coulomb/m²
 - Volt m²

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. Assume that a 1 kV, 50 Hz substation supplies three different kinds of loads, as shown in the Figure 1.
 - a) Determine the power factor of the substation. (3 Marks)
 - b) What value of capacitance is needed in each leg of a Δ -connected capacitor bank installed in parallel with the loads to make the substation power factor unity? (2 Marks)
(Round up your answer to the nearest full value)

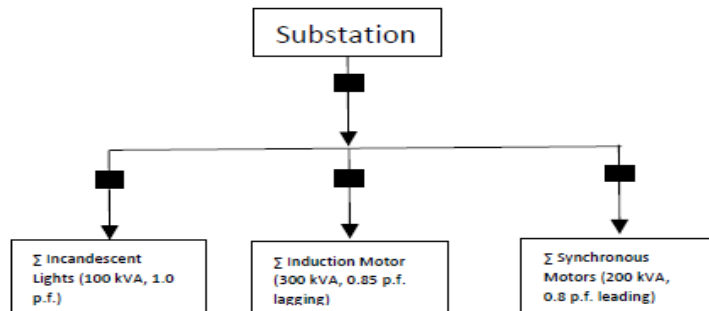


Figure 1.

2. Three resistors are connected in delta. If the line voltage is 11 kV and the line current is 1100 A, calculate the following:
 - a) The current in each resistor. (0.5 mark)
 - b) The voltage across each resistor. (0.5 mark)
 - c) The power supplied to each resistor. (1 mark)
 - d) The power supplied to the 3-phase load. (1 mark)
 - e) The ohmic value of each resistor. (1 mark)
 - f) Draw circuit diagram comprising key information. (1 mark)
3.
 - a) A transformers secondary no-load voltage is 480 volts and has a full load voltage measuring 465 volts. What would be the transformers regulation percentage? (1 mark)
 - b) A 37.5 KVA transformer has primary voltage rated at 480 volts and secondary voltage rated at 208 volts. What would be the primary and secondary line current? (1 mark)
 - c) With a secondary transformer output of 1,320 watts and a primary input of 1,800 watts, calculate the efficiency of the transformer. (1 mark)
 - d) With a turn's ratio of 1:2 and a secondary voltage of 960 volts, what would be the primary voltage? (1 mark)
 - e) What is the relation between current ratio and the voltage ratio of the transformer? (1 mark)

4. A single-phase motor draws a current of 16 A from a 240 V, 60 Hz line. A wattmeter connected into the line gives a reading of 2765 W.
- Calculate the power factor of the motor and the reactive power it absorbs. (1 mark)
 - If a capacitor having a reactance of 30Ω is connected in parallel with that motor, calculate:
 - The active power reading of the wattmeter. (0.5 mark)
 - The total reactive power absorbed by the capacitor and motor. (1 mark)
 - The apparent power of the AC line. (1 mark)
 - The line current. (1 mark)
 - The power factor of the motor/capacitor combination (0.5 mark)

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

Chhukha Hydro Power Plant is the oldest hydro power plant in the country with an installed capacity of 336 MW. It has four generating units with a rated output of 84 MW each. Each generator is of vertical shaft, salient pole, 93.333 MVA, 11kV, 50 Hz, 300 rpm, 0.9 pf with a continuous rated capacity of 102.66 MVA. The four Units are connected to two buses, Bus A and Bus B of 220 kV after the terminal voltage of 11kV is stepped up to 220kV through a 3X35MVA, 220/11kV generator transformers. The two buses are connected through a bus coupler. There are four 220 kV feeders, one going to Thimphu, one going to Malbase and two going to Birpara. To cater to the domestic load in the vicinity, there are 2X20 MVA, 220/66kV transformers with two 66kV feeders, one going to Olakha and one to Phuntsholing.

You are a new recruit in Chhukha Hydropower Plant. You are now given the responsibility to operate, maintain and bring new ideas to seamlessly have the power plant generate optimally and contribute to nation building. As an electrical engineer, answer the following:

- What are isolators and breakers? How are they different in terms of operation? (2+2 marks)
- What are the two instrument transformers that are commonly used in power system and briefly describe their functions? (1+1 marks)
- What is a power transformer? What does the generator transformer in CHP does and why? (1+1+1 marks)
- Name the three most common types of fault in a transformer and any three protection tools for transformers. Why is transformer rated in MVA? (2+2+2 marks)
- With the scenario described in the first paragraph, draw the single line diagram. (5 marks)
- What do you understand by the term Reactive Power? How will it affect your Plant operations? What is its Unit? (2+2+1 marks)

As the Royal Government of Bhutan has entered into PPA with the Government of India, the tariff for Chhukha Hydropower Plant has been revised from Nu. 2.20 to Nu. 2.55 per unit as per one of the clauses of the PPA. As the rates were increased, the Management of Chhukha Hydropower Plant decided to overload all four Units by 10% during the summer for four months (120 days) as there is excess water and taking into the consideration the technical feasibility of the machines. Taking 365 days in a year, CHP generates 20% of the rated capacity during the lean season.

7. Express 1 unit of electrical energy in Joules. (3 marks)
8. How much energy can Chhukha generate in a year considering both peak and lean season? (5 marks)
9. How much extra can Chhukha Hydro Power Plant earn in terms of revenue with the revised tariff? (3 marks)
10. What is the full form of PPA? Explain briefly. (2+2 marks)

Chhukha Hydropower Plant having been in service for the last 30 years, most equipment was becoming obsolete and the Management of Chhukha Hydropower Plant has decided to upgrade, renovate and modernize the Power Plant. One such initiative was to implement SCADA and you being one of the best engineers in the Plant, you are tasked for upgradation of Electro-Mechanical relays to the latest Numerical Relays. In view of the above, answer the following:

11. What is the difference between electro mechanical relay and a numerical relay? (3 marks)
12. What is the full form of SCADA? Explain briefly. (1+3 marks)
13. Explain briefly the working principle of a differential relay. (3 marks)

CASE II

You are one of the new Electrical Engineers for the Ministry of Economic Affairs. As a Ministry overlooking important Departments for accelerating the socio-economic development of the nation, there are numerous projects viz office buildings, industrial estates and others. You will soon be assigned to one of the projects and you would be required to have adequate knowledge on electrical engineering to carry out the electrical works. Please answer the following questions to showcase that you are fit for any of the aforementioned assignments.

1. You have been called to one of the project sites at Pasakha as there are works on installation of air-conditioners. One of the motors draws 4.5 kW from the power lines and it delivers 5 horsepower of output. Calculate the efficiency of the motor. [1 HP = 746 W] If an air conditioner motor compressor unit consumes 8500 volt amperes of power at a line voltage of 240 volts, calculate the current following through the circuit for determining the ampacity. (3+2 marks)

2. You are now assigned for designing 1500 square feet single-family one-bathroom dwelling at the Pasakha Industrial housing colony and has a 12kW electric range and a 5.5 kW, 240 volt drying machine. What would be the general lighting load? If the dwelling has the outside dimension of 10 feet x 20 feet, what would be the general lighting load required in VA? [NEC 220.40 : 3VA per square feet] (2+2 marks)

3. Following Loads are connected in the office of Department of Trade:

Sub-Circuit 1

- 2 lamps each of 1000W and
- 4 fans each of 80W
- 2 TV each of 120W

Sub-Circuit 2

- 6 Lamps each of 80W and
- 5 sockets each of 100W
- 4 lamps each of 800W

If supply voltages are 230 V AC, then calculate circuit current for each circuit and the total load. (3+2 marks)

4. A factory site has the following load demand:

Lighting system = 2000 W

Air conditioning and ventilation = 20000 W

To run the actual machine in the factory = 15 MW

The power authority looking at the load demand instruct industry site to procure suitable transformer to use at site.

- a) Why is it important to install transformer in this case? (1 mark)
- b) As per the standards it is safer to have transformer 20% more than required capacity. The power factor is usually at around 80%. With this information, what would be the suitable rating of the transformer for this factory site? (5 marks)
- c) It was found that the load demand during the initial operation of such factory was 20% and for second year at 50%. What would be the actual power consumed during these two years? (2 marks)
- d) During the load trend study, it was found that similar factory in the past has not consumed not more than 80% of the total load demand during the full operation. In this aspect, what capacity of transformer would be required keeping 20% safety above requirement? (3 marks)

5. In any electrical wiring, earthing is very important. Please explain why we need earthing. What is the difference between earthing and grounding? (3+2 marks)
6. You are assigned to work on the illumination for one of the office spaces as it is getting remodelled. The contractors executing the work have purchased fluorescent lamps with a rated luminous flux of 1750 lm. The desired illumination on the keyboard surfaces is 175 lx. Assume a single lamp illuminates each office desk. What distance above the surface should the lights be placed to achieve the desired illumination? If the contractors had also already purchased fixtures to hold the lights that when installed would be 1.5 m above the office desk surface, would the desired illuminance be achieved? If not, would the illuminance be greater or less than desired? What change in the lamp's luminous flux would be required to achieve the desired illuminance?
 [Hint: $E = \frac{P}{4\pi r^2}$] (3+3+1+3 marks)
7. In continuation to Question 6, you are also assigned to study the lighting system of your entire office and propose LED lighting system to reduce the cost. The following table shows the installed lighting system in your office premises:

Description	Quantity	Wattage	Light Output (Lumens)
Incandescent bulbs	40	100	1500 lm
CFL tubes	75	40	2600 lm
Halogen Flood Lights	10	250	2800 lm

The new LED lighting system has the following ratings:

LED Wattage	Light Output (Lumens)
10 W	750 lm
50 W	3500 lm

- a) With the given information, what would be the monthly electricity bill assuming the lights are continuously on for 30 days in a month and Nu. 2.5 per unit? (2 marks)
- b) All incandescent and CFL are getting replaced by the 10 W LED system and Halogen Flood Lights with the 50 W LED system. Keeping the light output as same, how much reduction can you bring in terms of wattage? What is the cost saving? (5 + 2 marks)
- c) What does LED stand for? (1 mark)

TASHI DELEK