ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2018
EXAMINATION CATEGORY: <u>TECHNICAL</u>

PAPER III: SUBJECT SPECIALISATION PAPER FOR ELECTRICAL/ELECTRICAL & ELECTRONICS ENGG.

Date	: 7 October 2018
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 being 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. Two electric bulbs have transparent filament of same thickness and material composition. If one of them generates 60W and other one with 100W, then

   a) 60W lamp filament has shorter length.
   b) 100W lamp filament has longer length.
   c) 60W lamp filament has longer length.
   d) Both the lamps have equal length of filament.

2. The path of magnetic flux in a transformer should have

   a) Low resistance
   b) Low reluctance
   c) High reactance
   d) Low impedance

3. The 60 Hz frequency voltage supply system

   a) would cause the incandescent bulb to turn ON and OFF for 60 times:
   b) would cause the incandescent bulb to turn ON and OFF for 120 times;
   c) would cause the incandescent bulb to turn ON and OFF for 600 times;
   d) would cause the incandescent bulb to turn ON continuously.

4. What should be the permittivity of the dielectric medium to obtain the high value of capacitance?

   a) Zero
   b) Low
   c) High
   d) Unity

5. If we slightly increase the rotor resistance of an induction motor, what effect does it have (increase or decrease) on starting i) torque, ii) efficiency and iii) power factor?

   a) i) & ii) will increase and iii) will decrease
   b) i) & ii) will decrease and iii) will increase
   c) i) will increase and ii) & iii) will decrease
   d) i) & iii) will increase and ii) will decrease

6. A 3 phase, 75 hp, 440 V induction motor has a full load efficiency of 91% and power factor of 83%. What is the nominal current per phase?

   a) 87.2 A
   b) 97.2 A
   c) 92.7 A
   d) 82.7 A

7. In analysing a hydropower site, it is found that the turbines should rotate close to 350 rpm. If the directly coupled generators must generate a frequency of 60 Hz, what is the number of poles on the rotor?

   a) 22
   b) 24
   c) 20
   d) 25

8. Maxwell-Wien Bridge is used for measuring:

   a) Capacitance
   b) Inductance
   c) Dielectric loss
   d) Phase angle

9. The possible Voltage and Current phasors for the following circuit would be:

   a) V
      I

   b)

   c)

   d) I
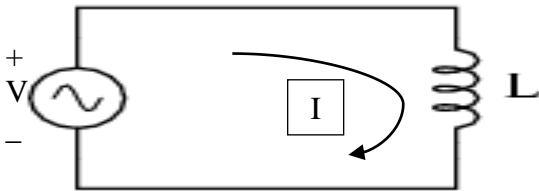
10. The power-factor of series resonant circuit is:

    a) Unity
    b) Zero
    c) 0.8 lagging
    d) 0.9 leading

11. Why are transformers core laminated?

    a) Transformer oil can pass into it easily than solid core.
    b) To reduce the weight of the transformer.
    c) Voltage ratio can be easily adjusted.
    d) Eddy current losses is reduced.

12. In series circuit which of the following will remain same in all parts of circuit?

    a) Power
    b) Current
    c) Voltage
    d) Resistance

13. In AC waveform, the relationship between frequency and time period is:

    a) $f = T$
    b) $f = T^2$
    c) $f = 1/T$
    d) $f = 1/T^2$

14. In overhead transmission line, the size of the feeder is determined by:

    a) The current it requires to carry.
    b) The voltage across the feeder.
    c) Corona effect.
    d) Distance of the transmission line.

15. High inductive load can result in:

    a) Drawing more active power.
    b) Drawing less current.
    c) Drawing more reactive power.
    d) Less voltage-drop in the power line.

16. Wattless current is said to flow when phase angle between voltage and current is:

    a) 90°
    b) 0°
    c) 180°
    d) 60°

17. For low head and large discharge, the hydraulic turbine used is:

    a) Pelton Turbine
    b) Francis Turbine
    c) Kaplan Turbine
    d) Micro turbine

18. What is the output from gate below:

    a) 0 1 0 1
    b) 1 0 1 0
    c) 0 0 0 1
    d) 1 1 1 0

19. Which of the following logic gates with two inputs will generate the outputs as 1 0 0 0

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

20. Please calculate the equivalent capacitance of the five (5) capacitors that are connected in series having value of 5 microfarads each:

    a) 5 microfarad
    b) 1 microfarad
    c) 15 microfarad
    d) 25 microfarad

21. The voltage induced in an inductor is

    a) Ratio of its inductance to current passing through it.
    b) Product of its inductance and rate of change of current passing through it.
    c) Ratio of its current passing through it to its inductance.
    d) Product of its inductance and current passing through it.

22. The Root Mean Square (RMS) value is defined based on which of the following?

    a) Charge transfer rate
    b) Heating effect
    c) Resistive value
    d) Frequency

23. In a AC - RLC series circuit, the voltage across the resistor, inductor and capacitor are 5V, 2V and 2V respectively. What would be the total voltage?

    a) 5V
    b) 2V
    c) 4V
    d) 25V

24. The frequency of EMF generated by the generator depends upon its

    a) Speed
    b) Number poles
    c) Both the speed and number of poles
    d) The supply voltage

25. If frequency is increased, then the skin effect will

    a) decrease.
    b) increase.
    c) remain constant.
    d) fluctuate at a wavelength of increased frequency.

26. The presence of earth in case of overhead lines

    a) Decrease inductance
    b) Increases capacitance
    c) Increase inductance
    d) Decrease capacitance

27. Which of the following decides the insulation level of 400kV lines?

    a) Lightning voltages
    b) Skin effect
    c) Switching over-voltages
    d) Radio interferences

28. Due to corona,

    a) Interference increases
    b) Power loss increases
    c) Charging current increases
    d) All of the above

29. Power transformers are generally designed to have maximum efficiency at

    a) No-load
    b) Closer to full load
    c) Half-load
    d) 10% overload

30. When the excitation is increased (over-excitation), the synchronous generator operates at?
   a) leading power factor
   b) unity power factor
   c) lagging power factor
   d) any of the above depending on the grid

PART II – Short Answer Questions (20 marks)

This part has 4 Short Answer Questions. Answer ALL the questions. Each question carries 5 marks.

1. 500 V DC shunt motor draws a line current of 5 A on a light-load condition. If the armature resistance is 0.15 ohm and field resistance is 200 ohms, determine the efficiency of the machine running as a generator delivering a load current of 40 Amps. (5 marks)

2. A 3-Phase, 300 rpm synchronous motor connected to a 4 kV, 50 Hz line draws a current of 320A and absorbs 2000 kW. Calculate the following: (5 marks)
   a) The reading on the watt-meter;
   b) Apparent power supplied to the motor;
   c) Power factor;
   d) Reactive power absorbed;
   e) Number of poles on the rotor.

3. The following information is given for a 300-kW, 600-V, and long-shunt compound generator: Shunt field resistance = 75ohm; armature resistance including brush resistance = 0.03 ohm; commutating field winding resistance = 0.011 ohm; series field resistance = 0.012 ohm; and divertor resistance = 0.036 ohm.
   a) Draw a generator circuit diagram. (2 marks)
   b) When the machine is delivering full load, calculate the voltage and power generated by the armature. (3 marks)

4. What do you understand by MCB (miniature circuit breaker); MCCB (moulded case circuit breaker); ELCB (earth leakage circuit breaker); and RCCB residual current circuit breaker)? Why RCCB is preferred over ELCB? (5 marks)

SECTION B

Case Study

Choose either Case I OR Case II from this section. Each case study carries 50 marks.

Case I

You are one of the newly selected electrical engineers in the Department of Hydropower and Power System, Ministry of Economic Affairs. The Department is selecting the best candidate among the newly recruited electrical engineers to depute an 'official on special assignment' for a year to Hydropower Plants in the country and the Bhutan Power Corporation Limited to enhance knowledge in the hydropower generation and power system operation. Therefore, the newly recruited employees are subjected to the following questions for examination of their fundamental knowledge in the power system engineering. Assuming you are one of the candidates, please answer the following:

1. Please explain the working principle of the distance relay. From the perspective of distance relaying, please explain the zone protection system of the power transmission lines – including the zone 1 setting; zone 2; and zone 3. (4+6 marks)

2. Please explain in detail what do you understand by the (i) *excitation system*; (ii) *under-excitation*; and (iii) *over-excitation* of the synchronous hydro-generator that is connected to the grid. (12 marks)

3. Extra-high voltage (EHV) transmission lines (for example, 400kV) are employed to transmit power over long distance; therefore, these lines generally have significant shunt capacitances. Please explain the phenomenon of shunt capacitance generated between:

   a) Individual phases (that is, between the phase conductors); and (4 marks)

   b) The lines (phase conductors) and the ground/earth**.** (4 marks)

The 63 MVAR shunt reactor is connected in the bus of 1020MW Tala Hydropower Power Plant. Please explain the purpose of the shunt reactor in the power system operation considering the case of Tala Hydropower Plant. (5 marks)

4. In the synchronous hydrogenation, governor controls the active power or load (thereby controlling the frequency), while automatic voltage regulator (through excitation) regulates the reactive power for voltage control of the grid. As such, frequency is depended on active power of the power system, while system voltage is depended on the reactive power. Please explain how the governor of synchronous hydropower generation has direct role in "load frequency control" of the grid. (6 marks)

5. What do you understand by the N-1 contingency planning in the electric transmission system? Please explain. (3 marks)

6. What is "Power Swing"? Please explain. Discuss its impact to the power system, especially in the distance relaying. (6 marks)

Case II

The Draft Hydropower Project Studies Report consists of following information.

  i. From the hydrology data of one of the river basin where hydro power plant will be constructed indicates the following 90% dependable average inflow collected from the year 1980 up to 2017:

Month	January	February	March	April	May	June
Inflow (m³/sec)	23.425	23.123	25.001	39.716	85.717	145.988

Month	July	August	September	October	November	December
Inflow (m³/sec)	146.893	130.787	127.793	118.742	55.219	35.712

  ii. Report indicates that the hydro project is feasible for Run of River (ROR) scheme with live some storage capacity.

  iii. The dam built will be of concrete gravity dam with its foundation at an elevation (EL) of 1250 m and average river bed level at EL1342 m. The length of the dam is 80 m and crest of the Dam at EL 1412 m. The full reservoir level (FRL) of the dam is at EL 1409 m. Minimum Draw Down Level (MDDL) of the dam is 3.5 m above top crest level of Intake Gate.

  iv. Dam will have 3 intake gates with its bottom crest level at EL 1389.5 m. The breadth of the gate is 4 m and height 4.5 m.

  v. The length of Head Race Tunnel is around 15 km including 600 m penstock.

  vi. The center-line of turbine is at 609 m.

  vii. The transportation of materials to the power house location is only possible by road. It was found that there were a total of 5 bridges on that road. While two bridges could withstand a maximum load of 100 tons, the weakest one could bear only 80 tons.

With the information provided above, please answer the questions below:

  1. What do you understand by:

      a) 90% dependable inflow? (1 mark)

      b) Run of River (ROR) Scheme? (1 mark)

      c) FRL or full reservoir level? (1 mark)

      d) MDDL or minimum draw down level? (1 mark)

      e) Concrete gravity Dam? (1 mark)

2. Why do we need several years of hydrological inflow data for planning and designing of hydro power plant? (3 marks)

3. What do you understand by live storage of the dam? In this case, up to what level of live storage can be utilized for generation and what is the total height of live storage? At what elevation is the MDDL? (4 marks)

4. Upon simulation of whole water conducting system (from dam till turbine nozzle), the head loss was found to be 15m. What is the gross head and net head for this hydropower plant scheme? (4 marks)

5. From the head derived, what would be the suitable runner for this power house? Which head (net or gross) is taken into consideration for choosing the runners? With simple justification, mention why you opted for that runner? What are the other types of runners that are available? What is the function of turbines in hydro power plant? (5 marks)

6. The product of turbine efficiency and generator efficiency gives the overall efficiency of hydro-generator to derive the total power capacity. The maximum inflow from the 90% dependable chart is used for deriving the maximum power capacity of the generator; and the average of three leanest in-flow is used for deriving minimum power capacity of the generator. Basic thumb rule for having number of units (generators) is the result of maximum discharge divided by minimum discharge. The designed turbine efficiency should be 92% and generator efficiency should be 98.5%. With this information provided:

    a) Calculate the firm power in MW taking, gravity = 9.8 m/s^2. (5 marks)

    b) How many generators should be installed in this power house? What would be rated power for each generator? (2 marks)

    c) What would be the rated power of this power plant? (1 mark)

    d) The power factor of generator is designed to be 0.9; what would be MVA rating of each generator? (1 mark)

    e) Why are the capacities of power plant rated in MW, while generator and transformer are rated in MVA? How much would 50 MW turbine connected to a 90MVA alternator in a power plant generates at full load? (4 marks)

7. It was found that one of the key deciding factors for choosing the power transformer was its weight. It is estimated that 1MVA is almost equivalent to 1 ton. With this assumption, which transformer would be most preferable (three phase or single phase) and why? (3 marks)

8. What is power transformer? How is power transformer different from distribution transformer? For this power plant, what would be the suitable rating for power transformer? (4 marks)

9. The proposed hydropower plant has turbine deflector in addition to its nozzle. What are the functions of the turbine nozzle and the deflector? Please explain, especially in relation to the load following of the grid. (4 marks)

10. Why are surge shafts (also called as surge tanks) required in the medium head and high head hydropower plant scheme? (2 marks)

11. For this project, the head race tunnel is 15km. What do you understand by the pressurized tunnel? (3 marks)

TASHI DELEK