ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2016
EXAMINATION CATEGORY: <u>TECHNICAL</u>

PAPER III: SUBJECT SPECIALIZATION PAPER FOR ELECTRICAL/ELECTRICAL & ELECTRONICS ENGG/

Date:	2 October 2016
Total Marks:	100
Examination Time:	150 minutes (2.5 hours)
Reading Time:	15 minutes *(prior to examination 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, printing error, clarify doubts and to read instructions in Question Paper. You are NOT permitted to write during this time.

3. This paper consists of **TWO Sections, namely Section A and 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 2 case studies. Choose only **ONE** case study and answer the questions under 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 correct Section, Part and Question Number will NOT be evaluated and no marks would 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. The Question paper has 9 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 (c). Each question carries ONE mark. Any double writing, smudgy answers or writing more than one choice shall not be evaluated.

1. A list of relays and the power system components protected by the relays are given in Col-A and Col-B respectively. Choose the correct match from the choices given below.

   Col-A   Col-B
   P. Distance relay   1. Transformers
   Q. Under frequency relay   2. Turbines
   R. Differential relay   3. Busbars
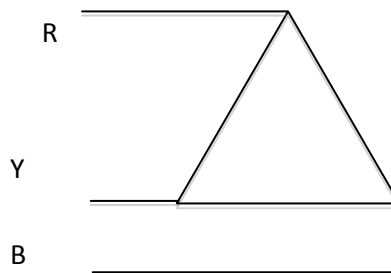   S. Buchholz relay   4. Shunt capacitors
                                  5. Alternators
                                  6. Transmission lines

   a) P-6, Q-5, R-3, S-1   c) P-5, Q-2, R-1, S-6
   b) P-4, Q-3, R-2, S-1   d) P-6, Q-4, R-5, S-3

2. The rated voltage of a 3-phase power system is given as

   a) rms phase voltage
   b) peak phase voltage
   c) rms line to line voltage
   d) peak line to line voltage

3. The phase sequence of the 3-phase system shown in the figure is

   a) RYB   c) BRY
   b) RBY   d) YBR

4. A 500kVA, 3-phase transformer has iron losses of 300W and full load Cu losses of 600W. The percentage load at which the transformer is expected to have maximum efficiency is

   a) 50.0%   c) 141.4%
   b) 70.7%   d) 200.0%

5. For harnessing low variable water heads, the suitable hydraulic turbine with high percentage of reaction and runner adjustable vanes is

   a) Francis
   b) Kaplan

   c) Pelton
   d) Impeller

6. The complete set of only those Logic Gates designated as Universal gates is

   a) NOT, OR and AND Gates
   b) XNOR, NOR and NAND Gates
   c) XOR, NOR and NAND Gates
   d) NOR and NAND Gates

7. The High Voltage DC (HVDC) transmission is mainly used for

   a) minimizing harmonics at the converter stations.
   b) inter-connecting two systems with the same nominal frequency.
   c) eliminating reactive power requirements in the operation.
   d) bulk power transmission over very long distances.

8. Out of the following power plant categories i) Nuclear, ii) Run-of-river, iii) Pump Storage, and iv) Diesel, the base load power plants are

   a) i) and ii)
   b) ii) and iii)

   c) i), ii) and iv)
   d) i), iii) and iv)

9. A circuit with resistor, inductor and capacitor in series is resonant at f_0 Hz. If all the component values are doubled, the new resonant frequency will be

   a) $2f_0$
   b) still f_0

   c) $f_0/4$
   d) $f_0/2$

10. The insulation resistance of a 20 km long underground cable is 8 MΩ. Other things being the same, the insulation resistance of a 10 km long cable will be?

    a) 16 MΩ
    b) 32 MΩ

    c) 4 MΩ
    d) 2 MΩ

11. In the load flow analysis, the load connected at a bus is represented as

    a) constant current drawn from the bus.
    b) constant impedance connected at the bus.
    c) voltage and frequency dependent source at the bus.
    d) constant real and reactive drawn from the bus.

12. In a 400kV network, 350kV is recorded at a 400kV bus. The reactive power absorbed by a shunt rated for 50 MVAR, 400kV connected at the bus is

    a) 61.73 MVAR   c) 45 MVAR
    b) 55.56 MVAR   d) 40.5 MVAR

13. When a transformer winding suffers a short circuit, the adjoining turns of the same winding experience

    a) an attractive force   c) no force
    b) a repulsive force   d) none of the above

14. A water boiler at home is switched on to the a.c. mains supplying power at 230V and 50 Hz. The frequency of instantaneous power consumed by the boiler is

    a) 0 Hz   c) 50 Hz
    b) 25 Hz   d) 100 Hz

15. If the fault current is 2000 A, the relay setting is 50% and CT ratio is 400:5, the plug setting multiplier will be

    a) 25 A   c) 50 A
    b) 15 A   d) 10 A

16. In a uniform electric field, the field lines and equipotentials

    a) are parallel to one another   c) intersect at 30°
    b) intersect at 45°   d) are orthogonal

17. In a microprocessor, the address of the next instruction to be executed, is stored in

    a) stack pointer
    b) address latch
    c) program counter
    d) general purpose register

18. Two incandescent light bulbs of 40W and 60W ratings are connected in series across the mains. Then, which of the following will be observed?

    a) the bulbs together consume 100W
    b) the bulbs together consume 50W
    c) the 60W bulb glows brighter
    d) the 40W bulb glows brighter

19. If an energy meter disc makes 10 revolutions in 100 seconds when a load of 450W is connected to it, the meter constant (in rev/kWh) is

    a) 1000   c) 1600
    b) 500   d) 800

20. Bundled conductors are mainly used in high voltage overhead transmission lines to

    a) reduce transmission line losses
    b) increase mechanical strength of the line
    c) reduce corona
    d) reduce sag

21. The color code of a 1 kΩ resistance is

    a) black, brown, red   c) brown, black, red
    b) red, brown, brown   d) black, black, red

22. Two heating elements of each 230V and 5kW rating are first joined in parallel and then in series to heat the same bucket of water through the same range of temperature. The ratio of the time taken in the two cases would be

    a) 1:2   c) 1:4
    b) 2:1   d) 4:1

23. A hydraulic turbine having rated speed of 250 rpm is connected to a synchronous generator. In order to produce power at 50Hz, the number of poles required in the generator is

    a) 6   c) 12
    b) 16   d) 24

24. The power factor of an alternator is determined by its?

    a) speed   c) excitation
    b) load   d) prime mover

25. The daily energy produced in a diesel station is 720MWh at a load factor of 0.60. What is the maximum demand of the station?

    a) 50 MW   c) 72 MW
    b) 30 MW   d) 720 MW

26. In a 3-phase, 5kV, 5MVA system, what is the base impedance?

    a) 0.5 ohms   c) 50 ohms
    b) 5 ohms   d) 500 ohms

27. A zero to 300V voltmeter has an error of ±2% of the full-scale deflection. If the true voltage is 30V, then the range of readings on this voltmeter would be

    a) 20V to 40V   c) 24V to 36V
    b) 29.4V to 30.6V   d) 29.94V to 30.06V

28. At the increasing temperature, the electrical conductivity would

    a) increase in metals as well as in intrinsic semiconductors.
    b) increase in metals but decrease in intrinsic semiconductors.
    c) decrease in metals but increase in intrinsic semiconductors.
    d) decrease in metals as well as in intrinsic semiconductors.

29. A single-phase energy meter having meter constant of 200 rev/kWh installed in an apartment is operating on 230V, 50Hz supply with a load of 10A, and at unity power factor for three hours continuously. The number of revolutions shown by the meter during this period is

    a) 13,800
    b) 1,380
    c) 2,760
    d) 1,830

30. For the circuit shown below, the value of 'R' connected between C & D is such that the equivalent resistance of the circuit by looking into circuit through terminals A and B is R only. Then the value of R is

    a) 2 Ω
    b) 3 Ω
    c) 4 Ω
    d) 6 Ω
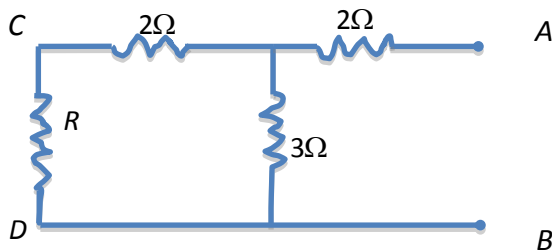
PART II – Short Answer Questions (20 marks).

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

1) A generating station has a maximum demand of 250MW, a load factor of 60%, a plant capacity factor of 50%, and a plant use factor of 72%. Find

    a) The daily energy produced by the generating station,
    b) The reserve capacity of the station, and
    c) The maximum energy that could be produced daily if the plant, while running as per schedule, were fully loaded.

2) The neutral of 10 MVA, 11 kV alternator is earthed through a resistance of 5 ohms. The earth fault relay is set to operate at 0.75 A. The CTs have a ratio of 1000:5. What percentage of the alternator winding is protected?

3) A 66 kV, 3-Phase, 50 Hz, 200 km long overhead transmission line, with each conductor having a resistance of 0.25Ω/km, an inductive reactance of 0.50 Ω/km and a capacitive admittance to neutral of 0.04 x 10^{-4} S/km, is open circuited at the receiving end. Under this situation, draw the nominal π-equivalent circuit indicating the values of each parameter?

4) What are the causes of low power factor and state the merits of improved power factor in a power system? Name the methods employed for power factor improvement?

SECTION B

Case Study

Choose either Case 1 or 2 from this section. Each case study carries 50 marks.

Case 1

A country endowed with abundant coal, hydropower and other renewable energy sources is desirous to enhance industrialization for sustained economic growth and employment generation besides the electrification of the balance 50% of far-flung unelectrified villages (i.e. 150,000 households) which remains to be electrified by a certain Five Year Plan.

To achieve these plans, the National Planning Commission has advised the Agency for Promotion of Industries and the Department of Electricity Development to come out with a holistic plan who in turn identified the following as necessary pursuits for achieving the mandated targets:

i) To develop and promote five special economic zones (SEZs) to establish environment friendly industries having assessed the firm power demand at 250 MW each.

ii) To harness its run-of-river projects followed by reservoir based projects to keep pace with the growing electricity demand, though construction of thermal power plants was also considered as Plan B alternative.

The issue of developing power generation sources, supplies to the SEZs and electrification of villages was taken up by the National Electricity Department. Considering you are the National Project Manager in charge of planning, implementation and commissioning of the required infrastructure, answer the following:

a) Assess the overall load demand for supply-side planning by assuming the maximum demand for a household as 2.5kW and load factor of 60%? (2 Marks)

b) Proposing for development of a run-of-river (ROR) hydroelectric plant for bulk power supply whose basic parameters are provided in the master plan as: Net Head = 450m, Discharge = 360 cumecs. Estimate the firm installed capacity of the proposed plant in MW and gross annual energy output in GWh considering the turbine and generator efficiencies as 92% and 98.65%? What is the standby capacity required to meet the total load or the reserve capacity made available by the plant? (6 Marks)

c) List four main advantages and three disadvantages associated with development of hydropower over other conventional sources? (5 Marks)

d) Explain what do you understand by ROR hydropower plant and describe one drawback of such type of projects? Also, draw a detailed schematic arrangement of a large ROR hydroelectric plant identifying its main components? (7 Marks)

e) Using the rule of thumb, estimate the most economical transmission voltage for power to be evacuated for supply to the SEZs and far-flung villages, assuming they are located beyond 640km? Also, explain why you cannot transmit the generated power at other voltages such as 11kV, 33kV, 66kV, etc. for this project? (5 Marks)

f) The power from the plant is to be evacuated to the SEZ load centers via voltage step-up and the step-down arrangements interconnected by the HV lines in a form of ring main system. The power transmitted to the SEZs is at the voltage level determined in e) above and from the receiving substation, power to SEZ is supplied at 132kV while the supply to the household locations is made at 11kV from the SEZ substation housing 3-winding transformers. Draw the single line representation depicting the proposed power system structure? (6 Marks)

g) The loads from the SEZs represent the daily base load for the new power system while the household loads add to the peak loads that varies from half to one third to full load of the household demands from 7 am in the morning to noon to evening seven during which the highest peak is observed. Illustrate the typical situation through an approximate daily load curve? (3 Marks)

h) Supposing that the ROR plant is built at a cost of $ 1.20 million per MW and the plant is expected to last for 50 years. Calculate the annual depreciation using straight-line method considering the 10% of initial value as the salvage value and what would be the plant's value in the 25th year? (3 marks)

i) The utility company is to charge the tariff for the power consumed by an SEZ at $ 0.5/kWh for the energy drawn and $ 92/kW for the demand made in a month. If the first month bill issued saw a consumption of 126,000 MWh and the maximum demand record of 220MW, find the amount billed for the month by the utility. What is the overall tariff in terms of $/kWh? (3 Marks)

j) The HV substations and the transmission lines are often struck by the lightening and power supplies are frequently being disrupted. Explain how lightning and thunder are caused and also list out three of the lightning protection measures employed in the substations and the transmission lines? (10 Marks)

OR

Case 2

The Utility Company has to make power supply arrangement to the large housing facility. The housing facility consists of 100 buildings with 6 apartments each with same size of 3 bedrooms, one large living room, a kitchen and a toilet. The total connected load of the facility is estimated around 13MW.

The primary supply is planned to be arranged by stepping down from the nearby 66kV line. Given this scenario, answer the following:

a) Draw the typical substation involving the following types of bus bar arrangements:

    i)   Single bus bar system with sectionalization;
    ii) Double bus single-breaker configuration;
    iii) Breaker and half configuration;

    The arrangement should be represented with the minimum substation equipment, such as transformers, circuit breakers, isolators, lightning arresters, CTs and PTs using appropriate circuit element symbols. (30 marks)

b) Of the three schemes, which one will you choose for implementation in this case? Explain your choice? (2 Marks)

c) If the incoming system voltage at the substation is observed to be at times higher or lower than the sending voltage, explain the phenomenon leading to such voltage fluctuations along with a typical circuit line and phasor diagrams? Also name the methods to control such fluctuations in a power system? (5 Marks)

d) The buildings at the facility have to be securely earthed. Why do we provide earthing and what are the various methods of earthing available? Explain one method with a sketch? (8 Marks)

e) For earthing a substation or a residential building, what factors decide the size of earth conductors and what should be the typical values of earth resistance for substations and residential buildings? If the earth resistance of an installation is high what are the methods of improving the earth resistance? (5 Marks)

TASHI DELEK