UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: March 2022

Module Number: EE5304 **Module Name: Power Systems II (C-18)**

[Three Hours]

[Answer **all questions**, each question carries 10 marks]

Q1. a) i) What is the effect of unsymmetrical spacing of conductors in a 3 phase transmission line?

ii) Starting from first principles, obtain the line to line capacitance of a single phase line considering the effect of earth. Define any symbols used. Assume the permittivity of free space is 8.854×10^{-12} F/m.

[5.0 Marks]

b) Consider a single phase line with radius of a conductor 0.01 m, spaced 3.5 m apart and 8 m above the ground. Calculate and compare the capacitance of a conductor to neutral per km with and without considering the effect of the earth.

[5.0 Marks]

Q2. a) With suitable derivations, show that A, B, C, D parameters of a long transmission line can be given as follows: (symbols have their usual meanings)

$$A = \cosh(\gamma l)\ ;\ B = Z_C \sinh(\gamma l)\ ;\ C = \frac{1}{Z_C}\sinh(\gamma l)\ ;\ D = \cosh(\gamma l)$$

[4.0 Marks]

b) A 60 MVA at 124 kV, 50 Hz at 0.8 power factor lagging load is fed by a long transmission line. It is found that the resistance and reactance are 25.3 Ω and 66.5 Ω respectively. Admittance of the line due to charging capacitance is 0.442×10^{-3} S.

i) Calculate A, B, C, D constants of the line.

ii) Find sending end voltage, sending end current, and sending end power factor.

iii) What is the efficiency of this line?

[6.0 Marks]

Q3. a) Consider a portion OP of a curved length l of the wire shown in Figure Q3 which is hanging in still air with O as the lowest point on the wire. Let the weight of conductor per meter length be w kg.

i) Derive the parabolic approximation of the catenary formed by the cable.

ii) Derive an expression for the maximum tension of the cable.

[4.0 Marks]

b) An overhead transmission line has a span of 275 m between level supports. The conductor has a radius of 0.9765 cm and weighs 0.844 kg/m and has an ultimate breaking strenght of 11925 kg. Conductor has a radial covering of ice 0.953 cm thick and is subjected to a horizontal wind pressure of 40 kg/m^2 of the ice covered projected area. Factor of safety is 3.0. Density of the ice is 913.5 kg/m^3.

i) Determine the sag of the transmission line.

ii) Determine the vertical sag of the transmission line.

[6.0 Marks]

Q4. a) i) What is the load flow study in a power system?

ii) Consider the 3-bus power system shown in Figure Q4. All the notations on the figure have their usual meanings. Using first principles, derive a general expression for the admittance matrix of the system. Clearly define any symbols used.

iii) What are the three types of buses available in a typical power system. State the known and unknown variables of each type of buses.

[4.0 Marks]

b) Table Q4. i) and Table Q4. ii) list the data of the 3-bus power system shown in Figure Q4. The voltage at bus-1 is 1.3 $\angle 0^o$ p.u.

i) Calculate the admittance matrix of the 3-bus power system.

ii) Calculate the phasor values of the voltages at buses 2 and 3 using Gauss Seidel method. Perform calculations for two iterations.

iii) Calculate the active and reactive power of bus-1 after second iteration.

[6.0 Marks]

Q5. a) i) What is meant by Economic Load Dispatch (ELD)?

ii) What are the factors affecting the total power generation cost of a power system?

iii) A power system consists of n thermal power plants. The fuel cost functions of these power plants in \$/h are $C_{G1}, C_{G2}, \ldots, C_{Gn}$. The system load is P_L. Show that for most economic operation, all thermal plants must operate at equal incremental cost. Neglect the transmission loss and the generator power limits.

[4.0 Marks]

b) A power system consisting of two thermal power plants supplies a load of 850 MW. The fuel cost function in \$/h of these two power plants are

$$C_{G1} = 275 + 5.4\,P_{G1} + 0.0014\,P_{G1}^2$$
$$C_{G2} = 412 + 4.5\,P_{G2} + 0.0027\,P_{G2}^2$$

P_{G1} and P_{G2} are in MW.

i) Find the power outputs of the two generators that results minimum total generation cost. Neglect the transmission line losses.

ii) Calculate the total generation cost for the power generation found in part i).

iii) The power loss function for the above power system is

$$P_{loss} = \alpha P_{G1}^2 + \beta P_{G2}^2$$

where P_{G1} and P_{G2} are in MW.
The optimal power outputs of generators G_1 and G_2 that results minimum total generations cost are found to be 551.08 MW and 410.12 MW respectively. Calculate the α and β coefficients of the loss function.

[6.0 Marks]

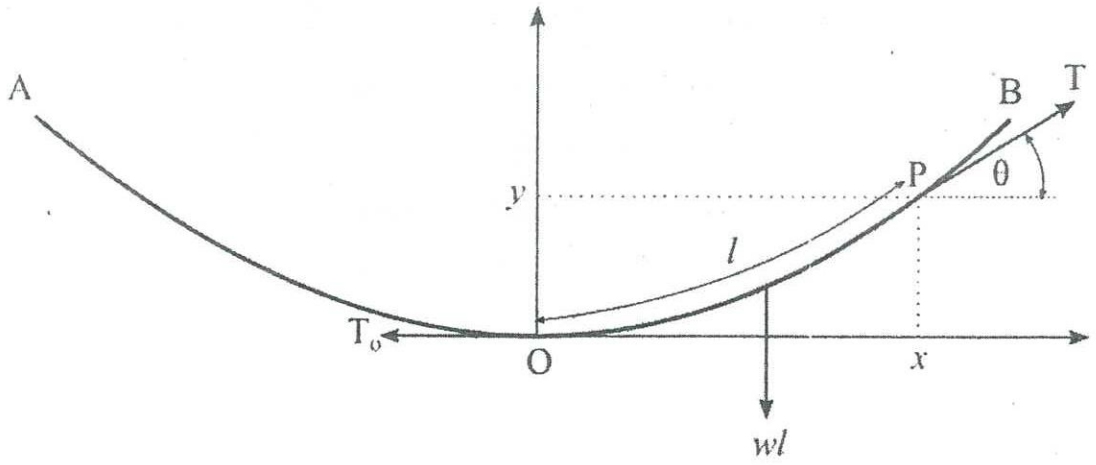

Figure Q3.

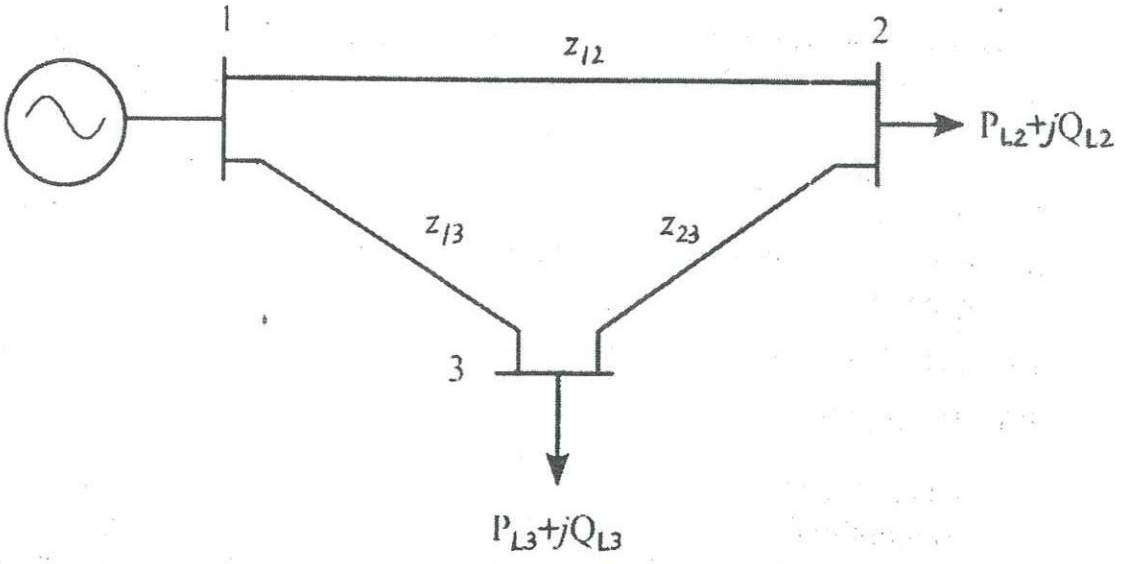

Figure Q4.

Table Q4. i) Loads.

Bus No.	P (p.u.)	Q (p.u.)
2	4.4	1.4
3	6.2	2.8

Table Q4. ii) Line impedances.

Bus No.	Line impedance (p.u.)
1-2	0.014+0.023j
1-3	0.023+0.039j
2-3	0.031+0.047j