

TRIBHUVAN UNIVERSITY
 INSTITUTE OF ENGINEERING
Examination Control Division
 2076 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

Subject: - Power Plant Equipment (EE 703)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

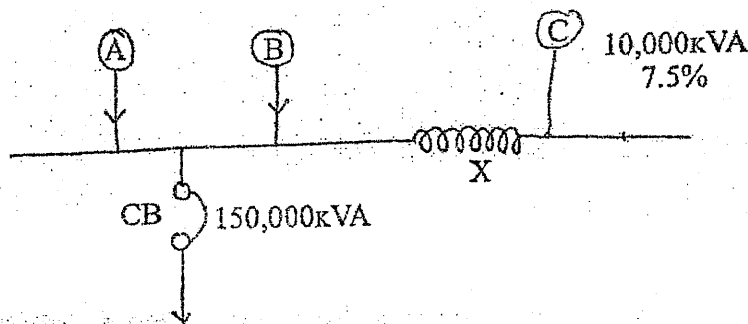
Part A (Electrical Part)

1. a) What do you mean by water hammer in context of hydro power plant? How it can be minimized? [5]
- b) For hydro dominated integrated system like Nepal, is pump storage hydro power plant economical? Justify your answer with its operation. [5]
2. a) Explain the importance of speed droop in sharing common load by two alternator operating in parallel with suitable block diagram and derivation. [5]
- b) What are the special characteristics of hydraulic turbine? Explain in brief. [5]
3. a) Explain the dynamic response of excitation system with stabilizing transformer with suitable mathematical deduction. [8]
- b) What is main function of reactor in power system network? [2]
4. a) Two generating units has following rating and droop characteristics

Unit-1	600MVA	$R_1=4\%$
Unit-2	500MVA	$R_2=6\%$

These two units are operating in parallel and sharing a total load of 900MW at nominal frequency of 60Hz. Unit-1 supplies 500MW and unit-2 supplies 400MW. If the load increases by 90MW, calculate the new frequency and new generation of each generator. [5]

- b) A small generating station has two alternators of 2500KVA and 500KVA with percentage reactance of 8 & 6 percentage respectively. The circuit breakers are rated at 150,000kVA. Due to increase in system load it is intended to add a third generator of 10,000kVA rating and 7.5% reactance. If the system voltage is 3300volts, find the reactance X necessary to protect the C.B. [5]



Part B (Mechanical Part)

5. Explain the closed cooling system with its advantages and disadvantages. [8]
6. A diesel engine power plant operated by a two stroke diesel engine was motored when the meter reading was 4.5 KW. Then the test on the engine was carried out for one hour run and the following observations were recorded: (i) Brake torque = 250Nm; (ii) Speed=1500rpm; (iii) Fuel consumed = 5 kg and (iv) Calorific value of fuel = 40MJ/kg. Determine:
- a) Mechanical efficiency
 - b) Indicated thermal efficiency
 - c) Brake thermal efficiency
- [8]
7. Explain how regeneration increases the output of the steam turbine power plant along with the neat sketch and show the cycle in P-V and T-S diagram. [6+2]
8. Air enters the compressor of an ideal gas turbine power plant at 100kPa, 300K. The pressure ratio is 10. The turbine inlet temperature is 1400K. Determine the efficiency of the plant. Also determine the increment in efficiency if a regenerator with effectiveness 80% is used in the plant. [Take $C_p=1.005$ kJ/kgK and $\gamma=1.4$] [12]
9. Sketch the basic components of a combine power plant. Also sketch the corresponding process on T-S diagram. [4]

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Electrical Part

1. Explain the use of Francis turbine in pumped storage plant. Is this type of power plant feasible to install in Nepal's power system? Give reasons. [8]
2. a) Explain the speed response of turbine generator coupled system with change in load as determined by inertia and damping constant. [6]
- b) Two generators of 600MW, 2% and 300 MW, 4% are supplying to a common load. When each generator is fully loaded, they operate at common frequency of 49 Hz. Calculate the system load shared by each unit when frequency increased to 50Hz. [8]
3. Obtain the transfer function of excitation system with stabilizing transferred. [8]
4. Two generators each of capacities 40Mva, 11kv having their sub transient reactance of 5% and 4% respectively operating in parallel and supplying to a common load by single feeder of reactance 2 ohm. Calculate the fault level when there is 3-phase to ground fault on the outgoing feeder. Also calculate the value of reactor to be connected in series with 2 ohm reactor to reduce the fault level by 40%. [5+5]

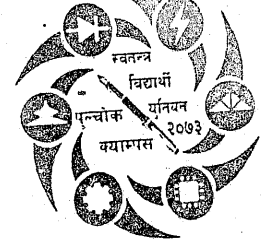
Mechanical Part

5. Make a layout of a diesel power plant showing the following systems and briefly discuss about them: [10]
 - (i) Air intake system
 - (ii) Cooling system
 - (iii) Fuel supply system
 - (iv) Lubrication system
 - (v) Exhaust system
6. A gas turbine unit has a pressure ratio of 6:1 and maximum cycle temperature of 610°C. The isentropic efficiencies of the compressor and turbine are 0.80 and 0.82 respectively. Calculate the power output in kilowatts of an electric generator geared to the turbine when the air enters the compressor at 15°C at the rate of 16 kg/s. Take $c_p = 1.005 \text{ kJ/kgK}$ and $\gamma = 1.4$ for the compression process, and take $c_p = 1.1 \text{ kJ/kg K}$ and $\gamma = 1.333$ for the expansion process. [10]
7. a) Differentiate between the operation of impulse and reaction turbines? [5]
- b) What are the essential requirements of steam power station design? [5]
8. What are the advantages and disadvantages of gas and steam combined cycle? Briefly discuss the popular designs of the combination cycles. [10]

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Group A
(Electrical Part)

1. Explain with example how pump storage hydropower plant can be installed together with base load plant for efficient operation and to reduce peak generation loss. [10]
2. a) What do you mean by Isochronous generator? Describe its transient response for a step increase in load. [4]
b) A power system consist of two generators operating in parallel and supplying a load of 1200 MW. Generator G_1 is rated as 900 MW with 2% drop regulation and generator G_2 is related as 450MW with 3% drop regulation. G_1 supplied 750 MW and G_2 supplies 450 MW and frequency is 60 Hz. When the load is increased by 150 MW, Calculate the new operating frequency and additional power generated by each generator. [8]
3. Explain the dynamic response of excitation system with suitable mathematical deduction. [8]
4. a) Two generators of capacities 40Mva, 11kv and 30 Mva, 11kv having their sub transient reactance of 5% and 4% respectively operating in parallel and supplying to a common load by single feeder of reactance 2 ohm. Calculate the value of reactor to be connected in series with feeder so as to reduce the fault label at the end of the feeder by 40%. [6]
b) Describe how a SCADA can be implemented in a power system. [4]

Group B
(Mechanical Part)

5. a) Briefly illustrate the main components of a diesel power plant. [6]
b) A single cylinder engine running at 1800 rpm develops a torque of 8 Nm. The indicated power of the engine 1.8 kW. Find the loss due to friction power as the percentage of indicated power. [4]
6. Discuss the methods to improve thermal efficiency of Gas Turbine Plant. [10]
7. a) What is the fundamental difference between the operation of impulse and reaction turbines? [5]
b) What are the advantages and disadvantages of steam power plant? [5]
8. What are the advantages of gas and steam combined cycle? Briefly explain the three popular designs of the combination cycles. [10]

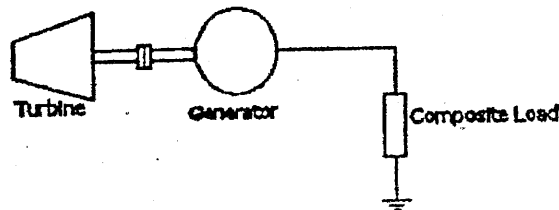
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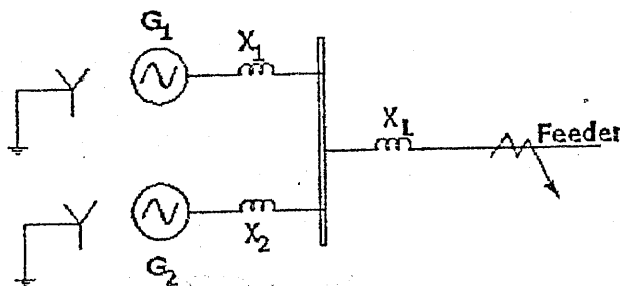
Electrical Part

1. Explain the operation of pump storage type hydro power plant with neat diagram. [8]
2. Below figure shows the block diagram of water turbine driving an electric generator without speed governor. Explain how the inertia and load damping constant can control the speed of the system against small change in load. Derive the transfer function showing the effect of inertia and load damping constant. [8]



3. Two generating units of 500MW and 250MW capacities respectively are operating in parallel and supplying power to a common load. When each generator is half loaded, they operate at a common frequency of 50Hz. The droop regulations are 5% and 6% respectively based on their respective ratings. If the load is increased by 100 MW, Calculate: [8]
 - a) New frequency at which they operates
 - b) Power supplied by each generator
4. Describe the excitation system of a synchronous generator with stabilizing transformer. Derive mathematical model of the system in term of transfer function of each component of the system. [8]
5. Below figure show the single line diagram of parallel operated generators. Their ratings are: [8]

G_1 : capacity = 50 MW, 11kV, $X_1 = 0.16$ pu based on its rating
 G_2 : capacity = 40 MW, 11kV, $X_2 = 0.12$ pu based on its rating
 $X_L = 2$ ohms



- a) If a three-phase to ground fault occurs at outgoing feeder, calculate the fault current and fault power at the outgoing feeder and fault current supplied by each generator.
- b) Calculate the value of inductor (in mH) of the reactor to be connected in series with X_2 so that both generators delivers equal amp of fault current during 3 phase to ground fault on the feeder.

Mechanical Part

6. Explain the working of combined gas-steam power plant with neat figure and also show the process on T-S diagram. [10]
7. Explain the different types of water cooling system with their advantages and disadvantages. [6]
8. Explain the closed and open Brayton cycle. [6]
9. Steam is generated in a boiler at 50 bar and 450°C. For the purpose of governing, the steam is throttle to 30 bar before it enters the high pressure state of turbine. after expansion in high pressure stage, the steam emerges just dry saturated and then reheated at the same pressure to 300°C before it expanded in the low pressure stage to a pressure of 0.06 bar, when it emerges again just dry and saturated. If the intermediate pressure is 3 bar, what are the states efficiencies? Also calculate the overall cycle efficiency and work ratio shared by HP stage to that of work shared by LP stage. [10]
10. A 4-stroke diesel engine develops 5 kW at 2000 RPM when its mean effective pressure is 7.5 bar. If for engine, $L = 1.25 D$, find their dimensions. [8]

Superheated steam table

P	T	v	u	h	s	P	T	v	u	h	s
kPa	°C	m³/kg	kJ/kg	kJ/kg	kJ/kg.K	kPa	°C	m³/kg	kJ/kg	kJ/kg	kJ/kg.K
300	(133.56)	(0.6059)	(2543.5)	(2725.3)	(6.9921)	5000	(263.98)	(0.03944)	(2596.5)	(2793.7)	(5.9725)
	150	0.6339	2570.7	2760.9	7.0779		300	0.04530	2697.0	2923.5	6.2067
	200	0.7163	2650.2	2865.1	7.3108		350	0.05193	2808.0	3067.7	6.4482
	250	0.7963	2728.2	2967.1	7.5157		400	0.05781	2906.5	3195.5	6.6456
	300	0.8753	2806.3	3068.9	7.7015		450	0.06330	2999.8	3316.3	6.8187
	350	0.9536	2885.3	3171.3	7.8729		500	0.06856	3091.1	3433.9	6.9760
	400	1.0315	2965.4	3274.9	8.0327		550	0.07367	3181.8	3550.2	7.1218
	450	1.1092	3047.0	3379.7	8.1830		600	0.07869	3272.8	3666.2	7.2586
	500	1.1867	3130.1	3486.1	8.3252		650	0.08362	3364.5	3782.6	7.3882
	550	1.2641	3214.7	3594.0	8.4604		700	0.08850	3457.1	3899.7	7.5117
	600	1.3414	3301.1	3703.5	8.5895		750	0.09334	3551.0	4017.7	7.6300
	650	1.4186	3389.1	3814.7	8.7134		800	0.09815	3646.3	4137.0	7.7438
	700	1.4958	3478.9	3927.7	8.8325		850	0.1029	3742.9	4257.5	7.8536
	750	1.5729	3570.5	4042.3	8.9475						

Table A2.1: Properties of SATURATED WATER – Pressure Table

P	T	v _l	v _g	v _t	u _l	u _g	u _t	h _l	h _g	h _t	s _l	s _g	s _t
kPa	°C	m³/kg	m³/kg	m³/kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg.K	kJ/kg.K	kJ/kg.K
6.0	36.167	0.001006	23.737	23.738	151.46	2272.5	2424.0	151.47	2415.0	2566.5	0.5208	7.8075	8.3283
300	133.56	0.001073	0.6048	0.6059	561.29	1982.2	2543.5	561.61	2163.7	2725.3	1.6721	5.3200	6.9921

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Group A

(Electrical Part)

1. Figure below shows the block diagram of water turbine controlled by an isochronous governor. Derive the expression for closed loop transfer function the system considering the inertia of the rotating system and the composite load. [8]

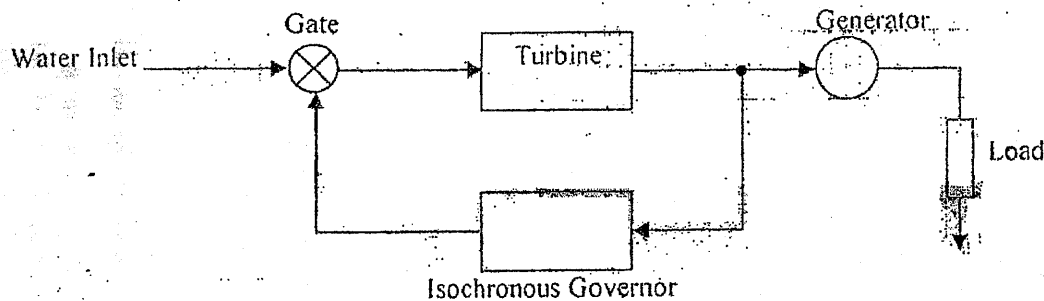


Fig.1

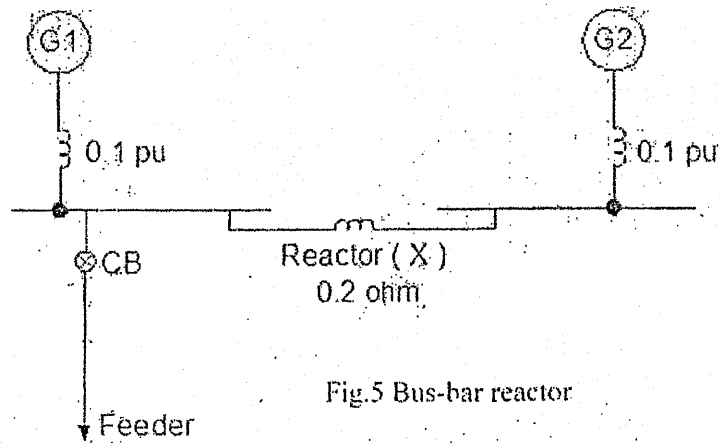
2. Two generators of 250MW and 500MW capacities respectively are operating in parallel and connected to a common bus. When each generator is half loaded, they operate at a common frequency of 50 Hz. Their droop characteristics are 4% and 2% respectively based on their respective capacities. When the system load is increased, the frequency decreases to 49.5 Hz. Calculate the increases in system load and load shared by each generator. [8]
3. Describe the operation of brushless excitation system of a synchronous generator with a neat diagram. [8]
4. Explain the fire fighting system for a power station with fixed piping system of CO₂ integrated with smoke detectors. [8]

5. Figure below shows a bus-bar reactor scheme. If a 3 phase to ground fault occurs on the outgoing feeder, calculate the fault current (in kA) supplied by each generator and fault MVA required for the circuit breaker (CB) on the feeder. Ratings of generators are given as follows:

[8]

G1: 30MVA, 11kV, $X_{g1}'' = 0.1$ pu

G2: 50MVA, 11kV, $X_{g2}'' = 0.1$ pu



Group B

(Mechanical Part)

- ✓ Attempt All questions.
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1. What are the advantages and disadvantages of diesel power plants? List the essential components of a diesel power plant and explain them briefly. [10]
2. Give the description of a simple gas turbine plant. What are the major applications of Gas Turbine Plants? [10]
3. a) Sketch a steam power plant with essential components and discuss briefly the functions of the major components. [5]
 - b) What is the fundamental difference between the operation of impulse and reaction turbines? [5]
4. What are the benefits and demerits of gas and steam combined power plant? Explain any one of the popular designs of the combination cycles. [10]

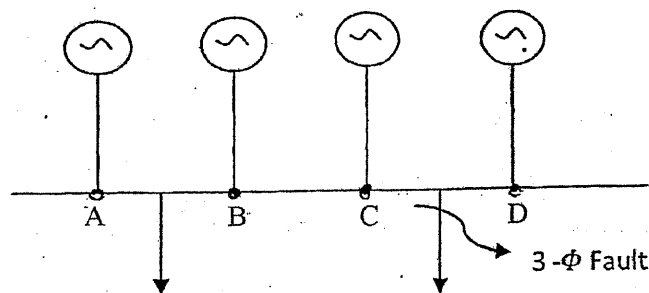
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Group A
(Electrical Part)

1. a) Describe the steady state and transient behavior of a turbine generator coupled system with governor. [6]
- b) Draw and explain the P-F and Q-V control loop of a hydrogenating system. [4]
2. a) Two generators are supplying power to a system. Their rating are 250 MW and 500 MW respectively. Each generator is half loaded and operating at a frequency of 60 Hz. If the system load is increased by 100 MW, the frequency drops to 59.5 Hz. What must be the individual droop of these generators so that they share the load according to their capacity? [5]
- b) What do you mean by isochronous governor? Write down its disadvantages when operated in parallel to supply a common load. [3]
3. a) Derive the transfer function of an excitation system with stabilizing transformer. [7]
- b) The figure below shows four identical generators, each rated 11 kV, 25 MVA and each having sub-transient reactance of 16% on its own rating. Find 3- ϕ fault level at one of the outgoing feeder. Also calculate the value of reactance to be connected in the bus bar between "B" and "C" so that fault level reduces by 40%. [5]



4. a) Why is reactor used in power system? Explain different types of reactor. [5]
- b) Describe the fire fighting system used in power station with necessary diagram. [5]

Group B
(Mechanical Part)

1. Explain fuel storage and supply system of a diesel power plant with a neat sketch. Also write down application of diesel power plants. [8]
2. The following observations were recorded during a trial of a four stroke engine with rope dynamometer. Engine speed = 650 rpm, Dia. of brake drum = 600 mm, Dia. of rope = 50 mm, Dead load on the brake drum = 32 kg, spring balance reading = 4.75 kg, Mechanical efficiency = 80%. Calculate the brake power and indicated power. [8]
3. An open cycle gas turbine plant uses heavy oil as fuel. The maximum pressure and temperature in the cycle are 500kPa and 650°C. The pressure and temperature of air entering into the compressor are 10^5 Pa and 27°C. The exit pressure of the turbine is also 10^5 Pa. Assuming isentropic efficiencies of compressor and turbine to be 80% and 85% respectively, find the thermal efficiency of the cycle. Take C_p (for air and gas) = 1kJ/kg°C and γ (for air and gases) = 1.4. If the plant consumes 5 kg of fuel per sec, find the power generating capacity of the plant. [10]
4. Explain how reheater increases the output of the steam turbine power plant along with neat sketch. Draw the layout and show the cycle in T-S diagram. [8]
5. Enumerate the advantages of a combined cycle plant. With the help of a neat diagram, explain the principle of working of a combined cycle plant to enhance the efficiency of electricity generation. [6]

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Group A
(Electrical Part)

1. a) What is water hammer effect and surge tank? [4]
b) Explain the basic principle of pump storage hydro power with a suitable example. [4]
2. a) Derive transfer function for speed response for load change in turbine generator set in the absence of governor. Also explain how isochronous governor can be incorporated together with turbine and generator with block diagram. [6]
b) Derive the transfer function of a water turbine and explain the response against unit stop change in gate opening. [6]
3. What is the role of excitation system? Derive transfer function of an excitation system with stabilizing transformer. [6]
4. a) Two generating units each rated as 250 MW and 500 MW have speed drop regulation of 20% and 10% respectively based on their rating. They are operated in parallel and each is half loaded at a common frequency of 50 HZ. If the load is increased by 60 MW, Calculate the new frequency at which operates all load shared by each generator. [8]
b) Explain the function of various parts of a power transformer with a neat sketch. [6]

Group B
(Mechanical Part)

1. Why do we need cooling system in diesel power plant? Explain different types of cooling system used in diesel power plant. [8]
2. In a test for four cylinders, four stroke diesel engine has a diameter of 120 mm, stroke = 140 mm, speed of engine = 2000 rpm, fuel consumption rate 15 kg/hour, calorific value of fuel = 42 MJ/kg. Difference in tension on either side of brake pulley = 40 kgf, brake circumference = 3.0m. If the mechanical efficiency is 80% then determine: [8]
 - i) Indicated horse power
 - ii) Brake thermal efficiency
 - iii) Indicated mean effective pressure
 - iv) Brake specification fuel consumption

3. In an open cycle regenerative gas turbine plant, the air enters the compressor at 1 bar and leaves at 6.9 bar. The temperature at the end of combustion chamber is 816°C . The isentropic efficiencies of compressor and turbine are 0.84 and 0.85 respectively. The regenerator effectiveness is 60%, determine (a) Thermal efficiency (b) Air rate (c) Work ratio [Take $C_p = 1005 \text{ J/kg.K}$ and $\gamma = 1.4$] [10]
4. List the common methods used for performance of a steam turbine power plant. Sketch layout for a regenerative scheme with an open feed water heater. Explain its working with corresponding processes on T-S diagram. [8]
5. Sketch the layout for a combined power plant in which waste heat of gas turbine outlet is used to heat feed water. Explain its working with processes on T-S diagram. [6]

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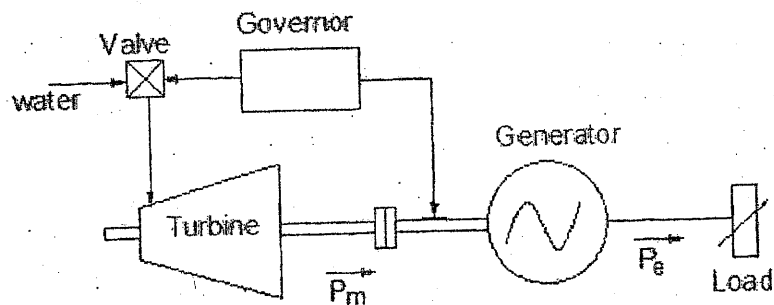
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Group A
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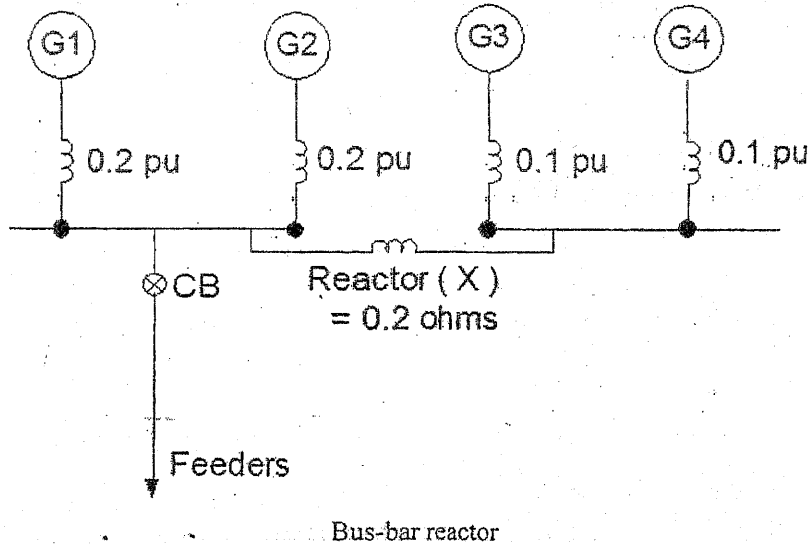
1. a) Describe the operation of pump storage hydro power plant. Is this type of plant suitable for Nepal Power system? Justify by your answer. [4]
- b) Describe how communication between two electric sub-stations can be made with Power Line Carrier Communication system. [3]
- c) What do you mean by water hammer in context of hydro power plant? [3]
2. a) In figure below shown a turbine-generator coupled system with speed governor. Excluding the action of governor, derive the transfer function relating the speed deviation ($\Delta\omega$) as the function of change in load, considering only inertia and load damping. [6]



- b) What do you mean by Isochronous Governor? What will be problem if two hydropower plants with isochronous governor are operated in parallel in to supply a common load? [4]
3. a) Two generators of 250 MW and 500 MW capacities respectively are operating in parallel and connected to a common bus. When each generator is half loaded, they operate at a common frequency of 50 Hz. Their droops characteristics are 4% and 2% respectively based on their respective capacities. When the system load is increased, the frequency decreases to 49.5 Hz. Calculate the increase in system load and load shared by each generator. [5]

- b) In figure below a bus-bar reactor scheme with four generators. If a 3 phase to ground fault occurs on the outgoing feeder, calculate the fault current (in kA) supplied by each generator and fault MVA required for the circuit breaker (CB) on the feeder. Rating of generators are given as follow: [5]

G1/G2 : 50MVA, 11kV, $X_{g1}'' = 0.2$ pu
 G3/G4: 100MVA, 11kV, $X_{g2}'' = 0.1$ pu



4. a) Describe static excitation system with necessary diagrams. [5]
 b) Derive the transfer function of excitation system with stabilizing transformer. [5]

Group B
(Mechanical Part)

1. Sketch the layout diagram of diesel power plant. Explain it in brief. [4+4]
2. A 4-cylinder, 4-stroke cycle engine having cylinder diameter 100 mm and stroke 120 mm was tested at 1600 rpm and the following readings were obtained. Fuel consumption = 0.27 liter/minute, Specific gravity of fuel = 0.74, B.P = 31.4 kW, Mechanical efficiency = 80%, Calorific value of fuel = 44000 kJ/kg. Determine: [8]
 - i) bsfc
 - ii) imep. and
 - iii) Brake thermal efficiency
3. List the common methods used for the performance improvement of the gas turbine power plants. Explain how re-heater increases network output of the plant. [8]
4. A gas turbine plant of 800 KW capacity takes the air at 100 KPa and 288 K with a mass flow rate of 6 kg/s. The pressure ratio of the cycle is 6 and the maximum temperature is limited to 900 K. A regenerator of 80% effectiveness is added in the plant to increase the overall efficiency. Assuming the isentropic efficiency of the compressor and turbine as 85%, determine the plant thermal efficiency and the net power developed. Take $C_p = 1.005$ KJ/KgK and $\gamma = 1.4$. [10]
5. Draw the basic component of a gas and steam turbine combined cycle. Explain how the waste heat is utilized in this cycle. [6]

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Group A
(Electrical Part)

1. Explain the operation of pump storage plant with neat diagram. For hydro dominated integrated system like Nepal is it economical? Justify your answer. [8]
2. a) Derive the Transfer Function of a hydraulic turbine given by $\frac{\Delta \bar{P}_m}{\Delta \bar{G}} = \frac{1 - T_w s}{1 + 0.5 T_w s}$; where the given symbol has usual meaning. Also state its special characteristics. [8]
- b) Two generating units have following ratings and dicop
Unit₁: 600MVA R₁ = 6%
Unit₂: 500MVA R₂ = 4%
The units are operating in parallel sharing a load of 900 MW at the normal frequency of 60Hz. Unit 1 supplies 500 MW and unit 2 supplies 400MW. If the load is increased by 90MW calculate the steady state frequency deviation and new generation on each unit. [8]
3. Draw schematic diagram of excitation system also include stabilizing transformer for improving dynamic response and determine block diagram of the excitation system by modeling each components. [8]
4. Explain reactors used in generating stations and substations with diagram. Also discuss their merits and demerits along with field of application. [8]

Group B
(Mechanical part)

1. What are the different methods used for cooling diesel engines? Explain the function of cooling tower. [6]
2. A diesel engine power plant operated by a two stroke diesel engine was motored when the meter reading was 4.5kW. Then the test on the engine was carried out for one hour run and the following observations were recorded: (i) Brake torque = 250 Nm; (ii) Speed = 1500rpm; (iii) Fuel consumed = 5kg/hr and (iv) Calorific value of fuel = 40MJ/kg. Determine: [10]
 - i) Mechanical efficiency
 - ii) Indicated thermal efficiency
 - iii) Brake thermal efficiency
 - iv) Indicated specific fuel consumption and
 - v) Brake specific fuel consumption

3. List the common method used for the performance improvement of the steam turbine power plant. Explain how reheating increases efficiency of the plant. [8]
4. On a reheat cycle, steam leaves the boiler and enters the turbine at 4 MPa, 400°C. After expansion in the turbine to 400 kPa, the steam is reheated to 400°C and then expanded in the low-pressure turbine to 10 kPa. Determine the cycle efficiency. [Refer the attached table for the properties of steam]. [10]
5. In a combined gas and steam turbine power plant, exhaust gases of regenerative gas turbine is used to heat feed water for the boiler of a steam power plant. According to this concept draw a complete circuit of a combined power plant showing "Heating feed water with exhaust gases". What are the reasons that inspire you to construct a combined cycle power plant? [6]

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

Subject: - Power Plant Equipment (EE703)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Assume suitable data if necessary.
- ✓ Candidates use separate answer book for each group.

**Group A
(Electrical Part)**

- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.

1. Explain the water hammer effect in penstock pipe and advantages of surge tank of hydropower plant. [8]
2. Explain with neat diagram, the P-F loop and Q-V loop in hydro generating system. [8]
3. What do you mean by isochronous governor? Explain with schematic diagram. [8]
4. What is excitation system? Explain the brush excitation system with neat diagram. [8]
5. Figure below shows a bus-bar reactor scheme. If a 3 phase to ground fault occurs on the outgoing feeder, calculate the fault current (in kA) supplied by each generator and fault MVA required for the circuit breaker (CB) on the feeder. Rating of generators are given as follow: [8]

G1 : 30MVA, 11kV, $X_{g1}'' = 0.1$ pu

G2: 50MVA, 11kV, $X_{g2}'' = 0.1$ pu

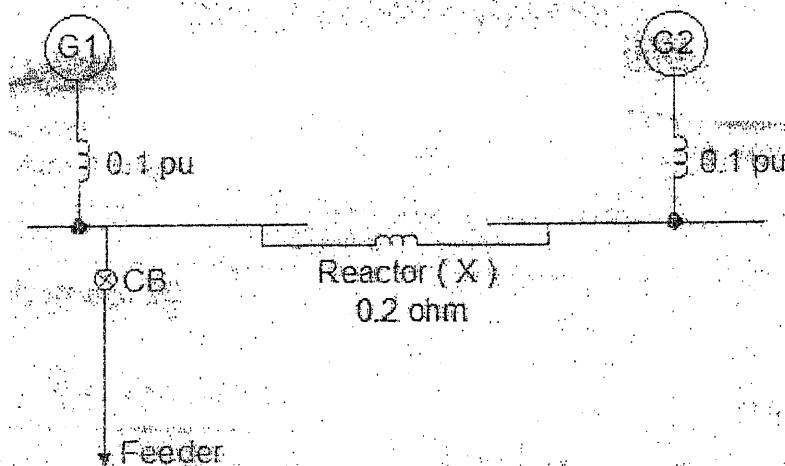


Fig.4 Bus-bar reactor

Group B
(Mechanical Part)

- ✓ *Attempt All questions.*
- ✓ *The figures in the margin indicate Full Marks.*
- ✓ *Necessary tables are attached herewith.*

1. Explain the fuel supply system of a diesel power plant with a sketch. [6]
2. What methods are there to reduce noise and vibrations of diesel engine of diesel power plant? Describe the cooling system of diesel power plant. [10]
3. List the common methods used for the performance improvement of the gas turbine power plants. Explain how regeneration increases efficiency of the plant. [8]
4. A steam power plant running on Rankine cycle has steam entering HP turbine at 20 MPa, 500°C and leaving LP turbine at 89.6 % dryness. Considering condenser pressure of 0.005 MPa and reheating occurring upto the temperature of 500°C determine:
a) the pressure at which steam leaves HP turbine
b) the thermal efficiency. [Refer the attached table for the properties of steam] [12]
5. List the common methods employed to utilize waste heat in combined power plants. [4]

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

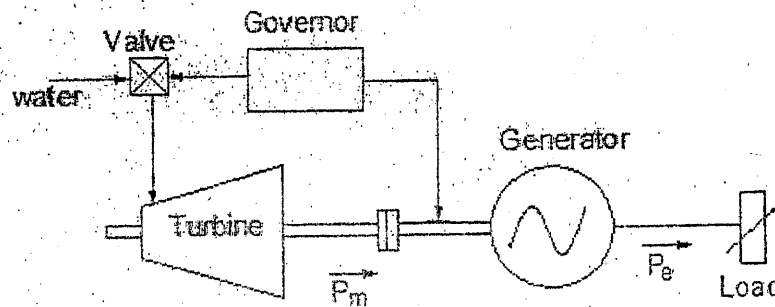
Subject: - Power Plant Equipment (EE703)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Assume suitable data if necessary.
- ✓ Candidates use separate answer book for each group.

**Group A
 (Electrical Part)**

- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.

1. Explain with neat diagram, how the delivery of the water to turbine is controlled in hydro generating station. [8]
2. a) The figure below shows a turbine-generator coupled system with speed governor. Explain the transient responses of electrical power output (P_e), mechanical power input (P_m) and speed due to sudden increase in electrical load by an amount of ΔP_L . [10]



- b) Describe the excitation system of a synchronous generator with stabilizing transformer. [6]
3. Two generators of 250 MW and 500 MW capacities respectively are operating in parallel and connected to a common bus. When Each generator is half loaded, they operates at a common frequency of 50 Hz. Their droops characteristics are 4% and 2% respectively based on their respective capacities. When the system load is increased, the frequency decreases to 49.5 Hz. Calculate the increase in system load and load shared by each generator. [8]
4. Explain different reactor schemes used in generating station and substations. [8]

Group B
(Mechanical Part)

✓ Attempt All questions.

✓ The figures in the margin indicate Full Marks.

1. Sketch the main components of a diesel power plant. Write down the function of starting air supply system. [6]
2. A two stroke diesel engine was motored when the meter reading was 1.5 kW. Then the test on the engine was carried out for one hour and the following observations were recorded: Brake torque = 120 Nm; Speed = 600 rpm; Fuel used = 2.5 kg; calorific value of fuel = 40.3 MJ/kg; Determine:
 - (a) Brake power,
 - (b) Indicated power,
 - (c) Mechanical efficiency and
 - (d) Indicated thermal efficiency. [10]
3. Air enters the compressor at 100 kPa, 300 K and is compressed to 1000 kPa. The temperature at the inlet to the first turbine stage is 1400 K. The expansion takes place isentropically in two stages, with reheat to 1400 K between the stages at a constant pressure of 300 kPa. A regenerator having an effectiveness of 90% is also incorporated in the cycle. Determine the thermal efficiency. Take $c_p = 1.005$ kJ/kg K and $\gamma = 1.4$. [12]
4. List the common methods used for the performance improvement of the steam turbine power plants. Explain how reheating increases efficiency of the plant. [8]
5. Sketch the basic components of a combine power plant. Also sketch the corresponding processes on T-s diagram. [4]

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

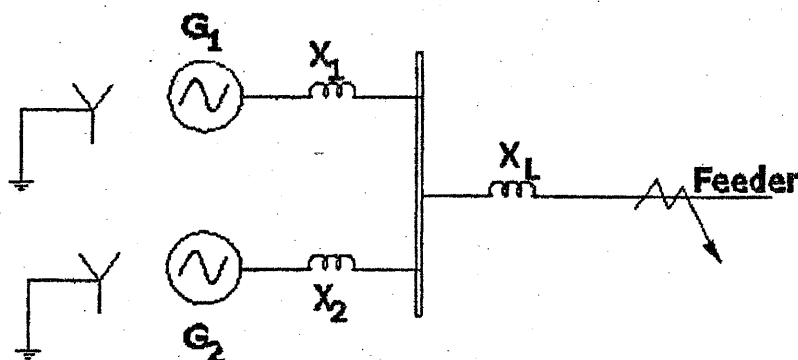
Subject: - Power Plant Equipment (EE703)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

Group A
 (Electrical part)

1. Explain the operation of pump storage type hydro power plant with a neat diagram. Is this type of power plant feasible to install in Nepal's power system in the current scenario? Support your answer with appropriate reasons. [8]
2. What do you mean by isochronous governor and explain its operation? Why it is not suitable for multiple number of generating units operating in parallel. Derive the mathematical model of governor with speed droop characteristics. [8]
3. Two generators of 250 MW and 500 MW capacities respectively are operating in parallel and supplying power to a common load. When each generator is fully loaded, they operate at a common frequency of 49 Hz. Their droop characteristics are 2% and 4% respectively based on their respective ratings. When the system load is decreased, the frequency increases to 50Hz. calculate the decrease in system load shared by each generator. [8]
4. What is excitation system? Explain the various types of excitation system employed in power plant on the basis of their performance with suitable connection diagram. [8]
5. Figure below shows the single line diagram of parallel operated generators. Their ratings are: [8]

G_1 : capacity = 50 MW, 11kV, $X_1 = 0.16$ pu based on its rating
 G_2 : capacity = 50MW, 11kV, $X_2 = 0.16$ pu based on its rating
 $X_L = 2$ ohms



Calculate the fault current in the feeder during 3 phases to ground fault on the feeder. Calculate the value of inductance (in mH) of the reactor to be connected in series with X_1 so that the fault current decreases by 40%.

Group B
(Mechanical part)

6. Why cooling system is necessary in a diesel engine? Explain different cooling system used in diesel engine power plant with neat sketches. [8]
7. In a test for four-cylinders, four-stroke engine has a diameter of 120 mm, stroke = 150 mm, speed of engine = 1800 rpm, fuel consumption of 0.25 kg/min, calorific value of fuel is 44000 kJ/kg. Difference in tension on either side of brake pulley = 40 kg, Brake circumference is 300 cm. If the mechanical efficiency is 85 %. Determine
(a) Brake-thermal efficiency,
(b) Indicated thermal efficiency,
(c) Indicated mean effective pressure and
(d) Brake specific fuel consumption. [8]
8. A regenerative gas turbine with intercooling and reheat operates at steady state. Air enters the compressor at 100 kPa, 300 K with a mass flow rate of 5.807 kg/s. The pressure ratio across the two-stage compressor is 10. The pressure ratio across the two-stage turbine is also 10. The intercooler and reheater each operate at 300 kPa. At the inlets to the turbine stages, the temperature is 1400 K. The temperature at the inlet to the second compressor stage is 300 K. The isentropic efficiency of each compressor and turbine stage is 80%. The regenerator effectiveness is 80%. Determine:
(a) the thermal efficiency,
(b) the back work ratio,
(c) the net power developed, in kW. Take $c_p = 1.005$ kJ/kg K and $\gamma = 1.4$. [12]
9. List the common methods used for the performance improvement of the steam turbine power plants. Explain how regeneration increases efficiency of the plant. [8]
10. Sketch the basic components of a combine power plant. Also sketch the corresponding processes on T-s diagram. [4]

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

Subject: - Power Plant Equipment (EE702)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Necessary tables are attached herewith.
- ✓ Use separate answer books for each part.
- ✓ Assume suitable data if necessary.

Group A
(Electrical Part)

1. What do you mean by steady state operation of turbine (with governor) generator coupled system. Describe the transient response of such system with sudden increase in generator load. [8]
2. a) Fig.2 shows the block diagram of water turbine driving an electric generator without speed governor. Explain how the inertia and load damping constant can control the speed of the system against small change in load. Derive the transfer function showing the effect of inertia and load damping constant. [8]

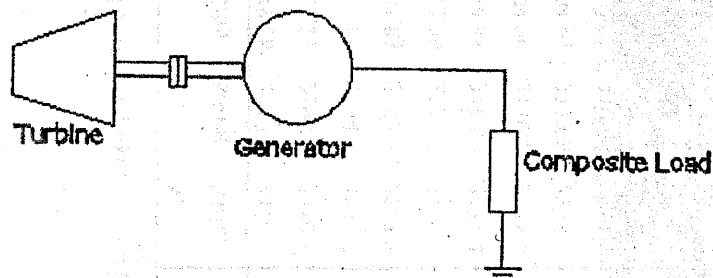


Fig.2

- b) Two generating units of 500MW and 250 MW capacities respectively are operating in parallel and supplying power to a common load. When each generator is half loaded, they operate at a common frequency of 50 Hz. If the droop regulation of 500MW generating set is 5% based on its rating, what must be the droop regulation of 250 MW generating unit based on its own rating show that they share the change in load according to their capacities. [8]
3. Describe the excitation system of a synchronous generator with stabilizing transformer. Derive mathematical model of the system in term of transfer function of each component of the system. [8]
4. Describe how a SCADA system can be implemented in a power system. [8]

Group B
(Mechanical part)

5. Write down the functions of lubricating oil in diesel engine. Sketch lubricating system of a diesel power plant and explain its working. [8]
6. A two stroke diesel engine was motored when the meter reading was 2 kW. Then the test on the engine was carried out for one hour and the following observations were recorded: Brake torque = 150 Nm; Speed = 900 rpm; Fuel used = 3 kg; calorific value of fuel = 40 MJ/kg; Determine:
(a) Brake power,
(b) Indicated power,
(c) Mechanical efficiency and
(d) Indicated thermal efficiency. [8]
7. List the common methods used for the performance improvement of the gas turbine power plants. Explain how inter-cooling increases efficiency of the plant. [8]
8. On a regenerative cycle, steam leaves the boiler and enters the turbine at 4 MPa, 400°C. After expansion to 400 kPa, some of the steam is extracted from the turbine to heat the feedwater in an open feedwater heater. The pressure in the feedwater heater is 400 kPa, and the water leaving it is saturated liquid at 400 kPa. The steam not extracted expands to 10 kPa. Determine the cycle efficiency. [Refer the attached table for the properties of steam] [12]
9. List the common methods employed to utilize waste heat in combined power plants. [4]

Exam.	Regular / Back		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

Subject: - Power Plant Equipments

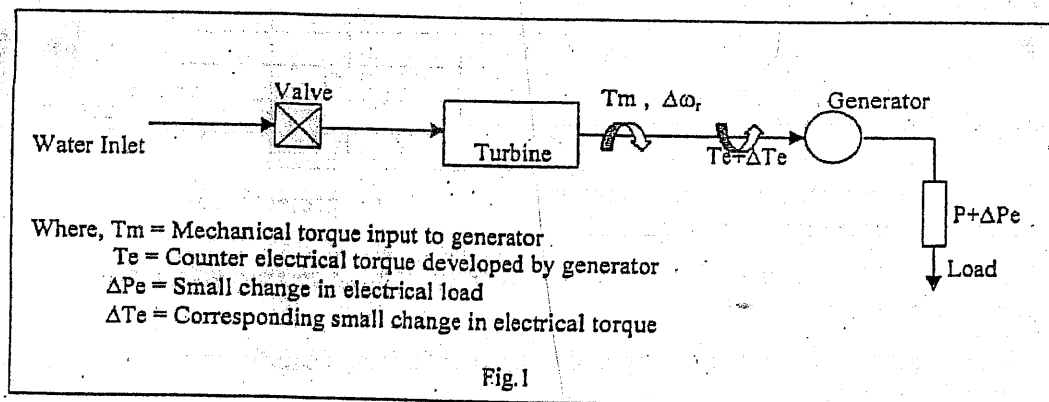
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Assume suitable data if necessary.

**Group A
 (Electrical Part)**

[40]

- ✓ Attempt any **Four** questions.
- ✓ **All** questions carry equal marks.

QN1 Fig.1 shows the block diagram of water turbine driven generator and electric load without governor. When there is small change in electrical load, the inertia of rotating mass and frequency sensitive component of load helps to stabilize the speed. Derive the expression of transfer function relating the speed deviation ($\Delta\omega_r$) with change in electrical load ΔP_e , assuming that the change in electrical load has frequency independent as well as dependent components. [10]



QN2 Describe the operation of excitation system with stabilizing transformer with a neat circuit diagram. Derive the transfer function block diagram of such excitation system. [10]

QN3 Two generators of 1000MW and 500 MW capacities are operating in parallel and supplying power to a common load. When each generator is half loaded, they operate at a common frequency of 50 Hz. At no-load, they operate at common frequency of 51 HZ. Calculate the droop of each generator. When the load is increased from half load to a certain load, the common frequency drops to 49.4 Hz. Calculate the additional power output from each generator [10]

QN4 What do you mean by Step Potential and Touch Potential refer to the grounding system of sub-station. A grounding mat of a substation has 4 nos of main conductors buried 1 m below the ground in parallel. The distance between each conductor is 0.5m. Calculate the step potential due to a fault current of 10kA. Given that: soil resistivity = 2000 ohm-m, Irregularity factor = 0.5. [10]

QN5 Explain the operation of a pump storage hydro power plant with a neat diagram. Also explain briefly fire fighting system used in power house. [6+4]

Group B
(Mechanical Part)

[40]

- ✓ *Attempt All questions.*
- ✓ *The figures in the margin indicate Full Marks.*

1. Discuss on working principle of hydropower plants with essential features. Show the power output variation in respect to head and discharge. (5)
2. How the water turbines are classified? Discuss on criteria of selecting suitable type of turbines for hydropower plant? (5)
3. A run-of river rate of $400 \text{ m}^3/\text{s}$ and head of 45 is available at a site proposed for hydro electric power plant. Assuming the turbine efficiency of 90% and speed of 250 rpm, find or suggest the least number of Francis turbines required, if Francis turbine has not greater than 200 specific speeds. (8)
4. Make a comparison of diesel engine power plants with steam power plants. (4)
5. Write the types and operation of gas turbines and explain it illustrating diagram, T-s diagram and p-v diagram. (4)
6. Illustrate and discuss the energy conversion chart for a steam power plant. Show the various energy streams flowing in a simple steam turbine system and derive steady flow energy equations. (10)
7. What do you understand by co-generation and where this type of technology can be applied? (4)

Exam. Level	Regular/Back			
	BE	Full Marks	80	
Programme	BEL	Pass Marks	32	
Year / Part	IV / I	Time	3 hrs.	

Subject: - Power Plant Equipment

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Assume suitable data if necessary.

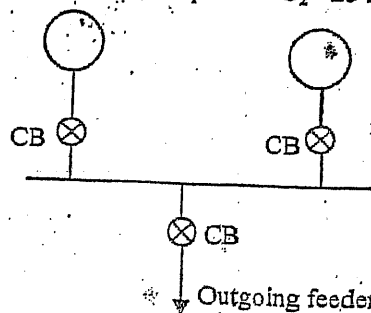
Group A
(Electrical Part)

[40]

- ✓ Attempt any Four questions.
- ✓ All questions carry equal marks.

1. Describe the operation of brushless excitation system of a synchronous generator with a neat diagram.
2. What do you mean by Step Potential and Touch Potential with reference to the grounding system of sub-station? How the concepts of these potential are used to design the grounding mat of a sub-station?
3. Two generators of 250MW and 500MW capacities respectively are operating in parallel and connected to an infinite bus. Each generator is fully loaded and operating at 50Hz. Their droops characteristics are 2% and 4% respectively. When the system load is decreased, the frequency increases to 50.5Hz. Calculate the decrease in system load and load shared by each generator with this change in load.
4. For the system shown below, calculate the fault level in MVA at out going feeder for a three phase to ground fault with zero fault impedance on this feeder. Calculate the value of series reactance to be connected in the outgoing feeder in order to reduce the fault level by 40%.

$G_1 = 25 \text{ MVA, } 11 \text{ kV, } X_{g1} = 0.15 \text{ pu}$ $G_2 = 25 \text{ MVA, } 11 \text{ kV, } X_{g1} = 0.3 \text{ pu}$



5. Why CO₂ is preferable for extinguishing the fire in power station? Explain the fire fighting system for a power station with fixed piping system of CO₂ integrated with smoke detectors.

Group B
(Mechanical Part)

[40]

- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.

1. Describe the working principle of hydropower plants. Show the power output variation with respect to head and discharge. [5]
2. Briefly discuss the differences among Pelton, Francis and Kaplan turbines and types of power plants they are suitable for. [5]
3. The quantity of water available for hydroelectric power plant is $260\text{m}^3/\text{s}$ under a head of 1.7m. Assuming the speed of the turbine as 50 rpm and its efficiency of 80%, determine and suggest the number of turbine units required. [8]
4. In which principle diesel power plants work? Do you agree that diesel power plants are environmentally friendly, if not give reasons? [4]
5. How a gas turbine power plant is operated? Explain it with, T-s diagram and P-v diagram. [4]
6. List out the main components of steam turbines and explain the function of each. Show the various energy streams flowing in a simple steam turbine system and derive steady flow energy equations. [10]
7. What do you understand by noise pollution? Briefly explain the methods adopted to reduce the noise pollution. [4]

Exam.		Regular / Back	
Level	BE	Full Marks	80
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Year / Part	IV /	Time	3 hrs.

Subject: - Power Plant Equipments

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- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

Group A
(Electrical Part)

[40]

- ✓ Attempt any Four questions.

1. Describe the operating principle of a pumped storage hydro power plant. Under what circumstances, such power plant would be more economical. [10]
2. Describe the modeling of excitation system with stabilizing transformer. Derive the transfer function of each component of the system and write down the closed loop control system with transfer functions so derived. [10]
3. Describe the operating principle of a coil pressure governor with neat diagram and also describe the transient behavior of generator-turbine-governor system. [10]
4. Two generators of 250 MW and 500 MW capacities respectively, are operating in parallel and connected to an infinite bus. Each generator is half loaded and operating at 50 Hz. Their droops characteristics are 2% and 4% respectively. When the system load is increased, the frequency drops to 49.5 Hz. Calculate the increase in system load and load shared by each generator. [10]
5. What are the various factors to be considered for designing a earthing system of substation yard. Write down the basic steps for designing the earthing system of substation yard. [10]

Group B
(Mechanical Part)

[40]

- ✓ Attempt All questions.

1. In what principle hydropower plants work? Show the power output variation in respect to head and discharge. [5]
2. Discuss on types of turbines that are applied in hydropower plants. [5]
3. A hydroelectric plant is supplied from a reservoir of $6 \times 10^6 \text{ m}^3$ capacity at a head of 75m. Determine the number of electrical units produced (kWh) during the year if the load factor is 0.6 and overall efficiency of generation is 72%. [8]
4. In which principle diesel power plants work? Do you think diesel power plants are environmentally friendly, if not given reasons? [4]
5. How a gas turbine power plant is operated? Explain it with illustrating diagram, T-s diagram and p-v diagram. [4]
6. Describe a steam power plant by a Rankine Cycle. Derive expressions for work done by steam on blades of the turbine using Turbine Vapour Cycle on T-h Diagram. [10]
7. What do you understand by co-generation in any power plants? What benefit can be achieved by applying it? [4]

Group B
(Mechanical Part)

[40]

- ✓ *Attempt All questions.*
- ✓ *All questions carry equal marks.*

1. Briefly describe the salient features of steam power plant and hydro power plant especially in terms of their operational requirements.
2. Describe different types of steam nozzles and their functions. Discuss the factors in which the exit velocity of steam in a steam nozzle depends on, with the help of appropriate equations.
3. Discuss the needs and the working of
 - a) Cooling systems for IC engines
 - b) Fuel handling system
4. a) Describe how sound is quantified, and discuss the ways of minimizing noise in a work place.
b) Discuss the effects of noise.

Exam.	Regular/Back		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

Subject: - Power Plant Equipment

- / Candidates are required to give their answers in their own words as far as practicable.
- / Assume suitable data if necessary.

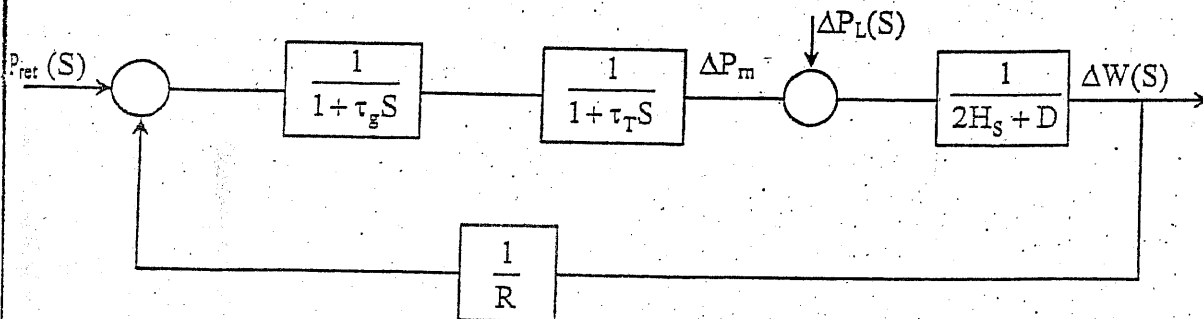
**Group A
 (Electrical Part)**

[40]

- / Attempt any Four questions.
- / The figures in the margin indicate Full Marks.

Automatic Generation Control loop in an isolated power system has the following equivalent block diagram.

[10]



Find the closed loop transfer function of above L.F.C. loop of the following values are given to parameters. Turbine $\tau_T = 0.5$, Governor $\tau_g = 0.2$. Inertia constant $H = 5$ sec, Governor speed regulation = R p.u. Assume that load varies by 0.8% for 1% change in frequency. Find the characteristic equation and determine the range of R for system stability.

Draw the block diagram of a voltage control loop with AVR, deriving the transfer functions of components. What are the basic types of Excitation System used in power plant.

[10]

a) Draw the schematic diagram of a Brushless Excitation System and a Static Excitation System.

[5]

b) What are the components in a modern synchronizing scheme in a power plant in automatic mode? What is meant by dead bus synchronization?

[5]

Describe the electrical and mechanical protections used for a large power transformer connected to a generator. Mention IEEE code numbers for the relays. Explain the working principle of Restricted Earth fault relaying using a schematic diagram.

[10]

a) What are the hardware used in a modern electro hydraulic governor? Explain the function of an oil accumulator with a nitrogen bladder.

[5]

b) Describe the different types of five detectors used in a power plant. Explain the fore-fighting system used for an oil-immersed transformer.

[5]

Group B
(Mechanical Part)

[40]

- ✓ Attempt All questions.
- ✓ All questions carry equal marks.

1. Briefly describe the salient features of steam power plant and hydro power plant especially in terms of their operational requirements.
2. Describe different types of steam nozzles and their functions. Discuss the factors in which the exit velocity of steam in a steam nozzle depends on, with the help of appropriate equations.
3. Discuss the needs and the working of
 - a) Cooling systems for IC engines
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4. a) Describe how sound is quantified, and discuss the ways of minimizing noise in a work place.
 - b) Discuss the effects of noise.
