(195)

(16)

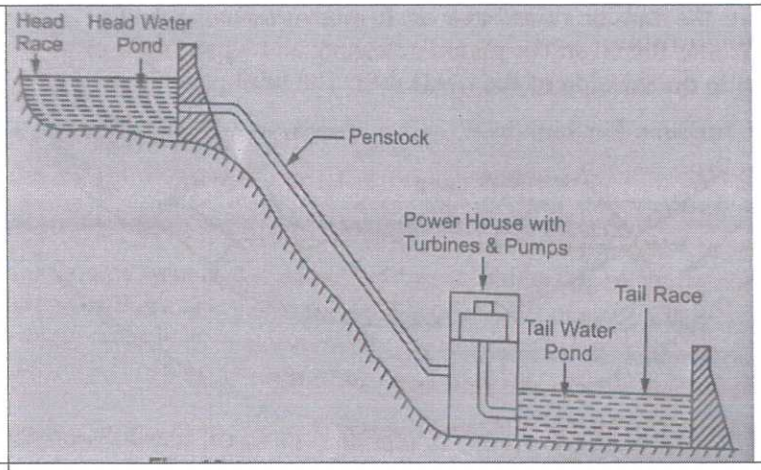
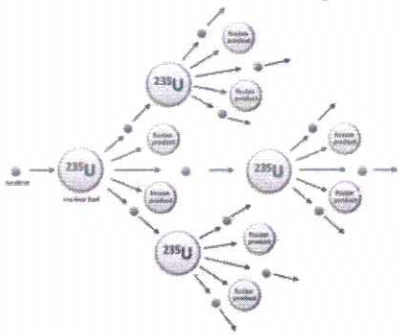
Scoring Indicators

COURSE NAME : Power Plant Engineering

COURSE CODE : 5023 (2021 Scheme) **QID :** 21092300 47B

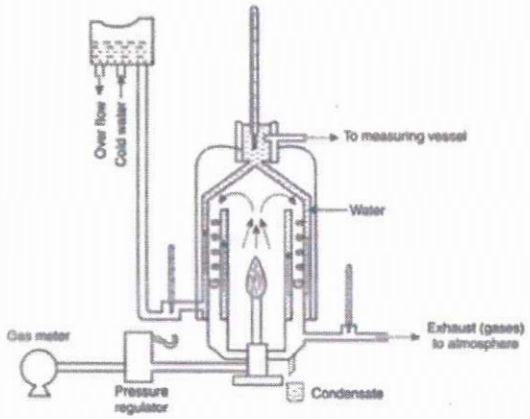
Q No	Scoring Indicators	Split score	Sub Total	Total score
	PART A			**9**
I. 1	Reheating, Bleeding, Regenerative $2 \times 1/2 = 1$		1	
I. 2	1. First demand (kW) estimated. 2. Growth of demand anticipated. 3. Reserve capacity required $2 \times 1/2 = 1$		1	
I. 3	Catchment area, Reservoir, Dam, penstock, surge tank, valve house, hydraulic turbine, Generator $2 \times 1/2 = 1$		1	
I. 4	Gas turbine is free from reciprocating parts Produces uniform torque Requires little or no water for cooling Weight per Kw power is less Can be driven at very high speed $2 \times 1/2 = 1$		1	
I. 5	Process in which heavy nucleus is split into smaller nuclei, when it is bombarded by a neutron		1	
I. 6	These are meant to absorb as many of the neutrons impinging upon them as possible. Rods made of boron-steel alloy and cadmium are most commonly used as control rods. Fission is built up by pulling the rods up the reactor; and operation stops when the rods are pushed down. They are made of boron steel alloy & cadmium. $2 \times 1/2 = 1$		1	
I. 7	Fog having increased acidity is called acid fog It happens due to environmental factors like air pollution due to SO2 NOX Acid fog leads to acid rain $2 \times 1/2 = 1$		1	
I. 8	Store oils only in properly sealed tank Fuel storage and transfer line temperature should not exceed 50 degree C Display the name of oil and its hazards properly in container and storage tank Before filling the oil proper inspection of container should be carried out $2 \times 1/2 = 1$		1	
I. 9	It is a constant-volume type calorimeter that measures the heat of a particular reaction or measures the calorific value of the fuels.tc.	$2 \times 1/2 = 1$	1	
	PART B			24
II. 1	Major power source in India is Coal, India has the richest coal deposit in the world. Around 30% of our total energy is produced from Renewable sources		3	

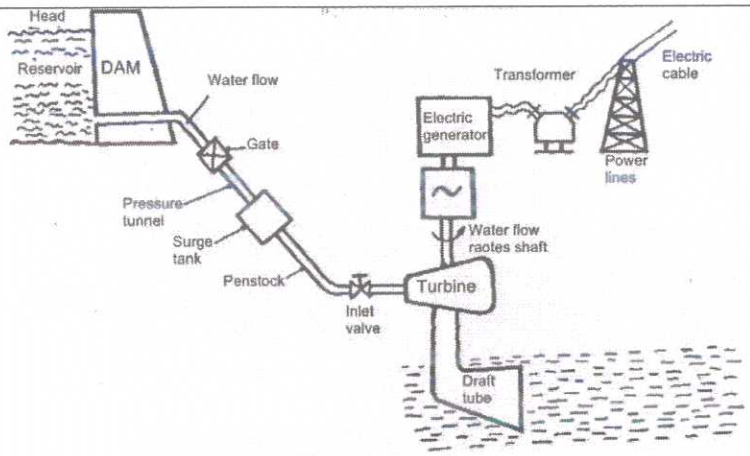
	Coal	205,235 MW	49 %	Any 6 points 3 Marks		
	Lignite	6620 MW	1.6 %			
	Gas	24824	6%			
	Diesel	580	0.1 %			
	Hydro	46850	11.2 %			
	Wind, Solar	125692	30.2			
	Small hydro power	4944	1.2 %			
	Nuclear	6780	1.6			
	Total fossil fuel 56.8 % Total non fossil fuel 43 %					
II. 2	Process of draining steam from the turbine at a certain point and this steam is used for pre heating the feed water. Pre heated water is then supplied to boiler				3	
II. 3	Flash point, Fire point, Pour point Octane number, cetane number, Calorific value, HCV, LCV			Any 5 Points	3	
II. 4	• Conventional:- Steam engines, Steam turbine, Diesel, Gas turbine, Hydro electric, Nuclear • Non conventional:- Solar power, Wind, Geothermal, Tidal According to type of load:- Base load, Peak load, Central power plant, Captive or own use power plant Any 6 points = 3 Marks				3	

II. 5		Fig. 2 Mark Marking 1 Mark	3	
II. 6	CHAIN REACTION · Chain reaction is a chemical or nuclear reaction , in which a neutron colliding with an atomic nucleus causes fission and the ejection of one or more other neutrons, which induce other nuclei to split. · The three additional neutrons emitted during the above nuclear reaction are called secondary neutrons. · They in turn, can cause fission in the neighboring nuclei, producing more and more secondary neutrons. This is called chain reaction, which continues until the whole of the fissionable material undergoes fission. 	Fig. 1 Descpt 2	3	

II. 7	• Depletion of fossil fuel • Climate change, • High initial investment, • Lack of Privatisation, • Displacement of population, • Deforestation, • Destroys wild life habitat, • Flood, • Release of green house gas, • Lack of incentives and promotions from Govt, Air pollution, Water pollution Any 5 points = 3		3	
II. 8	1. The raise or fall in temperature of natural aquatic environment induced by human intervention is known as thermal pollution 2. Major reason is dumping of hot water from power plants/industries into ground or river 3. Removal of trees and vegetation causes raising of temperature 4. hot water deposition into flowing streams leads to global warming 5. Radioactive emission from nuclear reactors increases temperature of water bodies and atmosphere 6. Secondary hot water from condenser is discharged into lakes and streams thereby increase temperature 7. Sudden temperature change in river and lake causes thermal shock to aquatic organisms Effects: • Decreases dissolved oxygen level in water • Toxins in water as a result of of dumping waste water, which causes chemical contamination • Cooling water from Nuclear reactor is slightly radioactive • Loss of biodiversity Any 5 points = 3 Mostly		3	
II.9	• Boiler shall not be used unless it is registered and certified • Boiler sha; not be operated after expiry of certificate • Boiler shall not be operated above rated pressure range • Explosion or damage of a boiler or a part of a boiler shall be reported to the chief inspector of boiler within 24 hours • Any repairs/welding/Tube replacing/ modification etc should be carried out on prior permission from Boiler inspector • Boiler cannot be operated without the presence competent certified staff • Register number as marked on boiler shall not be removed or tampered Any 5 Points		3	
II.10	Prevention Greenhouse effect 1. Reduce Carbon Emissions: The most effective way to prevent the greenhouse effect is to reduce carbon emissions. This can be achieved by using renewable energy sources, such as wind, solar, and hydro power, reducing dependence on fossil fuels, promoting energy efficiency, and adopting sustainable Any 5 points			

	the greenhouse effect is to reduce carbon emissions. This can be achieved by using renewable energy sources, such as wind, solar, and hydro power, reducing dependence on fossil fuels, promoting energy efficiency, and adopting sustainable practices. 2. Promote Afforestation: Trees absorb carbon dioxide from the atmosphere and release oxygen, making afforestation a crucial measure for reducing greenhouse gas concentrations. Promoting afforestation, especially in urban areas, can also help to reduce air pollution and enhance the quality of life. 3. Reduce Waste: Landfills are a major source of greenhouse gas emissions. Reducing waste can help to reduce the amount of methane produced in landfills. This can be achieved by reducing, reusing, and recycling waste materials. 4. Adopt Sustainable Agricultural Practices: Agriculture is another major source of greenhouse gas emissions. Adopting sustainable agricultural practices, such as reducing fertilizer use, promoting organic farming, and adopting water conservation techniques, can help to reduce greenhouse gas emissions from agriculture. 5. Promote Sustainable Transportation: Transportation is a major source of greenhouse gas emissions. Promoting sustainable transportation, such as public transportation,carpooling, cycling, and walking, can help to reduce greenhouse gas emissions and improve air quality.			

	PART C			42
III. 1	 • Used to find out the HCV of gaseous fuels. • It consists of a cylindrical combustion chamber surrounded by water jacket • Water in jacket absorbs heat of combustion • A measured quantity (using Gas meter) of gaseous fuel and air is burned in the combustion chamber to form combustion products. • Hot gasses flows through the tubes surrounded by water and finally leaves through bottom exit of chamber • Cooling water enters at the bottom of the jacket and move upwards, then leaves through the top of the chamber. • Thermometers are fixed at following points to measure inlet temperature of water, outlet temperature of water and to measure the temperature of condensate. $HCV = \frac{4.2\,m(t2-t1)}{v}$ KJ/m^3 m= mass of water collected during trial time (kg) t2 = exit temperature of water degree celsius t1 = inlet temperature of water degree celsius v = volume of fuel burned in meter cube	Figure 4 Marks Description 3 Marks	7	7

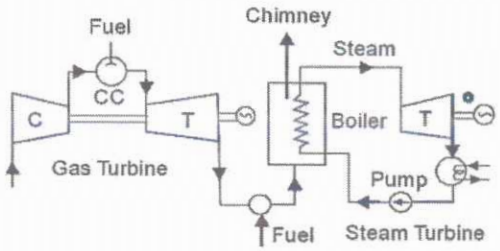
III. 2	**Flash point** : It is the lowest temperature at which the vapor of fuel will ignite and flashes for at least one second and then extinguish when an ignition source is present lowest flash point indicates the fuel is easier to ignite **Fire point:**It is the lowest temperature at which the vapor of fuel will continue to burn for at least 5 seconds. **Pour point:** It is the temperature at which a fuel becomes semi solid and loses its flow characteristics or pour point is temperature at which paraffin in the fuel has crystallized into gels and become resistant to flow. **Octane number**: It is the measure of ignition quality of petrol. if the number is higher. Then the chances of knocking will be less. knocking is the premature combustion of fuel in the combustion chamber. Octane number is applicable only for SI Engines. **Cetane number:** It is the measure of ignition quality of diesel fuel, if the number is higher then it is easier to start the engine using that fuel. May consider Calorific values also	2 1 1 2 1	7	7
III. 3	 Description 3 Figure 4		7	7
III. 4	Main disadvantages of a gas turbine power plant are higher fuel consumption and a small starting motor is needed to start the compressor initially. These limitations can be gainfully reduced in combining a gas turbine power plant with 1. **Combined Gas & Steam power plant:** a. Exhaust gas used for feed water heating b. Supercharged boiler c. Exhaust heat recovery steam gas plant	2	7	7

d. Combined nuclear gas turbine and fossil fuel fired steam steam turbine cycle
e. Integrated Gasifier combined cycle
f. Repowering
2. Combined Diesel and Gas turbine power plant
a. Turbo charging
b. Gas generator
c. Compound engine
3. Combined Gas turbine & Nuclear power plant

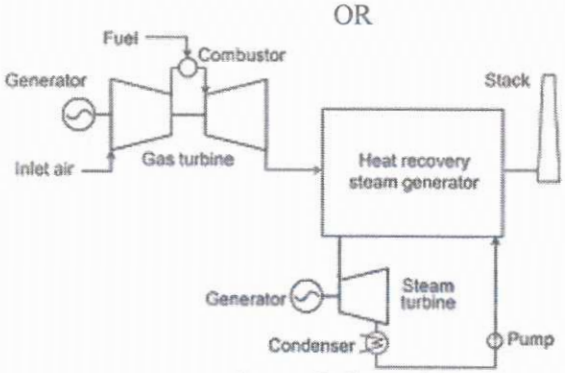
2

Combined Gas & Steam power plant:

The main equipment for any combined cycle power plant includes a steam turbine, a gas turbine, and a heat recovery steam generator. Heat energy in exhaust gasses from gas turbine is utilized in heat exchanger to raise the temperature of feed water coming from condenser.



OR



Steam & Gas turbine

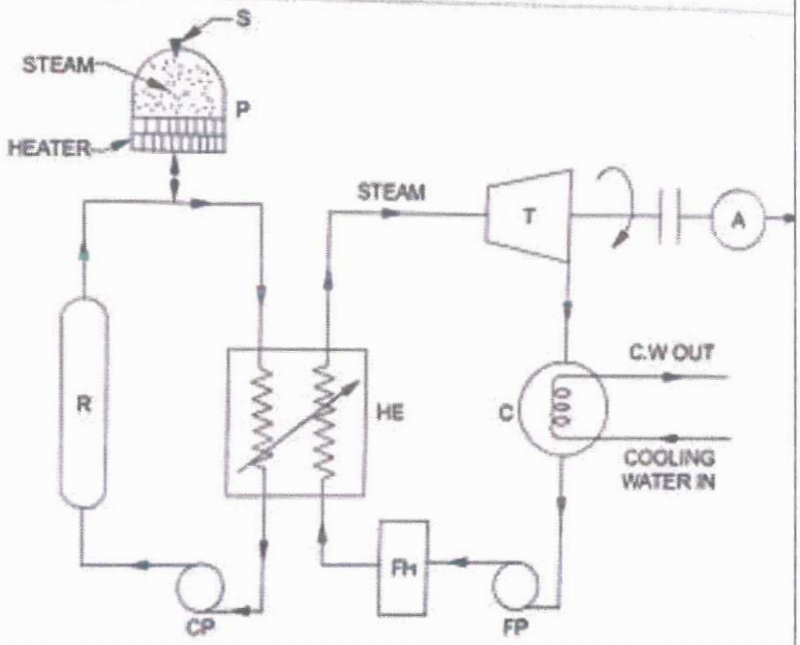
3

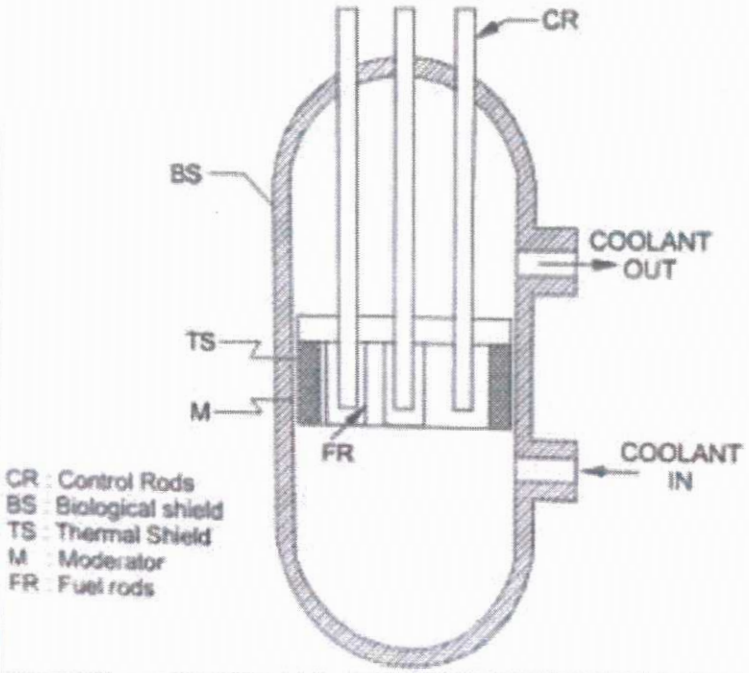
- In a combined cycle gas turbine, a gas turbine generator generates electricity and waste heat is used to make steam to generate additional electricity via a steam turbine.
- Both a Gas turbine and a steam turbine together produce up to 50% more electricity from the same fuel than a traditional simple cycle plant. The waste heat from the gas turbine is routed to the nearby steam turbine, which generates extra power.
- A combined cycle power plant produces high efficiencies (up to 55%) and with low emissions. In conventional plants 35 % electricity only and 65 % remaining as waste.
- Combined cycle power plant generates 65 % electricity

III. 5	The arrangement of boiling water reactor is simple when compared to the pressurizedwater reactor. The nuclear power plant using boilingwater reactor is shown in fig 3.8. In this type of reactoralso, enriched uranium is used as a fuel and water is used as a moderator, coolant and reflector in PWR. Only difference between PWR and BWR is that in a B. W.R, the steam is generated in the reactor itself instead of a separate steam generator. Water enters the reactor at the bottom. This water is heated by the released due to this fission of fuel and gets converted into steam, steam which leaves from the top of the reactor is passed through theand expanded. Exhaust steam from the turbine passes through the condenser and condensed. The condensed water is again recirculated again by using feed pump. India's first nuclear power plant at Tarapur has two B.W.R.S of *200MW* capacity each. ***Advantages:*** 1. The reactor vessel is much lighter than PWR since the pressure inside the reactor is small. 2. There is no heat exchanger, pressurizer and circulating pump. This reduces cost of the plant. 3. Thermal efficiency of BWR plant is more (30%) than a PWR plant (20%). 4. The metal temperature remains low for given output condition, 5. BWR. is a self-controlled reactor as the reactivity is automatically reduced, if the vapour is not dense to moderate the neutrons effectively. 6. A BWR is more stable than PWR and much stable than any other type of reactor. ***Disadvantages:*** 1. The steam entering the turbine is slightly radioactive. Hence, shielding of turbine and piping are needed. 2. Wastage of steam resulting in lowering of thermal efficiency on part load operation. 3. Lower power density (*33.6kW/litr*) and large in size. 4. Power demand fluctuations cannot be met.	7 3 2 2	7
III. 6	**Nuclear Fuels** There are many metals such as Uranium, Thorium and Plutonium used to produce nuclear energy. Among those, Uranium is most important nuclear fuel. It exists in three different forms in nature having mass numbers 234, 235 and 238. The average percentage in the earth is as follows: $92U^{238} = 99.28\%$; ${}_{92}U^{235} = 0.714\%$; ${}_{92}U^{?} = 6.006\%$ Among the above, U^{233} is called as primary fuel. It is naturally available up to 0.7% in the Uranium ore. It is more unstable and is capable of sustaining chain reaction. U^{233} and PU^{239} are known as secondary fuels. They are produced artificially from Th^{232} and U^{235} respectively. It is estimated that almost all the resources of Uranium are situated in U.S.A. (33%), South Africa (20%), Australia (20%) and Canada if(20%). The most economical and low cost Uranium is available in Australia. In India, a large amount of thorium is available.	7 Any 3 Names - 3 Description 4 Marks	7

III. 7	The greenhouse effect is a process that occurs when gasses in Earth's atmosphere trap the Sun's heat. This process makes Earth much warmer than it would be without an atmosphere. Global warming is a gradual increase in the earth's temperature generally due to the greenhouse effect caused by increased levels of carbon dioxide, CFCs, and other pollutants. **Reasons** Abundance of heat-trapping gasses in the atmosphere, Burning fossil fuels, Cutting down forests and farming livestock, Volcanic eruptions that eject dust and gas into the atmosphere Fertilizers containing nitrogen produce nitrous oxide emissions Fluorinated gasses are emitted from equipment and products that use these gasses Above reasons are increasingly influencing the climate and the earth's temperature. This adds enormous amounts of greenhouse gasses to those naturally occurring in the atmosphere, increasing the greenhouse effect and global warming. **List gasses which are responsible for the greenhouse effect.** • Carbon dioxide. • Methane. • Water vapor • Nitrous oxide. • Ozone. • Chlorofluorocarbons (CFCs)	Any 6 points 7 Marks	7	7

III. 8	• Displaying the information about oil handling hazards and way of handling and storing. • Storing the oil in a properly Sealed tank either in open or in the ground. • The tanks should be surrounded by oil tight Bond walls to prevent the leakage. • Implementing the TQM for the production of tanks • Before filling the oil in a tank, proper inspection should be carried out to achieve the same quality as per the standards. • If there are open storage tanks, then the electrical equipment within the space must meet the appropriate safety standards. • The fuel storage and transfer line temperature should not exceed 50 to 55 degree Celsius. • Smoking and carrying matches should not be permitted around the Storage area. • Battery operated items, example flashlight, mobile phone, camera, pagers extra are not permitted. • Safety helmet with dark yellow in color with a name in front of the portion should be used in premises. • Wearing of proper cotton clothes impervious gloves and safety shoes should be strictly • maintained. • A rated fire extinguisher should be provided around the Storage Area. • Avoiding skin contact during transferring or maintenance • Oil container should be labeled with all the information. • All lifting machines, lifting tools and tackles brought inside the refinery should be checked against the quality standard required. • Maintaining a pre-use checklist for the oil handling equipment. Immediate replacement of defective equipment.	Any Six points = 7 Marks	7	7

III. 9	**Pressurized Water Reactor :** • PWR nuclear power plant consists of a double loop cooling system. The coolant in the primary circuit gets heated by absorbing the heat energy liberated in the reactor core by fission process. • The circulating water pump and pressure equaliser in the primary circuit maintains the flow of water and pressure in the primary loop (100 to 130 atmospheric). • Pressure equalizer consists of heating coils and water sprayers, heating coils generate steam when higher pressure is required, similarly water is sprayed inside the equaliser to reduce the pressure of steam when needed. • The heat energy absorbed by primary coolant is exchanged into the secondary fluid at the heat exchanger and generates steam. • This steam is used to drive the turbine which is coupled to an Electrical generator. • In these reactors water is used as both moderator and coolant  R : Reactor P : Pressuriser S : Sprayer T : Turbine A : Alternator C : Condenser HE : Heat Exchanger CP : Coolant Pump FP : Feed Pump FH : Feed Water Heater Major limitation of this plant is water in primary loop gets radiated so risk of radiation to worker is high.	7 Figure - 4 Descpt - 3	7

III. 10	Principle parts of a nuclear rector  The basic components of a reactor for controlled release of nuclear energy are shown. The essential components of a nuclear reactor are (l) Reactor core (2) Moderator (3) Control rods(4) Thermal shield (5) Biological shield The core consists of the fuel and moderator, and the control rods are arranged for easy movement in and out of the core. Reactor Core: The assembly of fuel rod, moderator and control rods constitute reactor core, size of a reactor core should be larger than critical size. Reactor fuel (U235, 1J233,Pu239 etc") may be in solid form such as rods, plates or spheres; or in liquid form as slurry. Critical size: The minimum size of the reactor for a self-sustaining chain reaction is called critical size. Critical Mass: the minimum quantity of fuel required to continue chain reaction is called critical mass. Moderator : The function of moderator is to slow down the fast fission neutrons traveling at 4200 km/s to about 1.5 km/s before subsequent fission occurs. The type of moderator used depends upon the type of fuel used for example, 'Heavy Water' (chemically known as deuterium oxide D_2O) is used as a moderator when nuclear fuel is uranium. Graphite or Carbon is other type of moderator.	Figure 3 Description of 4 components 4 4+3=7	7	7

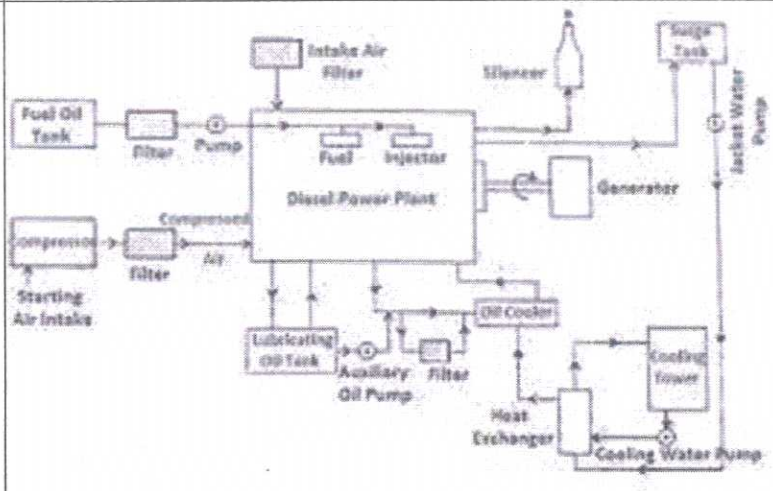
	Control Rods : These are meant to absorb as many of the neutrons impinging upon them as possible. Rods made of boron-steel alloy and cadmium are most commonly used as control rods. Fission is built up by pulling the rods up the reactor; and operation stops when the rods are pushed down. They are made of boron steel alloy & cadmium. Thermal Shielding : It surrounds the entire reactor core and absorbs some of the radiations in the form of α-ray and β-particles, It absorbs escaping neutrons produced by fission. It is usually made of iron' It gets heated but prevents the heating of reactor wall. Coolant flows through the shielding to take away the heat. Heat extraction unit: Conduction and convection heat transfer are used to extract heat energy from the reactor. Coolant may be circulated in tubes throughout the reactor to remove heat produced in the process of fission' The coolants generally used are air, water, carbon dioxide, helium, hydrogen fused salts, organic fluids, sodium, potassium, lead and bismuth alloys etc Biological shield: The whole of the reactor is enclosed in a biological shield to prevent the leakage of fast moving neutrons, slow neutrons' α - rays, β - particles etc' These radiations are much harmful to living organisms. This shield is made of iron or built with dense concrete			
III. 11	 **Schematic Diagram of Diesel Power Plant** DIESEL ENGINE: This is the heart of the power plant. It's like a big, powerful car engine. Diesel fuel is injected into the engine, and it burns the fuel to create power. 2. FUEL TANK: Diesel fuel is stored in a tank nearby. The engine draws fuel from here to run. 3. AIR INTAKE: Just like you breathe, the engine needs air to work.		7	7

Fig. 4.

Description of 5 Systems 3

4+3=7

	It sucks in air through an intake system. 4. EXHAUST SYSTEM: After burning fuel, the engine releases exhaust gases. A system called an exhaust pipe takes these gases out safely. 5. GENERATOR: This is the part that actually makes electricity. It's connected to the engine. When the engine turns, it makes the generator spin, producing electricity. 6. COOLING SYSTEM: Engines can get very hot, so they need a cooling system, like a car radiator. Water or coolant circulates to keep the engine from overheating. 7. CONTROL PANEL: People can control and monitor the power plant from here. They can start or stop the engine, and check how much electricity it's making. 2.4.2 WORKING OF DIESEL POWER PLANT: 1. FUEL COMBUSTION: Diesel fuel is injected into the engine's cylinders. The engine compresses the air in each cylinder, and when the air is super hot from compression, diesel fuel is injected. This causes an explosion, pushing a piston down. This motion is what powers the engine. 2. MECHANICAL ENERGY: The engine's piston moves up and down, creating mechanical energy. This mechanical energy is used to turn the generator. 3. ELECTRICITY GENERATION: As the generator spins, it produces electricity. It works like a big magnet inside a coil of wire, creating an electrical current. 4. VOLTAGE REGULATION: The control panel monitors the voltage (electricity power) and makes sure it's at the right level for use. 5. DISTRIBUTION: The electricity is sent to places that need it, like homes, schools, or factories, through power lines.			
III. 12	In this power plant water is taken from the river directly, these are of two types Without pondage & With Pondage **Without pondage:** these plants run only when enough quantity of water is available in the river, there is no control on flow of water. During high flow and low load period water is wasted and during low flow condition the plant doesn't produce rated power During floods the tail water level becomes high and the plant can't work properly due to less difference in pressure between Head race and tail race. **With pondage:** Run off river plants can work better while with pondage.Pondage helps to manage load fluctuations within a week or some longer period of time depending on size of pondage. During high flow periods these plants may be used as base load plant and during low flow these plants are used to support peak load conditions.	1 2 2	7	7

Advantage of Runoff River Plant:

- Micro-hydro is generally defined as electricity generation capacity up to 100 kW.
- Hydropower is a renewable, non-polluting and environmentally benign source of energy.
- Like all hydro-electric power, run-of-the-river hydro harnesses the natural potential energy of water, eliminating the need to burn coal or natural gas to generate the electricity needed by consumers and industry.
- These plants are set up nearer to the load centers.
- According to the requirement of load. Electricity can be generated constantly.
- Power is usually available continuously on demand.
- No fuel is required and only limited maintenance are required.
- It is long lasting technology.
- It has almost no environment impact.
- Micro hydropower plant has some more advantages over other types of plants such as wind, solar power plants these are
- The predictability of micro hydropower plant is very high and is vary with annual rainfall patterns.
- Output power varies only from day to day not from minute to minute.
- It has high efficiency which varies from 70% to 90% by far the best of all energy technologies.

2

Disadvantage of Runoff River Plant :

- River flows often vary considerably during monsoon type climates, and this can limit the firm power output to quite a small fraction of the possible peak output.
- There can be conflicts with the interest of fisheries on low head schemes and with irrigation needs on high head schemes.