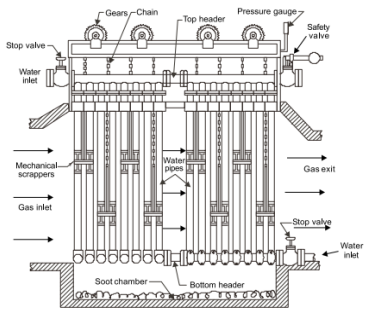
MODEL ANSWER

WINTER – 18 EXAMINATION

Subject Title: Basic Mechanical Engineering Subject Code: 22214

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q. No	Sub Q. N.	Answer	Marking Scheme
1	a)	**Wet Steam** is defined as steam which is partly vapour and partly liquid water suspended in it. **Dry steam**: the steam which do not contains any amount of water particle in it is called as dry steam	02 Marks for each sub question
	b)	**Boiler mountings**: Devices which are mounted on boiler for its control and safe operation are called "mountings" **Examples** (any two): (i)Water level indicator (ii) Safety valves (iii) High steam and low water safety valves (iv) Fusible plug (v) Pressure gauge (vi) Stop valve (vii) Feed check valve (viii) Blow off cock	
	c)	**(i) Piston:** Piston is a cylindrical part which reciprocates inside the cylinder and is used for doing work and getting work. **(ii) Cylinder:** It is a cylindrical block having cylindrical space inside for piston to make reciprocating motion. Upper portion of cylinder which covers it from the top is called cylinder head. This is manufactured by casting process and materials used are cast iron or alloy steel.	
	d)	**Economiser** 	

e) **Brake power:** It refers to the power available at crankshaft i.e. it is the useful shaft work.

$$\text{Brake power} = \frac{2\pi\, NT}{60} \text{ Watt}$$

where {N is speed of rotation of shaft in rpm, T is torque, N · m.}

Brake thermal efficiency:

Brake thermal efficiency is the ratio of energy in the brake power, bp, to the input fuel energy in appropriate units.

$$\eta_{bth} = \frac{bp}{\text{Mass of fuel/s} \times \text{ calorific value of fuel}}$$

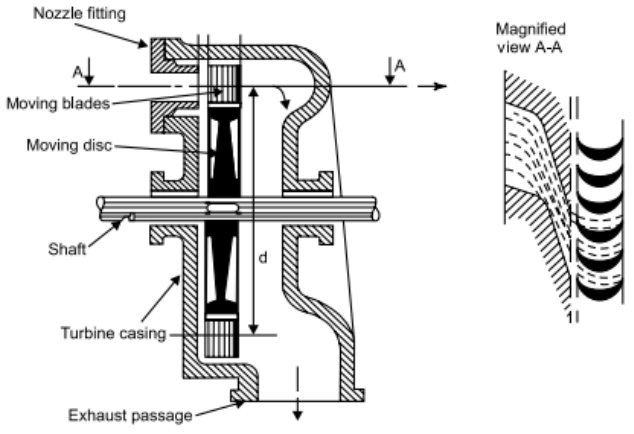
f) **Applications of refrigeration system:**

Comfort air conditioning is extensively used in residential buildings, hospitals, offices, working spaces, vehicles, trains, aero planes etc. Industrial air conditioning is used for spot cooling/heating, environmental laboratories, printing industry, textile industry, precision parts manufacturing, photographic product handling, computer rooms, control rooms of power plants etc. Refrigeration is extensively used for increasing the storage life of perishable items specially food products, vegetables, fruits, milk, beverages, chilling of water, ice formation etc. along with industrial applications in chemical manufacturing, petroleum refinery, petrochemical plants, paper and pulp industry

g) **"One 'Ton' of refrigeration** can be defined by the amount of heat being removed from one ton of water at 0^oC to form one ton of ice at 0^0C within 24 hours." Thus, a Ton of refrigeration shall quantify the latent heat required to be removed for solidification of water at 0^0C.

1 tonne of refrigeration (TR) = 336 1000 24 × = 14000 kJ/h.

2 a) **Simple impulse steam turbine:** — 2 Marks for sketch & 2 Marks for explain

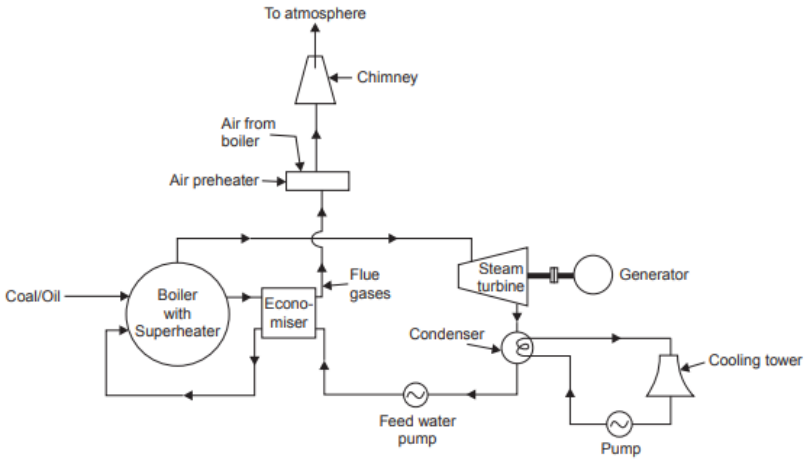


Schematic of simple impulse steam turbine stage

b)

Working: Schematic of impulse steam turbine is shown in Fig. It has single-stage having a nozzle fitted in the casing followed by ring of moving blades mounted on the shaft. Variation of velocity and pressure along the axis of turbine is also shown here. Here pressure drop occurs only in the nozzle and ideally no pressure drop occurs in blades.

High pressure steam from boiler enters the nozzle through pipings and leaves nozzle at predefined angle so as to smoothly flow over the moving blades. Steam velocity gets increased during its flow through nozzle due to its expansion occurring in it. During the passage of steam over the moving blades steam undergoes change in its' direction while losing the velocity and thus causing rotation of moving blade ring mounted on shaft



Layout of a steam power plant.

Functions of some important parts of a steam power plant (any two):

1. Boiler: Water is converted into wet steam.

2. Superheater: It converts wet steam into superheated steam.

3. Turbine: Steam at high pressure expands in the turbine and drives the generator

4. Condenser: It condenses steam used by the steam turbine. The condensed steam (known as condensate) is used as a feed water.

5. Cooling tower: It cools the condenser circulating water. Condenser cooling water absorbs heat from steam. This heat is discharged to atmosphere in cooling water.

6. Condenser circulating water pump: It circulates water through the condenser and the cooling tower. 7. Feed water pump. It pumps water in the water tubes of boiler against boiler steam pressure.

8. Economiser: In economiser heat in flue gases is partially used to heat incoming feed water.

9. Air preheater: In air preheater heat in flue gases (the products of combustion) is partially used to heat incoming air

2 M for sketch & 2 M for functions

	c)	**Need of compounding:** Compounding of steam turbine is required as in case of simple impulse turbine, the single stage may offer speed of the order of 30,000 rpm which cannot be directly used for any engineering application and needs to be reduced. Also such a high speed shall induce large stresses in the blades. Compounding is a thermodynamic means for reducing the speed of turbine where speed reduction is realized without employing a gear box. **Types of compounding**: (i) Pressure compounded impulse turbine (ii) Velocity compounded impulse turbine (iii) Pressure-velocity compounded impulse turbine	02 M for need & 02 M for Types
	d)	**Thermal Power Plant affects environmental segments** of the surrounding region very badly. Large amount of SOx, NOx & SPM are generated which damage the environment and are highly responsible for deterioration of health of human beings, animal kingdom as well as plants. Emission of SPM & RSPM disperse over 25 Kms radius land and cause respiratory and related aliments to human beings and animal kingdom. SPM gets deposited on the plants which affect photosynthesis. Due to penetration of pollutants inside the plants through leaves & branches, imbalance of minerals, micro and major nutrients in the plants take place which affect the plant growth severely. Spreading & deposition of SPM on soil, disturb the soil strata thereby the fertile and forest land becomes less productive. Because of continuous & long lasting emission of SOx & NOx, which are the principal pollutants emitted from a coal based power plant, structures & buildings get affected due to corrosive reactions	0 4 Marks
3	a)	**(i) Piston seizure : Due to overheating (mainly piston crown)** • Combustion default to be corrected • Replace bent/blocked oil injection jet • Installation of piston in the correct position • Avoid malfunctioning in the cooling system **(ii) Engine overheating**	1 mark for each

Causes	Remedies
(*a*) Lack of coolant	Add coolant; look for leak
(*b*) Ignition timing late	Adjust timing
(*c*) Loose or broken fan belt	Tighten or replace
(*d*) Thermostat stuck closed	Replace
(*e*) Clogged water jackets or radiator core	Flush and clean
(*f*) Defective radiator hose	Replace
(*g*) Defective water pump	Repair or replace
(*h*) Insufficient oil	Add oil
(*i*) High-altitude, hot-climate operation	Drive more slowly; keep and radiator filled
(*j*) Defective fan clutch	Replace
(*k*) Valve timing late; slack timing chain has allowed chain to jump a tooth	Retime, adjust or replace
(*l*) No vacuum advance in any gear	TCS system or distributor defective

(iii) Low power developed

(*a*) Defective ignition	Check timing, distributor, wiring, condenser coil, and plugs
(*b*) Defective fuel system; secondary throttle valves not opening	Check carburetor, choke, filter, air cleaner and fuel pump
(*c*) Throttle valve not opening fully	Adjust linkage
(*d*) Restricted exhaust	Check tail pipe and muffler: eliminate restriction
(*e*) Loss of compression	Check compression or leakage (• 33–4 to 33–7)
(*f*) Excessive carbon in engine	Service engine
(*g*) Defective valve action	Check with compression, leakage, vacuum testers (• 33–4 to 33–8)
(*h*) Excessive rolling resistance from low tires, dragging brakes, wheel misalignment, etc.	Correct the defect causing rolling resistance
(*j*) Heavy oil	Use correct oil

(iv) Smoky exhaust of diesel engine

Problem	Solution
➢ engine is burning oil	➢ Change the oil grade
➢ worn or broken piston rings	➢ Change piston ring
➢ worn valve guide or valve guide seals	➢ Change valve guide or seals
➢ leaking head gasket	➢ Change head gasket
➢ broken or cracked engine head	➢ Change or servicing engine head
➢ Air/fuel mixture is too rich	➢ Change injector
➢ leaky fuel injector	
➢	

b) **Three major automotive pollutants are** carbon monoxide (CO), unburned hydrocarbons (HC), and oxides of nitrogen (NOx). Carbon dioxide (CO_2) — 0 1 Mark each

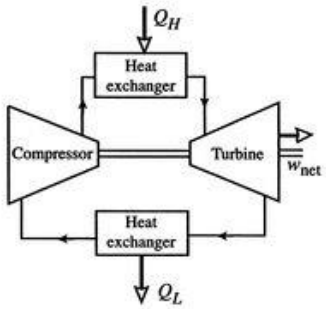
HYDROCARBONS (HC): Hydrocarbon emissions result when fuel molecules in the engine do not burn or burn only partially. Hydrocarbons react in the presence of nitrogen oxides and sunlight to form ground-level ozone, a major component of smog. Ozone can irritate the eyes, damage lungs, and aggravate respiratory problems. It is our most widespread urban air pollution problem. Some kinds of exhaust hydrocarbons are also toxic, with the potential to cause cancer.

NITROGEN OXIDES (NOx): Under the high pressure and high temperature conditions in an engine, nitrogen and oxygen atoms in the air we breathe react to form various nitrogen oxides, collectively known as NOx. Nitrogen oxides, like hydrocarbons, are precursors to the formation of ozone. They also contribute to the formation of acid rain.

CARBON DIOXIDE (CO_2): Carbon dioxide does not directly impair human health, but it is considered a “greenhouse gas”. In other words, as it accumulates in the atmosphere, it is believed to trap the earth’s heat and contribute to the potential for climate change.

Particulates the carbon particles (soot or smoke) is the main constituent of particulates. This has adverse effects on health and environment, where there is consistent correlation between particle levels and death rates. High levels of particles have also been linked with increased hospital admissions and asthma attacks. Smaller particles can carry carcinogenic particles into the lungs.

c) **Working of closed cycle gas turbine (constant pressure):**

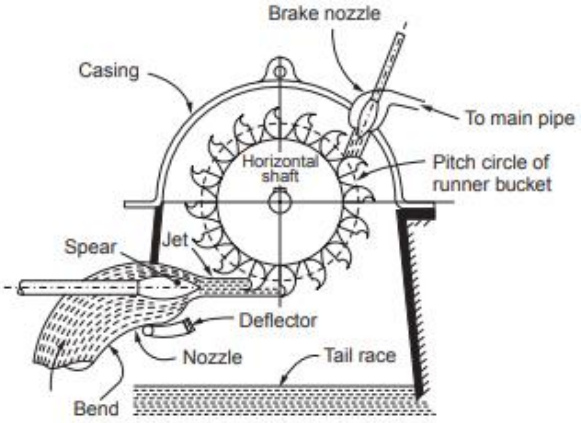


2 Marks for sketch & 2 Marks for explain

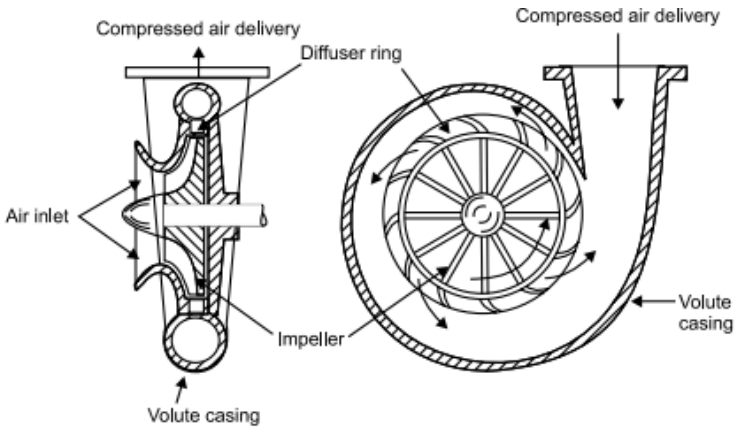
- CLOSE CYCLE GAS TURBINE-It uses air as working medium. In closed cycle gas turbine plant, the working fluid (air or any other suitable gas) coming out from compressor is heated in a heater by an external source at constant pressure.
- The high temperature and high-pressure air coming out from the external heater is passed through the gas turbine.
- The fluid coming out from the turbine is cooled to its original temperature in the cooler using external cooling source before passing to the compressor.
- The working fluid is continuously used in the system without its change of phase and the required heat is given to the working fluid in the heat exchanger.

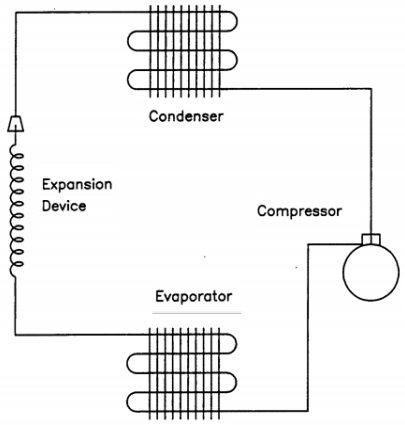
d) (i) For high head of water **Pelton Wheel** uses to generate power.

(ii) Sketch



1 Mark for Identify & 3 marks for sketch

4	a)	 *Centrifugal compressor* **Working:** Centrifugal compressor is a radial flow machine compressing the fluid due to the dynamic action of impeller. Centrifugal compressors have impeller mounted on driving shaft, diffuser and volute casing as shown in Fig. Centrifugal compressors have air inlet at the centre of impeller. The portion of impeller in front of inlet passage is called impeller eye. Impeller is a type of disc having radial blades mounted upon it. Compressor casing has a diffuser ring surrounding impeller and the air enters the impeller eye and leaves from impeller tip to enter diffuser ring. Volute casing surrounds the diffuser ring. Volute casing has cross section area increasing gradually up to the exit of compressor. These impellers of centrifugal compressors may also be of double sided type such that air can enter from two sides (both) of impeller. Thus double sided impeller shall have double impeller eye compared to single impeller eye as shown in Fig.	2 Marks for sketch & 2 Marks for explain
	b)	(i)**Automobile washing centre**: Reciprocating air compressor- High pressure requirement. (ii)**Gas Turbine**: Axial flow compressor – large quantity of air required.	2 M for each
	c)	**Applications compressed air (any four):** • To clean complicated machines, automobile and generators. • To derive air engines (i.e. air motors) which are used in coal mines • To operate pneumatic tools like drill, riveter and road drills. • To produce blast in the blast furnace. • To operate air brakes for locomotives and railways. • To start heavy diesel engines. • To cool large buildings. • To operate lifts, reams, pumps, and verity of other devices. • To start multi cylinder I.C. engines • Used in spray painting.	1 Mark for each

	d)	**Brake thermal efficiency** = Brake power/ Heat supplied = 2.83/13.43 = 0.21 = (21 %)	04 Marks
	e)	**Overall efficiency(η_o)** = Power available at the turbine shaft /ρ. g .Q. H = 15000 x 10^3 / 1000 x 9.81 x 6 x 350 = 0.728 (72.8 %)	04 Marks
5	a)	**Functions of** **(i) OLP:** Its function is to safeguard the refrigeration system from overloads. This can damage the components like compressor, valve, circuit parts, etc. **(ii) Thermostat**: Its function is to record the temperature of refrigerant in evaporator and accordingly operate On-Off circuit to save power. A thermostat is a component which senses the temperature of a refrigeration system so that the system's temperature is maintained near a desired set point. Usually it is fitted in evaporator for setting cooling temperature. **(iii) Defrost Heater**: Its function is to remove the frost(ice formation) over the evaporator coil and evaporator unit. Due to frosting the performance of refrigeration system decreases and hence defrost heater is required.	02 Mark for each
	b)	**Simple VCR system**  The main four components are Compressor, Condenser, Expansion Device,& Evaporator Vapour compression refrigeration cycle is the most widely used in the window air conditioning system. Figure shows the basic refrigeration cycle. Refrigeration is produced by continuously circulating, evaporating, and condensing a fixed supply of refrigerant in a closed system. The evaporation occurs at a low temperature and low pressure while the condensation occurs at a high temperature and high pressure. Thus it is possible to transfer heat from an area of low temperature (conditioned space) to an area of high temperature.	03 mark for sketch & 03 marks for Explain

Beginning the cycle at the evaporator inlet, the low pressure liquid absorbs heat, and evaporates, changing to a low pressure vapour at the evaporator outlet. The compressor pumps this vapour from the evaporator, increases its pressure, and discharges the high pressure vapour to the condenser. In the condenser, heat is removed from the vapour as it condenses and becomes a high pressure liquid. Between the condenser and the evaporator, an expansion device is located.

The flow of refrigerant into the evaporator is controlled by the pressure differential across the expansion device. As the high pressure liquid refrigerant enters the evaporator, it is subjected to a much lower pressure due to the suction of the compressor and the pressure drop across the expansion device. The refrigerant tends to expand and evaporate. In order to evaporate, the liquid must absorb heat from the air passing over the evaporator, and the cycle is repeated.

c) **Possible Causes & Remedies for "compressor do not start"** — 03 Marks

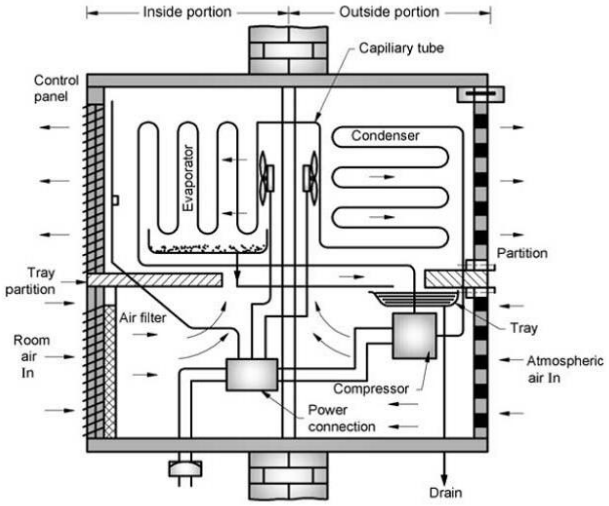
- Supply is not ok
- Voltage is low
- Valves of compressor choked due liquid entry or valves not operating
- Fault in electrical circuit
- Compressor motor not working or coil burned
- Compressor fan stops or fails
- Relay not proper
- Faulty thermostat

03 M

Remedies :

- Check / repair the electrical supply
- Check / repair compressor valves
- Check / repair compressor motor
- Check / repair thermostat

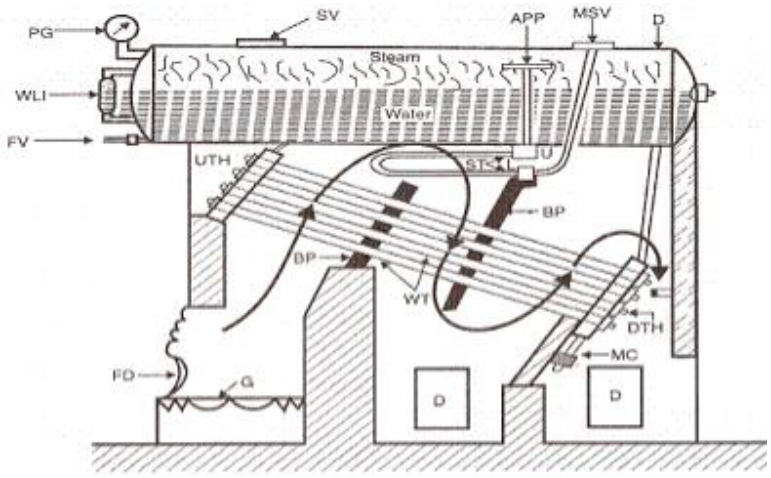
6 a) **Window AC**



03 M

		Window air conditioner is sometimes referred to as room air conditioner as well. It is the simplest form of an air conditioning system and is mounted on windows or walls. It is a single unit that is assembled in a casing where all the components are located. This refrigeration unit has a double shaft fan motor with fans mounted on both sides of the motor. One at the evaporator side and the other at the condenser side. The evaporator side is located facing the room for cooling of the space and the condenser side outdoor for heat rejection. There is an insulated partition separating this two sides within the same casing. **Front Panel**: The front panel is the one that is seen by the user from inside the room where it is installed and has a user interfaced control be it electronically or mechanically. Older unit usually are of mechanical control type with rotary knobs to control the temperature and fan speed of the air conditioner. The newer units come with electronic control system where the functions are controlled using remote control and touch panel with digital display. **Indoor Side Components:** **The indoor parts of a window air conditioner include:** • Cooling Coil with a air filter mounted on it. The cooling coil is where the heat exchange happens between the refrigerant in the system and the air in the room. • Fan Blower is a centrifugal evaporator blower to discharge the cool air to the room. • Capillary Tube is used as an expansion device. It can be noisy during operation if installed too near the evaporator. • Operation Panel is used to control the temperature and speed of the blower fan. A thermostat is used to sense the return air temperature and another one to monitor the temperature of the coil. Type of control can be mechanical or electronic type. • Filter Drier is used to remove the moisture from the refrigerant. • Drain Pan is used to contain the water that condensate from the cooling coil and is discharged out to the outdoor by gravity.	**03 M**

	b)	**Babcock and Wilcox Boiler**	03 M for each for sketch and explanation



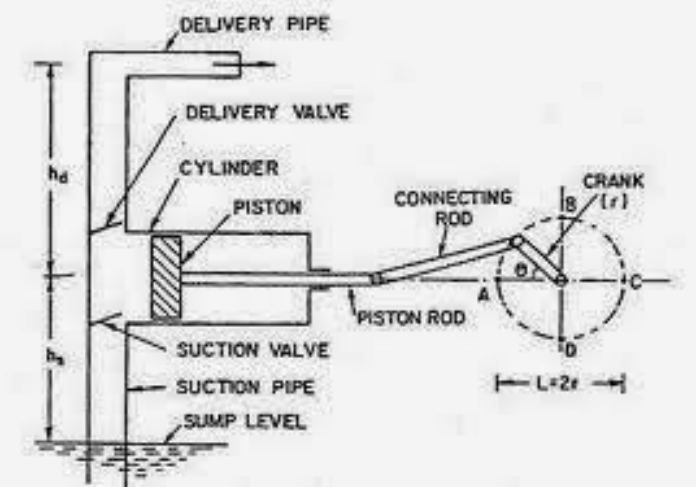
D = Drum
DTH = Down take header
WT = Water tubes
BP = Baffle plates
D = Doors
G = Grate
FD = Fire door
MC = Mud collector
WLI = Water level indicator

PG = Pressure gauge
ST = Superheater tubes
SV = Safety valve
MSV = Main stop valve
APP = Antipriming pipe
L = Lower junction box
U = Upper junction box
FV = Feed valve

Working of Babcock and Wilcox Boiler:

Coal is fed to the grate through the fire door and is burnt. Flow of flue gases: The hot flue gases rise upward and pass across the left-side portion of the water tubes. The baffles deflect the flue gases and hence the flue gases travel in the zig-zag manner (i.e., the hot gases are deflected by the baffles to move in the upward direction, then downward and again in the upward direction) over the water tubes and along the superheater. The flue gases finally escape to atmosphere through chimney.

Water circulation: That portion of water tubes which is just above the furnace is heated comparatively at a higher temperature than the rest of it. Water, its density being decreased, rises into the drum through the uptake-header. Here the steam and water are separated in the drum. Steam being lighter is collected in the upper part of the drum. The water from the drum comes down through the down –comer into the water tubes. A continuous circulation of water from the drum to the water tubes and water tubes to the drum is thus maintained. The circulation of water is maintained by convective currents and is known as “natural circulation”. A damper is fitted as shown to regulate the flue gas outlet and hence the draught.

	c)	**Single Acting Reciprocating Pump:**  The main parts of a reciprocating pump is as follows: 1. A cylinder with piston, piston rod, connecting rod and a crank. 2. Suction pipe, 3. Delivery pipe, 4. Suction valve, 5. Delivery valve and 6. Air vessel. Let's discuss all these parts in detail 1. A cylinder with piston, piston rod, connecting rod and a crank Cylinder is used to suck water and delivers it to the desired location. The piston executes reciprocating motion (back and forth motion) within the cylinder. Piston is connected to the crankshaft through connecting rod. 2. Suction Pipe: As its name indicates, it is used to suck the water from the water reservoir to the cylinder. It connects the inlet of the pump with water tank. 3. Delivery Pipe: It is a pipe which is used to deliver the water from the cylinder to the desired location. It connects the outlet of the pump to the tank where the water is to be delivered. 4. Suction Valve: It is a valve which is present at the suction side of the pump. It opens during suction of water from the tank to the cylinder and remains closed during compression of the liquid. 5. Delivery Valve: It is a valve which is present at delivery side and opens during compression of the liquid and remains closed when the water is sucked from the water tank. 6. Air Vessels: Air vessels in the reciprocating pump is used to get uniform discharge rate. It is provided on both suction and delivery side and connected to suction and delivery pipe.	03 M for each for sketch and explanation
