UNIT-V					
10	a)	Derive the expression for thrust developed in a jet propulsion system.	L3	CO5	5 M
	b)	Differentiate between solid and liquid propellant rocket engines.	L3	CO5	5 M
OR					
11	a)	Classify solar collectors and describe the construction and principle of flat-plate collectors.	L3	CO5	5 M
	b)	Discuss the applications of solar energy in domestic and industrial sectors.	L3	CO5	5 M

Code: 23ME3502

III B.Tech - I Semester - Regular Examinations - NOVEMBER 2025

THERMAL ENGINEERING
(MECHANICAL ENGINEERING)

Duration: 3 hours Max. Marks: 70

Note: 1. This question paper contains two Parts A and B.
2. Part-A contains 10 short answer questions. Each Question carries 2 Marks.
3. Part-B contains 5 essay questions with an internal choice from each unit. Each Question carries 10 marks.
4. All parts of Question paper must be answered in one place.

BL – Blooms Level CO – Course Outcome

PART – A

		BL	CO
1.a)	Define Volumetric Efficiency of an I.C Engine	L1	CO1
1.b)	Why does exhaust blowdown occur in actual cycles?	L2	CO1
1.c)	Classify the IC Engines based on ignition and working cycle.	L1	CO2
1.d)	How the boilers are classified?	L2	CO2
1.e)	Define critical pressure ratio in a steam nozzle.	L1	CO3
1.f)	Differentiate between parallel flow and counter flow condensers.	L2	CO3
1.g)	What do you meant by multi-stage compression in reciprocating compressors?	L1	CO4
1.h)	What is the function of intercooling in a gas turbine plant?	L2	CO4
1.i)	Define thrust in a jet engine.	L1	CO5
1.j)	What are solar collectors? Give examples.	L2	CO5

PART – B

			BL	CO	Max. Marks
UNIT-I					
2		Compare air standard cycle and actual cycle with neat sketches. Explain the reasons for deviation of actual cycle from air standard cycle.	L2	CO1	10 M
OR					
3		Explain the concepts of time loss factor and heat loss factor in actual engine cycles. How do they affect the efficiency?	L2	CO1	10 M
UNIT-II					
4	a)	Explain the construction and working of Four Stroke CI Engine with a neat sketch.	L3	CO2	5 M
	b)	With a neat diagram explain the working of battery ignition system.	L2	CO2	5 M
OR					
5	a)	A single cylinder, four stroke cycle oil engine is fitted with a rope brake. The diameter of the brake wheel is 600 mm and the rope diameter is 26 mm. The dead load on the brake is 200 N and the spring balance reads 30 N. If the engine runs at 450 r.p.m, what will be the brake power of the engine?	L3	CO2	5 M
	b)	Describe Working Principles of Lamont Boiler with a neat sketch.	L2	CO2	5 M

UNIT-III					
6	a)	Define the term 'steam nozzle'. Explain various types of nozzles	L2	CO3	5 M
	b)	Discuss the concept of Wilson line.	L3	CO3	5 M
OR					
7	a)	Define the term degree of reaction as applied to a reaction turbine. Show that for a Parson's reaction turbine, the degree of reaction is 50 percent.	L2	CO3	5 M
	b)	Explain the working of a surface condenser with a neat sketch	L3	CO3	5 M
UNIT-IV					
8	a)	What is an air compressor? How are they classified? Enumerate the applications of compressed air.	L2	CO4	5 M
	b)	Describe with a neat sketch the construction and working of a single stage single acting reciprocating air compressor	L3	CO4	5 M
OR					
9	a)	What is a centrifugal compressor? How it defers from an axial flow compressor.	L2	CO4	5 M
	b)	What is the purpose of intercooling in a gas turbine and where the intercoolers are applicable in gas turbines?	L2	CO4	5 M

Scheme of Evaluation

III. B.Tech, I- Semester

Thermal Engineering - 23ME3502

November - 2025

Mechanical Engineering

1. a. Definition —— 2 marks
   b. any two points —— 2 marks
   c. any two classifications —— 2 marks
   d. any two boilers —— 2 marks
   e. Definition (or) formula —— 2 marks
   f. any two points —— 2 marks
   g. Definition —— 2 marks
   h. function —— 2 marks
   i. Definition —— 2 marks
   j. function and Example —— 2 marks

2. Diagram —— 4 marks } —— 10 marks
   Explanation —— 6 marks }

3. Time loss factor —— 5 marks } —— 10 marks
   Heat loss factor —— 5 marks }

4. a). Diagram —— 2 marks } —— 5 marks
   Explanation —— 3 marks }

b). diagram — 2 marks } — 5 marks
Explanation — 3 marks

5. a) Given Data — 2 marks } — 5 marks
Solution — 3 marks

b) diagram — 2 marks } — 5 marks
Explanation — 3 marks

6. a) function of Nozzle — 1 mark } — 5 marks
diagrams — 2 marks
Explanation — 2 marks

b) diagram — 2 marks } — 5 marks
Explanation — 3 marks

7. a) Diagram — 2 marks } — 5 marks
derivation — 3 marks

b) any one condenser
diagram — 2 marks } — 5 marks
Explanation — 3 marks

8. a. function — 1 marks } — 5 marks
classifications — 2 marks
Applications — 2 marks

b) diagram — 2 marks } — 5 marks
Explanation — 3 marks

9. a) function —— 2 marks } —— 5 marks
Explanation —— 3 marks }

b). T-S diagram —— 2 marks
Explanation —— 3 marks

10. a derivation —— 5 marks

b) any five points —— 5 marks

11. a) classifications —— 2 marks } —— 5 marks
diagram —— 1.5 marks }
working —— 1.5 marks }

b) applications —— 2 marks } —— 5 marks
Explanation —— 3 marks }

Scheme of Evaluation

III-B.Tech. I-Semester

THERMAL ENGINEERING-23ME3502- NOVEMBER- 2025

MECHANICAL ENGINEERING

PART-A

1.a) Define Volumetric efficiency of an IC engine.

The ratio of the actual mass of air drawn into the cylinder to the theoretical mass of air that could occupy the swept volume at atmospheric density.

1.b). Why does exhaust blowdown occur in actual cycles?

The exhaust valve opens early to release high-pressure gas and reduce the work required by the piston to push gases out during the next stroke.

1.c). Classify the IC Engines based on ignition and working cycle.

Based on ignition:

Spark Ignition (SI) engines.

Compression Ignition (CI) engines.

Based on working cycle:

Two-stroke engines.

Four-stroke engines.

1.d). How the boilers are classified?

Boilers can be classified based on:

Contents inside tubes: Water-tube, Fire-tube

Pressure: Low, Medium, High-pressure boilers

1.e). Define critical pressure ratio in a steam nozzle.

Critical pressure ratio is the ratio of exit pressure to inlet pressure at which steam velocity becomes sonic.

$$\frac{P_2}{P_1} = \left(\frac{2}{n+1}\right)^{\frac{n}{n-1}}$$

1.f). Differentiate between parallel flow and counter flow condensers.

Parallel flow: Steam and cooling water flow in the same direction.

Counter flow: Steam and cooling water flow in opposite directions, giving better heat transfer effectiveness.

1.g) What do you mean by multi-stage compression in reciprocating compressors?

Multi-stage compression means compressing air in two or more stages, with intercooling between stages, to reduce work input and achieve higher delivery pressure efficiently.

1.h) What is the function of intercooling in a gas turbine plant?

Intercooling reduces the temperature of air between compressor stages, lowering compressor work and increasing overall plant efficiency.

1.i) Define thrust in a jet engine.

Thrust is the force produced by accelerating a mass of air and fuel through the engine, as per Newton's third law. It propels the aircraft forward.

1.j) What are solar collectors? Give examples.

Solar collectors absorb solar radiation and convert it into heat energy.

Examples:

Flat plate collectors

Evacuated tube collectors

Parabolic trough collectors

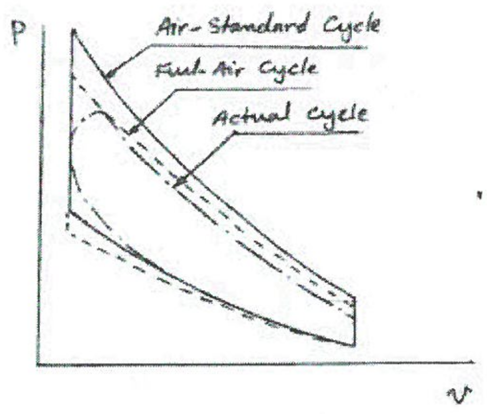
PART-B

UNIT-1

2.Compare air standard cycle and actual cycle with neat sketches. Explain the reasons for deviation of actual cycle from air standard cycle.

Air-Standard Cycle (Ideal):

- Assumes **air as working fluid** throughout the cycle.
- All processes are **internally reversible** and frictionless.
- Combustion is replaced by **heat addition**.
- Exhaust is replaced by **heat rejection**.



Actual Cycle:

- Working fluid is a mixture of **air + fuel + combustion products**.
- Processes are **irreversible** due to friction, pressure losses, and heat transfer.
- Combustion occurs at **variable pressure & temperature**.
- Exhaust gases carry some energy along with pumping losses.

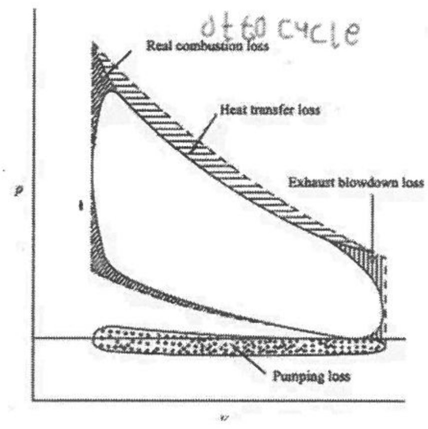
OR

3. Explain the concepts of time loss factor and heat loss factor in actual engine cycles. How do they affect the efficiency?

Time Loss Factor (TLF):

The time loss factor in steam turbines or compressors is defined as the ratio of the time required to pass the moving blades over the stator blades to the total time of a machine cycle. It accounts for the loss of work due to the relative motion between the moving and fixed blades during operation.

- Indicates loss in cycle efficiency due to finite time for combustion.
- Peak pressure occurs after TDC instead of at TDC.
- Reduces the mean effective pressure and work output.



Heat Loss Factor (HLF):

The heat loss factor in boilers, steam turbines, or thermal systems is defined as the ratio of the heat lost to the surroundings to the total heat supplied. It quantifies the inefficiency due to heat loss during the operation of a thermal system.

- Represents loss due to heat transfer from gases to cylinder walls.
- Decreases temperature and pressure during combustion.

Effect on Efficiency:

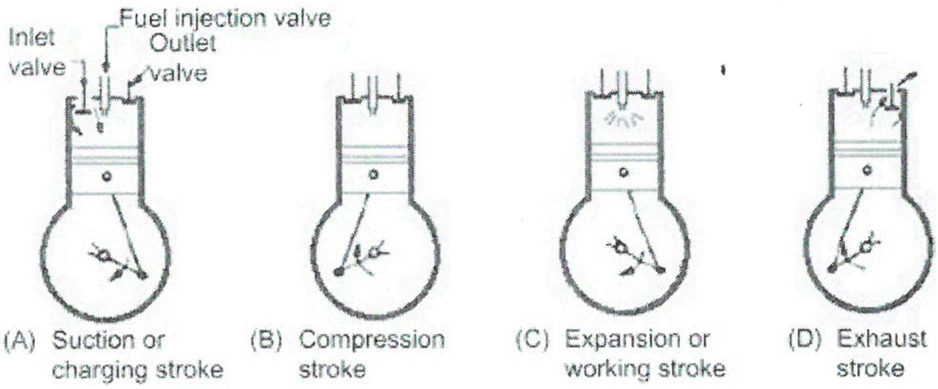
- Both TLF and HLF decrease thermal efficiency and power output.
- Reduces Overall efficiency.

UNIT–II

4.a) Explain construction and working of Four-Stroke CI Engine with neat sketch.

Construction:

- **Cylinder, piston, connecting rod, crankshaft**
- **Fuel injector** instead of spark plug
- **Air filter, fuel pump, inlet and exhaust valves**



Working: (4 strokes)

Suction Stroke

- The piston moves downward (TDC to BDC).
- The intake valve opens.
- Only air (no fuel) enters the cylinder.
- The exhaust valve remains closed.

Purpose: Fill the cylinder with fresh air.

Compression Stroke

- The piston moves upward (BDC to TDC), compressing the air.
- Both valves are closed.
- Air temperature rises due to high compression.

Purpose: Increase air pressure and temperature for auto-ignition.

Power (Expansion) Stroke

- Piston moves from TDC to BDC
- Near the end of compression, diesel fuel is injected into the hot compressed air.
- Fuel self-ignites (no spark plug needed).

- Rapid combustion pushes the piston downward.

Purpose: Produce power that rotates the crankshaft.

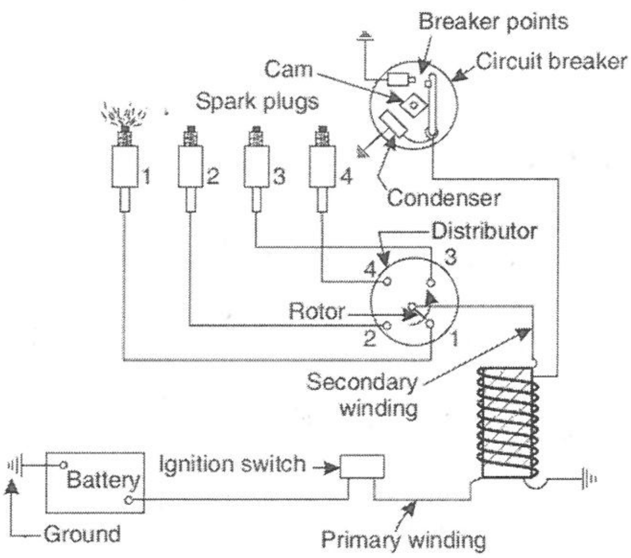
Exhaust Stroke

- The piston moves upward again (BDC to TDC).
- The exhaust valve opens.
- Burnt gases are expelled from the cylinder.

Purpose: Clear the cylinder for the next cycle.

4(b) Working of battery ignition system with neat diagram.

Components:



- Battery
- Ignition switch
- Ignition coil
- Breaker points
- Distributor
- Spark plug.

Working:

A battery ignition system is an electrical system used in spark-ignition (petrol) engines to produce the high-voltage spark required to ignite the air–fuel mixture. It works by using a 12-volt battery as the main power source. When the ignition switch is turned on, current flows from the battery to the primary winding of the ignition coil through the contact breaker. The primary winding creates a strong magnetic field around the coil. As the engine rotates, the cam opens the contact breaker points, suddenly interrupting the current flow. This sudden break causes the magnetic field in the primary winding to collapse rapidly, which induces a very high voltage in the secondary winding of the coil due to electromagnetic induction. A condenser is connected across the contact breaker to prevent sparking at the breaker points and to ensure a quick collapse of the magnetic field, resulting in a stronger spark. The high voltage produced in the secondary winding is then sent to the distributor, which distributes it to the appropriate spark plug according to the engine firing order. When the high voltage reaches the spark plug, it jumps across the plug gap and produces a spark, igniting the air–fuel mixture in the engine cylinder. This process repeats continuously as the engine runs, ensuring smooth and efficient combustion.

OR

5.a) A single cylinder, four stroke cycle oil engine is fitted with a rope brake. The diameter of the brake wheel is 600 mm and the rope diameter is 26mm. The dead load on the brake is 200N and the spring balance reads 30 N. If the engine runs at 450 r.p.m, what will be the brake power of the engine?

Given Data

brake wheel diameter, $D = 600mm$.

rope diameter, $d = 26 mm$

dead load on the brake, $W = 200N$.

Spring balance, $S = 30N$.

Speed, $N = 450$ r.p.m.

Brake power, $B.P = ?$

effective radius,

$$r = \frac{600+26}{2}$$

$$r = \frac{626}{2}$$

$$r = 313 mm$$

$$B.P = \frac{2\pi N (W-S) \times r}{60,000}$$

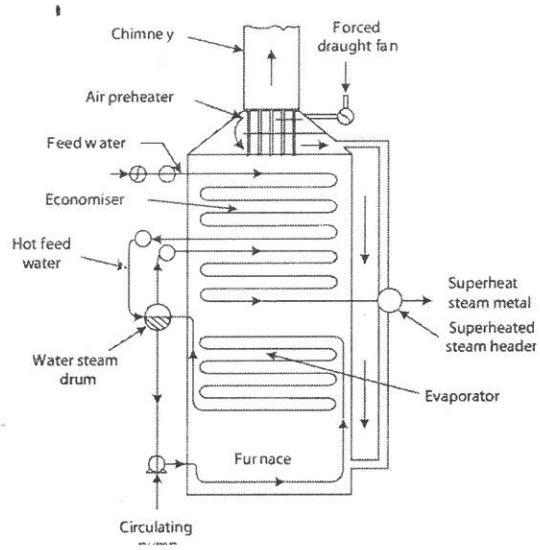
$$= \frac{2\pi \times 450 \times (200-30) \times 313 \times 10^{-3}}{60,000}$$

$$= 2.50 \text{ kw}$$

5.b) Working principle of Lamont Boiler with neat sketch.

Principle:

The Lamont boiler is a high-pressure, forced circulation, water-tube boiler widely used in power plants. It uses a pump to circulate water through the boiler, making it suitable for supercritical and high-pressure applications.



Working:

- Water from the water drum is pumped into the downcomer tubes and directed to the riser tubes.
- The pump ensures continuous water flow, even against high pressure.
- Water flows through the riser tubes inside the furnace and absorbs heat from combustion gases.
- As water absorbs heat, it partially converts into steam, and the density difference between water and steam creates natural circulation.
- The water-steam mixture rises to the steam drum, where steam separates from the water.
- The dry saturated steam can be superheated before leaving the boiler.
- The water remaining in the steam drum returns to the water drum through downcomers, completing the circulation loop.

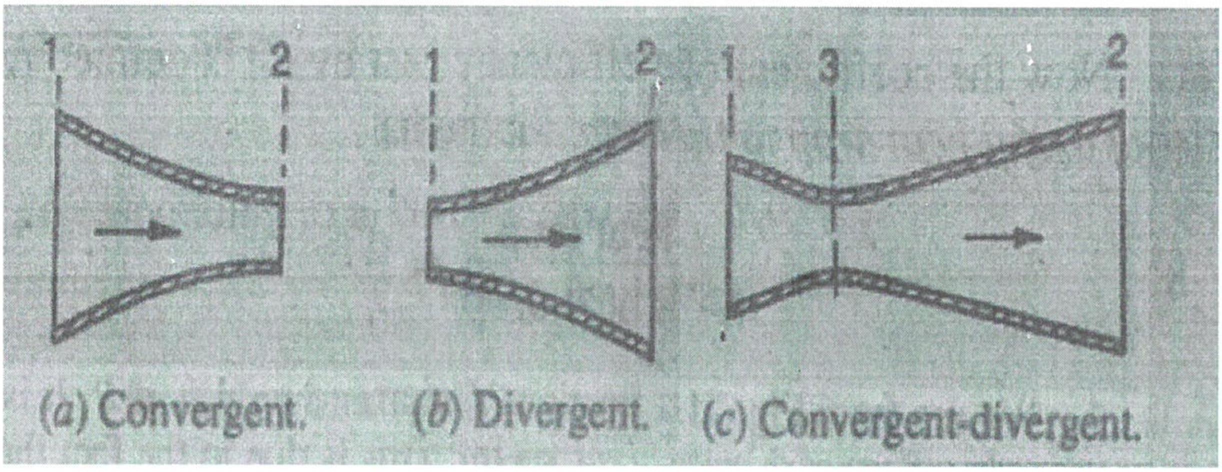
UNIT–III

6.a) Define steam nozzle & explain different types.

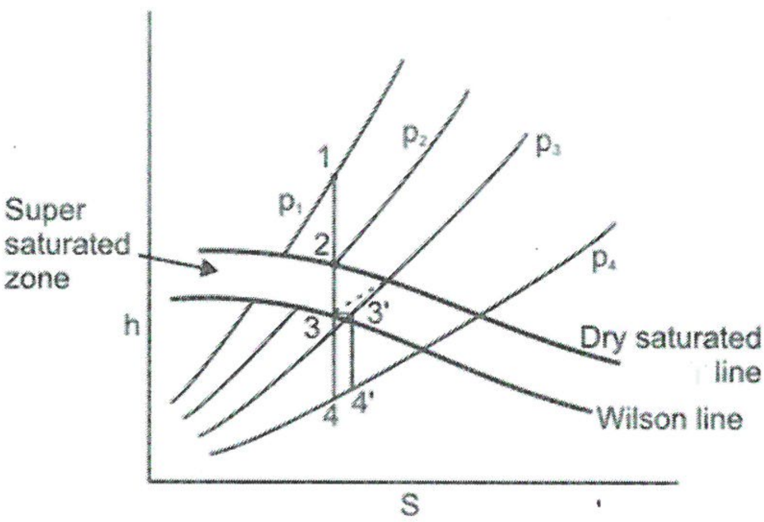
Steam Nozzle: A steam nozzle is a device used in steam turbines to convert the thermal energy of steam into kinetic energy. It accelerates the steam by allowing it to expand, increasing its velocity while reducing its pressure.

Types:

1. **Convergent nozzle:** A convergent nozzle has a gradually decreasing cross-sectional area. As the fluid passes through it, velocity increases while pressure decreases. It is mainly used for subsonic flows and can accelerate gases up to Mach 1 at the exit.
2. **Convergent–divergent nozzle:** This nozzle first converges to a throat and then diverges. It is used for accelerating gases from subsonic → sonic → supersonic speeds.
3. **Divergent nozzle:** A divergent nozzle has a gradually increasing area from inlet to exit. It is used when the flow entering is already at sonic or high subsonic speeds. As the fluid expands, its velocity decreases while pressure increases



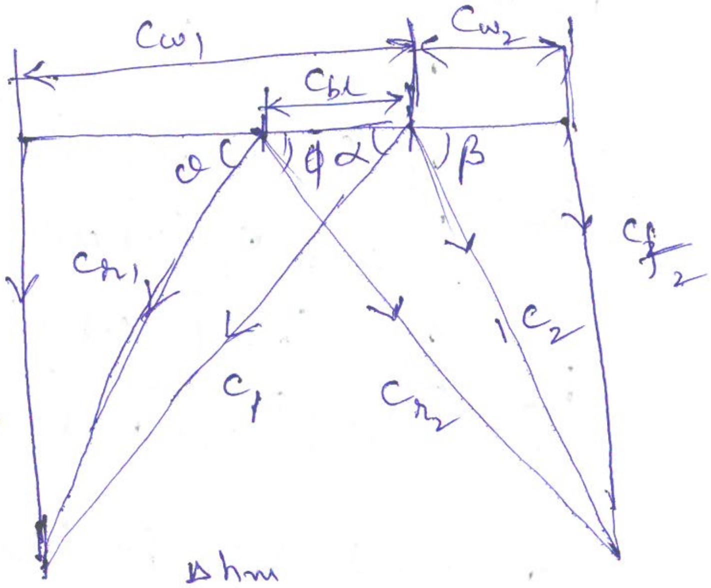
6.b) Wilson line concept.



In steam nozzles, the expansion of steam is ideally assumed to be *isentropic*, meaning no heat loss and constant entropy. In actual practice, steam does not expand perfectly isentropically because of friction, shock losses, condensation, and boundary-layer effects. This causes the real expansion path to deviate from the vertical isentropic line on the temperature–entropy (T–s) diagram. The Wilson Line is an empirical straight line drawn on the wet steam region of the T–s diagram to represent the actual expansion path of steam inside a nozzle. It shows how the presence of moisture (wetness) during expansion causes entropy to increase and reduces the available kinetic energy. The Wilson line helps engineers estimate the actual dryness fraction, exit velocity, and nozzle efficiency, instead of assuming ideal conditions.

OR

Q7(a) Degree of reaction and proof for Parson's turbine.



Degree of reaction (R_d)

The degree of reaction of reaction turbine stage is defined as the ratio of heat drop over moving blades to the total heat drop in the stage.

$$R_d = \frac{\Delta h_m}{\Delta h_f + \Delta h_m}$$

The heat drop in moving blades is equal to increase in velocity of steam passing through the blade.

$$\Delta h_m = \frac{C_{r_2}^2 - C_{r_1}^2}{2}$$

The total heat drop in stage ($\Delta h_f + \Delta h_m$) is equal to the work done by the steam in the stage.

$$\Delta h_f + \Delta h_m = C_{bl}(C_{w_1} + C_{w_2})$$

Therefore, $$R_d = \frac{C_{r_2}^2 - C_{r_1}^2}{2 C_{bl}(C_{w_1} + C_{w_2})}$$

From velocity Δ^{le}, $\sin\phi = \frac{C_{f_2}}{C_{r_2}} \Rightarrow C_{r_2} = \frac{C_{f_2}}{\sin\phi} = C_{f_2}\operatorname{cosec}\phi.$

$$\sin\theta = \frac{C_{f_1}}{C_{r_1}} \Rightarrow C_{r_1} = \frac{C_{f_1}}{\sin\theta} = C_{f_1}\operatorname{cosec}\theta \Rightarrow C_{r_1} = C_{f_1}\operatorname{cosec}\theta.$$

$$\tan\phi = \frac{C_{f_2}}{C_{w_2}+C_{bl}} \Rightarrow \cot\phi = \frac{C_{w_2}+C_{bl}}{C_{f_2}} \Rightarrow C_{w_2} = C_{f_2}\cot\phi - C_{bl}$$

$$\tan\theta = \frac{C_{f_1}}{C_{w_1}-C_{bl}} \Rightarrow \cot\theta = \frac{C_{w_1}-C_{bl}}{C_{f_1}} \Rightarrow C_{w_1} = C_{f_1}\cot\theta + C_{bl}$$

$$C_{w_1}+C_{w_2} = C_{f_1}\cot\theta + C_{bl} + C_{f_2}\cot\phi - C_{bl}$$

$$C_{w_1}+C_{w_2} = C_{f_1}\cot\theta + C_{f_2}\cot\phi$$

The velocity of flow remains constant through the blades.

$$C_{f_1} = C_{f_2} = C_f$$

$$R_d = \frac{C_f^2(\operatorname{cosec}^2\phi - \operatorname{cosec}^2\theta)}{2C_{bl}C_f(\cot\theta+\cot\phi)} = \frac{C_f}{2C_{bl}}\left[\frac{(\cot^2\phi+1)-(\cot^2\theta+1)}{\cot\phi+\cot\theta}\right]$$

$$R_d = \frac{C_f}{2C_{bl}}\left[\frac{\cot^2\phi-\cot^2\theta}{\cot\phi+\cot\theta}\right] = \frac{C_f}{2C_{bl}}\left[\cot\phi-\cot\theta\right]$$

If the turbine is designed for 50% reaction $(\Delta h_f = \Delta h_m)$, then the equation becomes.

$$\frac{1}{2} = \frac{C_f}{2C_{bl}}(\cot\phi-\cot\theta)$$

$$C_{bl} = C_f(\cot\phi - \cot\theta) \longrightarrow (1)$$

and

$$C_{bl} = C_f(\cot\alpha - \cot\beta) \longrightarrow (2)$$

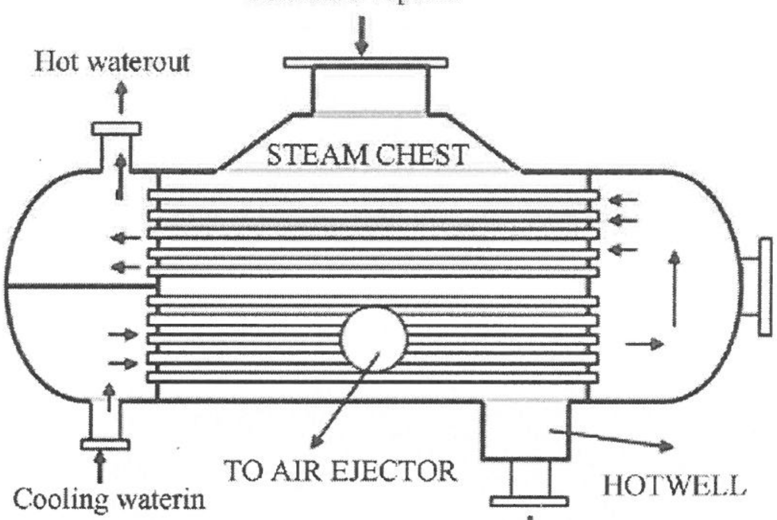
comparing equation (1) & equation (2)

$$\theta = \beta \quad \text{and} \quad \phi = \alpha$$

which means that the moving blade and fixed blade must have the same shape if the degree of reaction is 50%. This condition gives symmetrical velocity diagram. This turbine is known as parason's reaction turbine

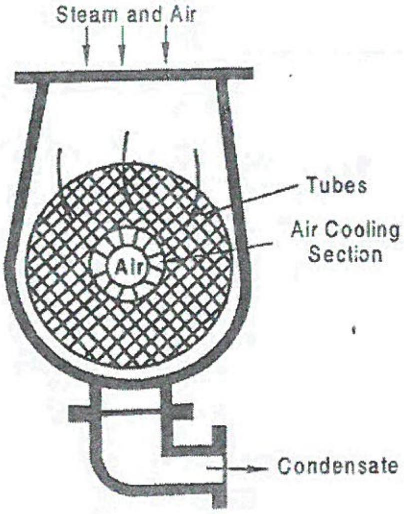
7.b) Explain the working of a surface condenser with a neat sketch Working:

Downflow type surface condenser :



(i) Down-flow Surface Condenser The sectional view of a down-flow surface condenser is shown in Fig. 23.7. The exhaust steam enters the top of the condenser shell and flows downward over the water tube. The water tubes are double passed. The cold water flows in the lower side first and then in the upper side in reverse direction. It enables the maximum heat transfer rate for a condenser. The extraction pump connected at the bottom of the condenser draws the condensate out of the condenser.

OR



Central Flow Surface Condenser

(ii) Central-flow Surface Condesner The sectional view of a central-flow surface condenser is shown in Fig. 23.8. The suction pipe of an air extraction pump is located at the centre of the condenser tubes. The steam flows radially inward. The condensate is collected at the bottom of the shell from where it is taken out by the condensate extraction pump. The steam gets access to the entire periphery of tubes, and thus a large surface area for heat transfer is available as compared to a down flow condenser.

UNIT–IV

8.a) What is an air compressor? How are they classified? Enumerate the applications of compressed air.

Air Compressor:

An air compressor is a mechanical device that takes in air at atmospheric pressure and compresses it to a higher pressure, then stores or supplies it for useful work. It converts mechanical energy (from an electric motor, engine, or turbine) into compressed air energy by reducing the volume of the air. The high-pressure air produced by the compressor is used for a wide range of applications such as operating pneumatic tool's, spray painting, air brakes, industrial processes, refrigeration, and air-conditioning systems. Air compressors can be classified as positive displacement·compressors and dynamic compressors.

Classification:

- **Positive displacement:** Reciprocating, rotary vane, screw
- **Dynamic type:** Centrifugal, axial

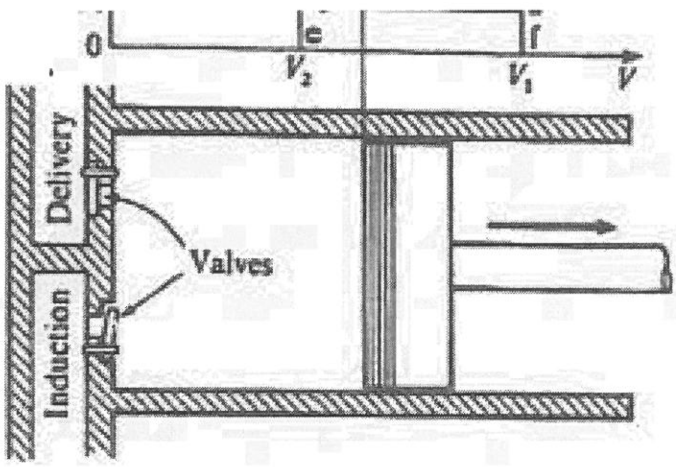
Applications:

- Pneumatic tools
- Spray painting
- Refrigeration systems
- IC engines supercharging
- Industrial automation

8.b) Describe with a neat sketch the construction and working of a single stage single acting reciprocating air compressor

Construction:

- Cylinder, piston, crank, connecting rod
- Inlet & delivery valves
- Air filter
- Receiver tank



Working:

A single-acting reciprocating air compressor is a positive displacement machine in which air is compressed on only one side of the piston during each crankshaft revolution. The compressor consists of a cylinder, piston, crankshaft, connecting rod, inlet valve, and delivery valve. When the crankshaft rotates, the piston moves backward, creating a vacuum inside the cylinder. This causes the inlet (suction) valve to open, and atmospheric air is drawn into the cylinder. As the piston reaches the back dead centre and begins to move front, the inlet valve closes. During this upward stroke, the air trapped inside the cylinder is compressed, increasing its pressure and temperature. When the air pressure exceeds the delivery line pressure, the delivery (discharge) valve opens, allowing the compressed air to flow out into the receiver tank. Once the piston completes the stroke, the delivery valve closes again. This cycle of suction and compression continues with every revolution of the crankshaft. Since compression takes place on only one side of the piston, it is called a single-acting compressor. It is simple in construction, reliable, and widely used for moderate pressure applications.

OR

9(a) What is a centrifugal compressor? How it defers from an axial flow compressor.

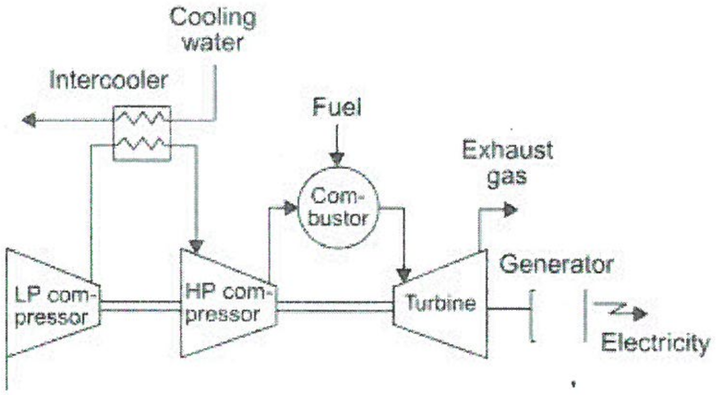
Centrifugal Compressor:

A centrifugal compressor is a type of dynamic (or turbo) compressor that increases the pressure of a gas by converting kinetic energy into pressure energy. It is widely used in gas turbines, refrigeration, air-conditioning, and process industries.

Differences:

Centrifugal	Axial
Radial flow	Parallel to axis
Low pressure ratio per stage	High per stage
Simple construction	Complex
Low flow rate	Very high flow rate

9(b) Purpose of intercooling in gas turbine & where used?



Intercooling is the process of cooling the air between successive stages of compression in a multi-stage gas turbine or compressor. It is used in multi-stage (usually two-stage) compression systems to improve the efficiency of the gas turbine.

Main Purposes of Intercooling

By cooling the air between stages, its temperature decreases, reducing the specific volume.

As a result, the work required by the second stage of the compressor is lower, reducing the total compression work.

Since less work is needed to compress air, more of the turbine's energy is available for power output, improving overall cycle efficiency.

Intercooling prevents the air temperature from becoming excessively high at the compressor exit, which is beneficial for material strength and turbine operation.

Intercooling allows the system to achieve higher overall pressure ratios without excessively increasing the compressor work, leading to better performance.

Application:

- Multi-stage compression in gas turbine power plants
- Aircraft gas turbines
- Industrial gas turbine systems

UNIT–V

10(a) Derive expression for thrust in jet propulsion.

Let C_a = forward velocity of aircraft through air

(∴ Assuming atmospheric air to be still the velocity of air)

At the entry to the aircraft the atmospheric air velocity will be C_a

C_j = velocity of jet relative to the exit nozzle.

Mass of products leaving the nozzle $= \left(1 + \frac{m_f}{m_a}\right)$

we know that thrust is the force produced due to change of momentum.

absolute velocity of gases leaving aircraft

$= C_j - C_a$

Absolute velocity of air entering aircraft is equal to zero.

change of momentum $= \left(1 + \frac{m_f}{m_a}\right)\left(C_j - C_a\right)$

Hence the thrust

$$T = \left(1 + \frac{m_f}{m_a}\right)\left(C_j - C_a\right) \text{ N/kg of air per sec.}$$

where, $\dot{m}_f$ = mass flow rate of fuel

$\dot{m}_a$ = mass flow rate of air

10(b) Solid vs Liquid Rocket Engines.

Solid Propellant	Liquid Propellant
Solid propellants are in **solid form**, usually a mixture of fuel and oxidizer cast into a single grain.	Liquid propellants are in **liquid form**, stored separately as fuel and oxidizer in tanks.
The fuel and oxidizer are **pre-mixed** during manufacturing.	Fuel and oxidizer are **stored separately** and mixed only in the combustion chamber.
Once ignited, **cannot be stopped or throttled** easily.	Can be **started, stopped, and throttled** during operation.
Simpler design; no pumps or complex feed systems required.	More complex due to **pumps, valves, injectors,** and feed lines.
Offers **high reliability** and long storage life.	Requires careful **handling and maintenance** due to risk of leakage and corrosion.
Lower specific impulse (less efficient).	Higher specific impulse (more efficient performance).
Used in missiles, boosters, and military rockets.	Used in spacecraft, launch vehicles, and long-duration missions.

OR

11(a) Classification & construction of flat plate collectors.

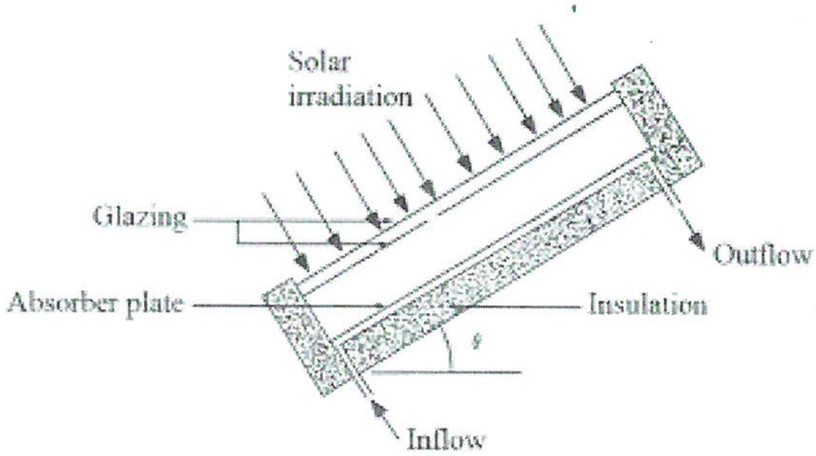
Classification:

- Flat plate collectors
- Evacuated tube collectors
- Concentrating collectors

Construction of Flat Plate Collector:

- Transparent cover (glass)

- Absorber plate
- Tubes/risers for fluid
- Insulation
- Casing/frame



Working Principle:

A flat plate collector is a device used to collect and convert solar energy into heat for water or air heating. It mainly consists of a flat absorber plate, transparent cover (glass), insulation at the back, and fluid-carrying tubes or channels. The absorber plate is usually coated with a dark material to maximize absorption of solar radiation. When sunlight strikes the collector, the absorber plate heats up, and this heat is transferred to the fluid (water or air) flowing through the tubes in contact with the plate. The transparent cover allows sunlight to pass through but reduces heat loss by trapping radiated heat (greenhouse effect). The insulation at the back and sides minimizes heat loss from the collector. The heated fluid is then circulated to a storage tank or directly used for domestic or industrial purposes. Flat plate collectors are simple in design, reliable, and widely used for water heating, space heating, and industrial process heat.

11(b) Discuss the applications of solar energy in domestic and industrial sectors.

Domestic:

1. **Water Heating:**
   - Solar water heaters are widely used in homes for bathing, washing, and space heating.
   - Flat plate and evacuated tube collectors are commonly used.
2. **Space Heating:**
   - Solar energy can heat rooms in cold climates using solar air heaters and thermal storage systems.

3. **Cooking:**
   - Solar cookers use reflective surfaces or transparent covers to concentrate sunlight and cook food without fuel.
4. **Lighting and Electricity Generation:**
   - Solar photovoltaic (PV) panels can power lights, fans, small appliances, and recharge batteries.
5. **Desalination and Water Purification:**
   - Solar stills use sunlight to evaporate and condense water, providing drinking water in remote areas.

Industrial:

Process Heating:

- Solar thermal collectors provide heat for drying, chemical processes, and food processing.

Power Generation:

- Solar power plants (using PV or concentrated solar power) generate electricity for industrial use.

Steam Generation:

- Solar collectors can produce steam for turbines in small or large industries.

Water Heating for Industrial Use:

- Industries use solar-heated water for cleaning, washing, and other processes, reducing fossil fuel consumption.

Desalination at Large Scale:

- Solar energy can drive large-scale desalination plants for supplying fresh water to industries and communities.

Material Drying:

- Solar energy is used in agriculture and food industries to dry grains, fruits, and other products efficiently.