1. (a) List the methods employed to increase the efficiency of Rankine cycle
   (b) In a Rankine cycle, the steam at inlet to turbine is saturated at a pressure of 35 bar and the exhaust pressure is 0.2 bar. Find (i) the pump work (ii) The turbine work (iii) The Rankine efficiency (iv) The condenser heat flow and (v) the dryness at the end of expansion. Assume flow rate of 9.5 kg/sec.

2. (a) In an engine the dry volumetric analysis of the products was CO2 0.0527, O2 0.1338 and N2 0.8135. Assuming that the fuel is a pure hydrocarbon and that it is completely burnt, estimate the ratio of carbon to hydrogen in the fuel by mass and the air-fuel ratio by mass.
   (b) Explain how gases are analyzed with the help of Orsat apparatus.

3. (a) Give the schematic representation of reheat Rankine cycle and derive an expression for its thermal efficiency.
   (b) Discuss the affect of the following on Rankine cycle efficiency (i) Inlet pressure (ii) Exhaust Pressure

4. (a) What is adiabatic flame temperature? How flame temperature can be calculated?
   (b) Calculate the amount of theoretical air required for the combustion of one kg of acetylene (C2H2) to CO2 and H2O

5. (a) Describe the different processes of Rankine cycle. Derive the expression for its efficiency and show them on P-v and T-s diagrams.
   (b) A simple Rankine cycle works between pressure of 30 bar and 0.04 bar, the initial condition of steam being dry saturated, calculate the cycle efficiency, work ratio and specific steam consumption.

**UNIT – 2**

1. (a) Give the working principle and construction details of La Mount boiler with a neat sketch.
   (b) Obtain an expression for draught in mm of water column when the discharge is maximum.

2. (a) Explain the terms (i) Evaporative capacity (ii) Equivalent Evaporation (iii) Factor of evaporation (iv) Boiler efficiency.
(b) How much air is used per kg of coal burnt in a boiler having chimney of 32.3 m height to create a draught of 19 mm of water column when the temperature of flue gases in the chimney is 3700 °C and the temperature of the boiler house is 29.50 °C.

3. (a) What are the main items of the boiler heat balance?

(b) A boiler is equipped with a chimney of 30 meters height. The flue gases, which pass through the chimney are at temperature of 2880 °C, where as the atmospheric temperature is 210 °C. If the airflow through the combustion chamber is 18 kg/kg of fuel burnt, find (i) the theoretical draught produced in mm of water and in height of hot gases column and (ii) velocity of flue gases passing through the chimney, if 50% of the theoretical draught is lost in friction at the grate and passage.

4. The following particulars were recorded during a steam boiler trial:
Steam pressure=11 bar, Mass of feed water = 4600 kg/hr, Feed water temperature = 750 °C, steam dryness = 0.96, coal used = 490 kg/hr, Calorific value of coal = 35,700 kJ/kg, moisture in the coal = 4% by mass, mass of dry flue gases = 18.57 kg/kg of coal, flue gas temperature = 3000 °C, boiler house temperature = 160 °C, specific heat of flue gases = 0.97 kJ/kg K. Draw the heat balance sheet of the boiler per kg of coal.

5. (a) Explain the terms forced draught, induced draught and balanced draught.

(b) From the data given below, estimate the power of motor required to drive an induced draught fan: Draught to be maintained = 50 mm of water, Mean temperature of flue gases = 4750K, Temperature of boiler house = 3100K, Efficiency of the fan = 75%, Air supplied = 15 kg/kg of coal, Coal consumption = 1600 kg/hr. If the induced draught fan is to be replaced by forced draught fan of the same efficiency, what would be the power consumption in this case?

6. In a boiler trial of one hour duration the following observations were made: Steam generated =5250 kg, coal burnt = 695 kg, calorific value of coal = 30200 kJ/kg, dryness fraction of steam =0.94, rated pressure of the boiler = 12 bar, temperature of steam leaving the super heater = 240 °C, temperature of hot well = 470 °C. Calculate
   (a) Equivalent evaporation per kg of fuel without super heater
   (b) Equivalent evaporation per kg of fuel with super heater
   (c) thermal efficiency of the boiler without super heater
   (d) thermal efficiency of the boiler with super heater
   (e) heat supplied by the super heater per hour. Take C p of steam as 2.184 kJ/kg K.

7. (a) Establish a condition for maximum discharge of flue gases through chimney.

(b) Calculate the draught in mm of water column produced by a chimney 30 m high when the average temperature of hot gases is 225 °C and the temperature of outside air is 20 °C. The quantity of air supplied is 18 kg/kg of fuel.

8. (a) Enumerate the various accessories normally used in a steam generating plant.
(b) A boiler with super heater generates 6000 kg/hr of steam at 15 bar and 0.8 dryness. The boiler exit temperature is 300 °C. The feed water temperature is 80 °C. The overall efficiency of the plant is 85%. Determine the consumption rate, assuming a calorific value of 30000 kJ/kg. Also find the equivalent evaporation from and at 100 °C. What will be the area of super heater surface if the overall heat transfer coefficient is 450,000 kJ/m²-hr?

**UNIT – 3**

1. (a) Explain the terms “over expanding” and “under expanding” as applied to a fluid flow through a nozzle.
   
   (b) At one stage of a steam turbine, the nozzles expand 9 kg of steam per second from a pressure of 15 bar and 2500 °C to 6 bar. The actual heat drop in the nozzle is 175 kJ. Calculate the number of nozzles required for a given outlet area for each nozzle approximately 3.5 sq.cm and adjust the outlet dimensions to suit this number.

2. (a) What do you mean by supersaturated flow? Explain with the help of h – s diagram.
   
   (b) Dry saturated steam at a pressure of 11 bar enters a convergent-divergent nozzle and leaves at a pressure of 2 bars. If the flow is frictionless and the expansion index is 1.14, calculate (i) the exit velocity of steam and (ii) ratio of cross section at exit and that at throat.

3. (a) Derive an expression for maximum discharge through convergent-divergent nozzle for steam.
   
   (b) Steam at a pressure of 10 bar and 0.9 dry discharges through a nozzle having a throat area of 450mm². If the back pressure is 1 bar, find the final velocity of steam and cross-sectional area of the nozzle at exit for maximum discharge

4. (a) Derive an expression for the mass of steam discharged through a nozzle.
   
   (b) Find the throat area, exit area and exit velocity for a steam nozzle to pass 0.2 kg/sec when the inlet conditions are 12 bar and 2500 °C and the final pressure is 2 bar. Assume that the expansion is isentropic and inlet velocity is negligible. Take n=1.3 for superheated steam.

5. Describe the changes which occur in a convergent divergent nozzle as the back pressure is slowly increased from the design pressure up to the pressure at entry.

6. A group of convergent divergent nozzles is required to expand 5 kg/s of steam from 14 bar, 0.98 dry to 1.5 bar. The velocity at the throat pressure of 8 bar is 3% less than the theoretical value and complete expansion takes place with an efficiency of 0.9. If the throat section of the nozzle is about 1.7 cm², determine the suitable number of nozzles and specify the proper throat and outlet areas.
7. (a) Define degree of under cooling and degree of super saturation.
(b) Super saturated expansion occurs in a nozzle provided with steam at 2 MPa and 325°C. The law of expansion may be taken as $PV^{1.3} = \text{Constant}$ and the discharge pressure is 0.36 MPa. For a steam flow rate of 450 kg/min., determine i. throat and exit diameter ii. degree of under cooling iii. degree of super saturation.

**UNIT – 4**

1. In a single stage impulse turbine, the isentropic nozzle heat drop = 251 kJ/kg, nozzle efficiency = 90%, nozzle angle = 200°, ratio of blade speed to whirl component of steam speed = 0.5, blade velocity coefficient = 0.9, the velocity of steam entering the nozzle = 20 m/s. Find the blade angles at inlet and outlet if the steam enters without shock and leaves the blades in an axial direction.

2. The first stage of an impulse turbine is compounded for velocity and has two rows of moving blades and one ring of fixed blades. The nozzle angle is 150° and the leaving angles of blades are respectively, first moving 300°; fixed 200°; second moving 300°. The velocity of steam leaving the nozzle is 540 m/s. The friction loss in each blade row is 10% of the relative velocity. Steam leaves the second row of moving blades axially. Find the blade velocity, blade efficiency and the specific steam consumption.

3. What is compounding? Describe various ways of compounding impulse turbines and give their merits and demerits.

4. An impulse turbine with a single row wheel is to develop 100 kW and the blade speed is 150 m/s. A mass of 2 kg/s is to flow through the nozzle with exit velocity of 350 m/s. The velocity coefficient of the blade is 0.8, while the steam is to flow axially after passing through the blade ring. Find out the nozzle angle and the blade angles at exit and inlet. Also calculate the diagram efficiency.

5. (a) What is the disadvantage of having very small exit angles for nozzles and moving blades of an impulse turbine?
(b) One stage of an impulse turbine consists of a row of nozzles and one row of moving blades. The steam enters the nozzles at a pressure of 15 bar, dry saturated with a velocity of 130 m/s. Pressure drops along the nozzles to 9 bar. The nozzles have discharge angle of 200° and the steam passes into the blades without shock. If velocity coefficient for nozzle 0.9, determine for maximum efficiency conditions
   i. the blade angles for equiangular blades ii. the blade efficiency iii. the stage efficiency

**UNIT – 5**
1. (a) A reaction turbine running at 360 rpm consumes 5 kg of steam per second. Tip leakage is 10%. Discharge blade tip angle for both moving and fixed blades is 200. Axial velocity of flow is 0.75 times blade velocity. The power developed by a certain pair is 4.8 kW where the pressure is 2 bar and dryness fraction is 0.95. Find the drum diameter and the blade height.
(b) Distinguish between Impulse and Reaction turbines.

2. (a) At a stage of a reaction turbine, the rotor diameter is 1.4 m and speed ratio 0.7. If the blade outlet angle is 200 and the rotor speed 3000 rpm, find the blade inlet angle and diagram efficiency. Also find the % increase in diagram efficiency and rotor speed if the turbine is designed to run at the best theoretical speed.
(b) Enumerate the different losses in a steam turbine.

3. (a) Define “Blade efficiency” and “Stage efficiency” of steam turbines.
(b) What do you mean by “compounding of steam turbines”? List the methods of compounding steam turbines.

4. (a) Define the term degree of reaction for the reaction turbine and show that its value is 0.5 for the Parson’s reaction turbine.
   (b) In a reaction turbine, both the fixed and moving blades have same tip angles of 300 and 220 for inlet and outlet respectively. The mean blade speed is 90 m/s and steam consumption is 8 kg/s. Determine the power required if isentropic heat drop in a pair is 23.5 kJ/kg.

5. The blade tip angles of a reaction turbine are 320 and 250 for fixed and moving blades respectively. The mean ring diameter of a pair of blades is 1.5 m and the blade height is 0.15 m. The steam which passed through the pair at a rate of 20 kg/s is dry saturated at 24 bar. Find
   (a) axial velocity (b) blade speed and (c) power developed at that speed.

6. A reaction turbine has drum diameter of 2.15 m at a speed of 750 rpm with 14.5 kg/s of steam consumption. The height of the blade at a certain location is 0.16 m while the discharging angle is 250. The pressure at this place is 4 bars and dryness fraction is 0.97. Estimate the power developed in the particular ring by assuming the turbine efficiency of 75%. Also find the heat drop while the steam passing over the pair of blades.

7. (a) Draw the combined velocity triangle for Parson’s reaction turbine and Explain the salient features.
   (b) In a single stage reaction turbine, both the fixed and moving blades have the same tip angles of 350 and 200 for inlet and outlet respectively. Determine the power required if the isentropic heat drop in both fixed and moving rows is 23.5 kJ/kg. The mean blade speed is 80 m/s and the steam consumption is 22,500 kg/h.
1. (a) What are the functions of condensers in a steam power plant? Explain with a simple diagram.
   
   (b) Differentiate between wet air pump and dry air pump and also derive the equation for volumetric efficiencies for both the cases.

2. (a) Derive the equations for the estimation of vacuum efficiency and condenser efficiency.
   
   (b) What are the advantages and limitations of surface condensers over jet condensers?

3. (a) What are the different types of cooling towers? Explain with suitable figures.
   
   (b) Draw the schematic diagram of parallel flow jet condenser and explain its working principle

4. (a) How the steam condensers are classified? Explain with basic principle and operation.
   
   (b) What are the sources of air leakage in steam condensers? Explain the affect of air leakage on condenser performance.

5. The following observations were recorded during a trial on a steam condenser. Condenser vacuum = 0.93325 bar; Barometer reading = 1.02 bar; Mean condenser temperature = 35 0C; hot well temperature = 28 0C; condensate collected=1800 kg/hr; mass of cooling water=80000 kg/hr; inlet temperature of cooling water = 15 0C; Outlet temperature of cooling water = 27 0C;
   
   Calculate
   
   (a) vacuum corrected to a standard of 760 mm of Hg
   (b) vacuum efficiency (c) under-cooling of condensate (d) condenser efficiency
   (e) state of steam entering into the condenser
   (f) mass of air present per cubic meter of condenser volume
   (g) mass of air present per kg of uncondensed steam.

6. (a) Draw the schematic diagram of parallel flow jet condenser and explain its working principle.
   
   (b) Draw the schematic diagram of low level counter flow jet condenser and explain its working principle.

7. (a) What factors contribute to loss of efficiency in the steam condensers? Explain.
   
   (b) Exhaust steam having a dryness fraction of 0.84 enters a surface condenser where the vacuum is 695 mm of Hg and is condensed to water at 35.8 0C. The temperature of the hot well
is 32.6°C. The circulating water enters the condenser at 15°C and leaves at 35°C. The barometric pressure is 756 mm of Hg, calculate
i. the mass of circulating water required per kg of steam, and
ii. the mass of air extracted per m³ of condenser volume.

UNIT – 7

1. Compare the maximum work delivered by an aircraft gas turbine which works with two stage compression with inter cooling. The compressor pressure ratio is 4 and the temperature limit is 1000 k, for the given ambient conditions of 1 bar and 301 k. If the temperature and pressure at 6000 m altitude is – 250 c and 0.5 bar, find the % change in network output, efficiency and exhaust gas temperature if the volume flow rate is 2.5 m³/sec.

2. In a gas turbine installation, the air is compressed in a single stage compressor from 1 bar 200 c to 6.25 bar. The air after compression is heated in a chamber to a temperature of 7500 c. The hot air is expanded in the turbine and then reheated to a temperature of 7500 c. The hot air is once again expanded in the second turbine. Find the power that can be developed per kg of air.

3. In a gas turbine plant air enters the compressor at 1 bar and 70 c. It is compressed to 4 bar with an isentropic efficiency of 82%. The maximum temperature at the inlet to the turbine is 8000 c. The isentropic efficiency of the turbine is 85%. The calorific value of the fuel used is 43.1 MJ/kg. The heat losses are 15% of the calorific value. Calculate thermal efficiency, air-fuel ratio, specific fuel consumption in kg/kWh and ratio of compressor work to turbine work. Take cp for gases = 1.15 kJ/kg k and specific heat ratio for gases = 1.33

4. A closed cycle gas turbine (with reheat) power plant operates using helium as the working medium. The pressure ratio is 10. The maximum permitted temperature is 1000 k. Assuming the work output to be maximum, calculate the efficiency. If the air is used instead of helium, calculate the efficiency and difference in heat added. Assume ideal Brayton cycle. Temperature at the inlet of compressor = 270 C; Cp of helium = 5.204 kJ/kg k; and specific heat ratio of helium = 1.67.

5. (a) Explain the working principle of gas turbine along with p-v and T-s diagrams.
   (b) Describe the differences between closed cycle gas turbine and open cycle gas turbine.

6. (a) Explain the operating principle of Brayton cycle with a schematic diagram, p-v and T-s diagrams.
   (b) Derive the thermal efficiency of Brayton cycle in terms of pressure ratio and polytropic index.
7. (a) What are essential components required for the operation of gas turbine cycle and explain their functionality.

(b) What are the advantages and limitations of gas turbine power generation units in comparison with other power generating units.

UNIT – 8

1. (a) With a neat sketch and T-S diagram, explain the working of turbojet engine and also derive the expression for the thrust developed.

(b) What is meant by thrust augmentation and explain how it is effected.

2. (a) Draw a schematic diagram of a solid propellant rocket and explain its working.

(b) What are the advantages and disadvantages of rocket engines?

3. (a) With the aid of the schematic diagram and thermodynamic cycle, explain the working of a turboprop engine.

(b) With a neat sketch, explain the principal elements of a liquid bipropellant rocket engine.

4. (a) List the common Bipropellants used in liquid propellant rockets.

(b) Explain “Thermal Efficiency”, “Transmission Efficiency”, “Propulsive Efficiency” and “Propeller Efficiency” with respect to jet propulsion engines.

5. (a) How to classify the jet propulsive engines? What are different applications of jet propulsions.

(b) Explain the operating principles of rocket engine with a neat diagram?

6. (a) Define and explain the terms:

   i. Thrust
   ii. Thrust power
   iii. Effective jet exit velocity
   iv. Propulsive efficiency related to turbojet engines.

(b) Describe the nuclear rocket engine with a neat sketch and explain its merits and demerits.

7. (a) Discuss the advantages and limitations of turboprop engine over turbo jet engine.

(b) What is the operating principle of a rocket engine? Discuss the advantages and disadvantages of rocket engines.

8. (a) A rocket engine operates for 3.0 s during which its mass reduces from 20kg to 13kg. Find thrust and the total impulse if average specific impulse of the propellant is 240 s. Find also effective velocity and the maximum acceleration of the vehicle.