DEPARTMENT OF MECHANICAL ENGINEERING

ME -Thermal Engineering-II

UNIT I – STEAM POWER CYCLE			
Rankine cycle – Schematic layout, comparison between Rankine cycle and Carnot cycle. Thermodynamic analysis, concept of mean temperature of heat addition, methods to improve cycle performance: Reheat cycle – Regenerative cycle – Binary vapour cycle.			
PART-A (2 Marks)			
1.	Discuss the methods using to improve Rankine cycle efficiency	BT-1	Remembering
2.	Draw P-V and T-S diagram of Rankine cycle.	BT-1	Remembering
3.	What is difference between Rankine cycle and carnot cycle.	BT-1	Remembering
4.	Draw the Schematic layout of Reheat cycle	BT-1	Remembering
5.	Draw the Schematic layout of Regenerative cycle	BT-3	Applying
6.	Explain the concept of Mean temperature of heat addition	BT-2	Understanding
7.	Draw the different processes of Rankine cycle on a T-S diagram. Mention the different operations of Rankine cycle.	BT-2	Understanding
8.	Explain the different operations of Rankine cycle.	BT-2	Understanding
9.	State the methods of increasing the thermal efficiency of a Rankine cycle. Draw the neat sketch of it.	BT-1	Remembering
10.	Discuss the advantages of a regenerative feed heating in steam power cycle.	BT-1	Remembering

PART-B (10 Marks)			
1.	In a Rankine cycle, the steam at inlet to turbine is saturated at pressure of 30 bar and exhaust pressure is 0.25 bar. Determine (i)The pump work (ii) Turbine work (iii) Rankine efficiency (iv) Condenser heat flow (v) dryness at the end of expansion.Assume flow rate of 10 kg/s..	BT-5	Evaluating
2.	Steam at 70 bar and 450^{0}C is supplied to a steam turbine. After expanding to 25bar in high pressure stages, it is reheated to 420^{0}C at the constant pressure. Next; it is expanded in intermediate pressure stages to an appropriate minimum pressure such that part of the steam bled at this pressure heats the feed water to a temperature of 180^{0}C. The remaining steam expands from this pressure to a condenser pressure of 0.07bar in the low pressure stage. The isentropic efficiency of HP stage is 78.5%, while that of the intermediate and LP stage is 83% each. Determine the minimum pressure at which bleeding is necessary, the quantity of steam bled per kg of flow at the turbine inlet and the efficiency of the cycle.	BT-1	Remembering

3.	In a single regenerative heater system, the steam is supplied to the turbine at a rate of 68000 kg/hr and 15420 kg of steam is blowed per hour at 10 bar and the remaining is passed to the condenser. Determine the enthalpy of steam at entry of regenerative heater and entry condition at the entry of the condenser	BT-1	Remembering
4.	A power generating plant uses steam as working fluid and operates at boiler pressure of 50bar, dry saturated and a condenser pressure of 0.1bar. Calculate for these limits: i) The cycle efficiency; ii) The work ratio and specific steam consumption for Rankine cycle. Take pumping work also into account.	BT-2	Understanding
5.	The steam is supplied to a steam turbine at a pressure of 32 bar and a temperature 410°C. The steam then expands isentropically to a pressure of 0.08bar. Find the dryness fraction of steam at the end of expansion and thermal efficiency of the cycle. If the steam is reheated at 5.5 bar to a temperature of 395° C and then expands isentropically to 0.08 bar, what will be the dryness fraction at the end of final expansion and the thermal efficiency of the cycle?	BT-2	Understanding
6.	What is reheating? Explain with neat sketch.	BT-6	Creating
7.	Consider a regenerative vapour power cycle with a feed water heater. The steam enters the first stage turbine at 8 MPa, 500oC and expands to 0.7 MPa, where some of the steam is extracted and diverted to feed water heater operating at 0.7 MPa. The remaining steam expands through the second stage turbine to a condenser pressure of 0.008 MPa. The saturated liquid exits the feed water heater at 0.7 MPa. The isentropic efficiency of each turbine is 85%, while each pump operates isentropically. If the net power output of the cycle is 105 MW, determine i) Thermal efficiency of the cycle ii) The mass flow rate of steam entering the first turbine stage.	BT-1	Remembering
8.	Draw and explain the working principle of Binary vapour cycle with a neat sketch.	BT-5	Evaluating
9.	A rankine cycle operates between pressures of 80 bar and 0.1 bar. The maximum cycle temperature is 60^0C.If the steam turbine and condensate pump efficiencies are 0.9 and 0.8 resp. Calculate the specific work and thermal efficiency?	BT-5	Evaluating
10.	In a steam power cycle, the steam supply is at 15 bar and dry and saturated. The condenser pressure is 0.4 bar. Calculate Carnot and rankine efficiencies of the cycle? Neglect pump work.	BT-5	Evaluating

UNIT II – BOILERS AND DRAUGHT			
Classification of steam boilers – Modern high pressure boilers –Mountings and accessories – Methods of feed water treatment – Equivalent evaporation – Boiler efficiency – heat losses in a boiler – Heat balance sheet. **Draught:** Classification – Natural draught: Chimney height and diameter – Condition for maximum discharge through a chimney – Artificial draught: Forced draught, induced draught and balanced draught.			
PART-A (2 Marks)			
1.	What is water level indicator?	BT-1	Remembering
2.	Compare force and induced draught	BT-1	Remembering
3.	What are the functions of a boiler chimney? Why chimney is not provided in a locomotive boiler?	BT-1	Remembering
4.	What is the function of fusible plug?explain.	BT-1	Remembering
5.	Merits and demerits of the dead weight safety valve.	BT-2	Understanding
6.	What are the major differences between mountings and accessories? Give three examples of each.	BT-2	Understanding
7.	Explain the function of the boiler chimney.	BT-1	Remembering
8.	Why is there no chimney in the case of a locomotive boiler?	BT-1	Remembering
9.	What is safety valve? And define safety valve.	BT-4	Analysing
10.	Explain various types of draughts used in usual practice.	BT-1	Remembering

PART-B (10 Marks)			
1.	Describe with a neat diagram, the construction and working of a Bebcock and Wilcox water tube boiler.	BT-5	Evaluating
2.	Describe with a neat line sketch of a Cochran boiler mentioning its Distinguishing features. State the advantages for this type of boiler.	BT-1	Remembering
3.	Discuss, briefly, the working of an economiser in a boiler plant giving a neat sketch.	BT-1	Remembering
4.	Discuss the function of a safety value. State the minimum number of safety value to be used in boiler.	BT-2	Understanding
5.	(a)A coal fired boiler plant consumes 400 kg of coal per hour. The boiler evaporates 3200 kg of water at 44.5^{o}C into superheated steam at a pressure of 12 bar and 274.5^{o}C. If the calorific value of fuel is 32760	BT-2	Understanding

	kJ/kg of coal, determine: 1. Equivalent evaporation "from and at 100^{o}C,'' and 2. Thermal efficiency of the boiler. Assume specific heat of superheated steam as 2.1 kJ/kg K.		
6.	Explain with neat sketch any three of the following mounting: i) Water level indicator ii) Pressure gauge iii) Feed check value iv) Blow of cock v) High steam and low water safety value vi) Junction or stop value	BT-6	Creating
7.	A boiler generates 13000 kg of steam at 7 bars during a period of 24 hrs and consume 1250 kg of coal whose CV. = 30000 kJ/kg. Taking the enthalpy of steam coming out of boiler = 2507.7 kJ/kg and water is supplied to the boiler at 40^{o}C. Find: (a) efficiency of the boiler (b) Equivalent evaporation per kg of coal.	BT-1	Remembering
8.	With the help of neat sketch, explain and injector for feeding water to the boiler drum. Why it is not used for large capacity boilers? Explain its location in boiler installation.	BT-5	Evaluating
9.	Explain with neat sketches any two of the following boiler accessories: i) Injector ii) super heater iii) Air preheated iv) Economizer.	BT-5	Evaluating
10.	In a boiler , the following observations were made : Pressure of steam = 10 bar Steam condensed = 540 kg/h Fuel used = 65 kg/h Moisture in fuel = 2% by mass Mass of dry flue gases = 9 kg/kg of fuel Lower calorific value of fuel = 32000 kJ/kg Temperature of the flue gases = 325^{o}C Temperature of boiler house = 28^{o}C Feed water temperature = 50^{o}C	BT-5	Evaluating

	Mean specific heat of flue gases = 1 kJ/kg K Dryness fraction of steam = 0.95Draw up a heat balance sheet for the boiler.		

UNIT III – STEAM CONDESNSERS AND NOZZLES: Types and Shapes of nozzles - Flow of steam through nozzles, Critical pressure ratio-Variation of mass flow rate with pressure ratio-Effect of friction- Metastable flow.			
PART-A (2 Marks)			
1.	Define critical pressure ratio in steam flow through Nozzles.	BT- 1	Remembering
2.	Discuss merits and demerits of surface condensers and jet condensers.	BT- 5	Evaluating
3.	Explain working principle of surface condenser.	BT - 2	Understanding
4.	Draw the Shape of Supersonic Nozzle.	BT - 3	Applying
5.	Express the effects of friction on the flow through a steam nozzle.	BT - 3	Applying
6.	What are the applications of steam nozzles	BT - 2	Understanding
7.	Explain the difference between jet condensers and surface condensers	BT - 6	Creating
8.	Explain working principle of jet condenser.	BT - 3	Applying
9.	Where is nozzle control governing is used?	BT - 1	Remembering
10.	What are the types of jet condensers? Explain any one with neat sketch/	BT - 5	Evaluating

PART-B (10 Marks)			
1.	(a) Mention the types of nozzles you know, Where are these used?	BT - 1	Remembering
	(b) Steam having pressure of 10.5 bar and 0.95 dryness is expanded through a convergent-divergent nozzle and the pressure of steam leaving the nozzle is 0.85 bar. Find the velocity at the throat for maximum discharge conditions. Index of expansion may be assumed as 1.135. Calculate mass rate of flow of steam through the nozzle.	BT - 2	Understanding
2.	(a) Dry saturated steam enters a frictionless adiabatic nozzle with negligible velocity at a temperature of 300^{o}C. It is expanded to pressure of 5000 KPa. The mass flow rate is 1 kg/s. Calculate the exit velocity of the steam.	BT - 2	Understanding
	(b) Steam is expanded in a set of nozzles from 10 bar and 200^{o}C to 5 bar. What type of Nozzle is it? Neglecting the initial velocity find minimum area of the nozzle required to allow a flow of 3 kg/s under the given conditions. Assume that expansion of steam to be isentropic.	BT-3	Applying
3.	In a steam nozzle, the steam expands from 4 bar to 1 bar. The initial velocity is 60 m/s and the initial temperature is 200^{o}C. Determine the exit velocity if the nozzle efficiency is 92%.	BT-3	Applying
4.	Describe (Derive) the expression for critical pressure ratio in terms of index of expansion.	BT - 1	Remembering
5.	Dry saturated steam enters a steam nozzle at a pressure of 15 bar and is discharged at a pressure of 2 bar. If the dryness fraction of discharge steam is 0.96, what will be the final velocity of steam? Neglect initial velocity of steam. If 10% of heat drop is lost in friction, Examine (find) the percentage reduction in the final velocity.	BT - 5	Evaluating

6.	Dry saturated steam at a pressure of 11 bar enters a convergent-divergent nozzle and leaves at a pressure of 2 bar. If the flow is adiabatic and frictionless, determine: (i) The exit velocity of steam. (ii) Ratio of cross section at exit and that at throat. Assume the index of adiabatic expansion to be 1.135.	BT - 6	Creating
7.	The nozzles of De-Laval stream turbine are supplied with dry saturated steam at a pressure of 9 bar. The pressure at the outlet is 1 bar. The turbine has two nozzles with a throat diameter of 2.5 mm. Assuming nozzle efficiency as 90% and that of turbine rotor 35%, find the quality of steam used per hour and the power developed.	BT - 3	Applying

8.	Dry saturated steam at a pressure of 8 bar enters a convergent divergent nozzle and leaves it at a pressure of 1.5 bar. If the flow is isentropic and if the corresponding expansion index is 1.33, find the ratio of cross-sectional area at exit and throat for maximum discharge.	BT-4	Analysing
9.	Air at a pressure of 20 bar and at a temperature of 18°C is supplied to a convergent divergent nozzle having a throat diameter of 1.25 cm and discharging to atmosphere. The adiabatic index for air is 1.4 and the characteristic constant is 287. Find the weight of air discharged per minute.	BT-5	Evaluating
10.	Derive an expression for maximum discharge through convergent divergent nozzle for steam.	BT-1	Remembering

UNIT IV-STEAM TURBINES

Types, Impulse and reaction principles, Velocity diagrams, Work done and efficiency – optimal operating conditions. Multi-staging, compounding and governing.

PART-A (2 Marks)			
1.	Distinguish between impulse and reaction principle.	BT - 2	Understanding
2.	Discuss the importance of compounding of steam turbine.	BT - 1	Remembering

3.	Explain ‘Degree of Reaction’ in a steam turbine.	BT - 4	Analysing
4.	Discuss the importance of compounding of steam turbine.	BT - 1	Remembering
5.	What is meant by Pressure Compounding?	BT - 2	Understanding
6.	How are the steam turbines classified?	BT - 4	Analysing
7.	Define Diagram efficiency.	BT - 5	Evaluating
8.	Discuss the advantages of a steam turbine over the steam engines.	BT - 1	Remembering
9.	Define a steam turbine and state its fields of application.	BT - 2	Understanding
10.	What methods are used in reducing the speed of the turbine rotor?	BT - 5	Evaluating

PART-B (10 Marks)			
1.	A simple impulse turbine has one ring of moving blades running at 150 m/s. the absolute velocity of steam at exit from the stage is 85 m/s at an angle of 80° from the tangential direction. Blade velocity co-efficient is 0.82 and the rate of steam flowing through the stage is kg/s. if the blades are equiangular, determine: (i) Blade angles (ii)Nozzle angle (iii) Absolute velocity of the steam issuing from the nozzle (iv) Axial thrust.	BT - 6	Creating
2.	The velocity of steam exiting the nozzle of the impulse stage of a turbine is 400 m/s. The blades operate close to the maximum blading efficiency. The nozzle angle is 20°. Considering equiangular blades and neglecting blade friction, calculate for a steam flow of 0.6 kg/s, the diagram power and the diagram efficiency.	BT - 1	Remembering

3.	A single-stage impulse turbine is supplied steam at 5 bar and 200°C at the rate of 50 kg/min and it expands into a condenser at a pressure of 0.2 bar. The blade speed is 400 m/s and nozzles are inclined at 20°C to the plane of the wheel. The blade angle at the exit of the moving blade is 30°C. Neglecting friction losses in the moving blade, Evaluate (i) Velocity of the steam entering the blades (ii) Power developed, (iii). Blade efficiency and (iv) Stage efficiency.	BT - 5	Evaluating
4.	At a stage of reaction turbine, the mean diameter of the rotor is 1.4 m. The speed ratio is 0.7. Determine the blade inlet angle if the blade outlet angle is 20°. The rotor speed is 3000 rpm. Also find the diagram efficiency. Find the percentage increase in diagram efficiency and rotor speed if the rotor is designed to run at the best theoretical speed, the exit angle being 20°.	BT - 1	Remembering
5.	In a single stage impulse turbine the blade angles are equal and the nozzle angle is 20°. The velocity coefficient for the blade is 0.83. Find the maximum blade efficiency possible. If the actual blade efficiency is 90% of maximum blade efficiency, find the possible ratio of blade speed to steam speed.	BT - 2	Understanding
6.	A single stage impulse turbine rotor has a diameter of 1.2 m running at 3000 rpm. The nozzle angle is 18°. Blade speed ratio is 0.42. The ratio of the relative velocity at outlet to relative velocity at inlet in 0.9. The outlet angle of the blade is 3° smaller than the inlet angle. The steam flow rate is 5 kg/s. Draw the velocity diagram and find the following : (i) Velocity of whirl (ii) Axial thrust on the bearing (iii) Blade angles (iv) Power developed	BT - 6	Creating

7.	A de-Lavel turbine it supplied with dry steam and works on a pressure range from 10.5 bar to 0.3 bar. The nozzle angle is 20° and the blade exit angle is 30°.The mean blade speed is 270 m/s. If there is a 10% loss due to friction in the nozzle and blade velocity coefficient 0.82, find the thrust on the shaft per kW power developed.	BT - 3	Applying
8.	Explain with a neat sketch of velocity compounding, pressure compounding, pressure-velocity compounding.	BT-3	Applying
9.	A simple impulse turbine has one ring of moving blades running at 150 m/s. the absolute velocity of steam at exit from the stage is 85 m/s at an angle of 80^o from the tangential direction. Blade velocity co-efficient is 0.82 and the rate of steam flowing through the stage is kg/s. if the blades are equiangular, determine: (i) Blade angles (ii)Nozzle angle (v) Absolute velocity of the steam issuing from the nozzle (vi) Axial thrust.	BT - 6	Creating
10.	A single row impulse turbine develops 132.4 kW at a blade speed of 175 m/s, using 2 kg of steam per sec. Steam leaves the nozzle at 400 m/s. Velocity coefficient of the blades is 0.9. Steam leaves the turbine blades axially. Calculate nozzle angle, blade angles at entry and exit, assuming no shock.	BT - 3	Applying
12.	In a stage of impulse reaction turbine operating with 50% degree of reaction, the blades are identical in shape. The outlet angle of the moving blades in 19^o and the absolute discharge velocity of steam is 100 m/s in the direction 70^o to the motion of the blades. If the rate of flow through the turbine is 15000 kg/hr., calculate the power developed by the turbine.	BT - 3	Applying
13.	A stage of a steam turbine is supplied with steam at a pressure of 50 bar and 350^{o}C, and exhausts at a pressure of 5 bar. The isentropic efficiency of the stage is 0.82 and the steam consumption is 2270 kg/min. Determine the power of the stage.	BT - 3	Applying

14.	The velocity of steam exiting the nozzle of the impulse stage of a turbine is 400 m/s. The blades operate close to maximum blading efficiency. The nozzle angle is 20^o. Considering equiangular blades and neglecting blade friction, calculate for a steam flow of 0.6 kg/s, the diagram power and the diagram efficiency.	BT - 3	Applying

UNIT V : GAS TURBINES AND JET PROPULSION			
Gas Turbines: Classifications, simple layout, essential components and performance – Ideal and actual cycle – Regeneration – Inter cooling and reheating – Constant pressure gas turbine – Constant volume gas turbines – Methods improvement of thermal efficiency – Effects of operating variables. **Jet Propulsion:** Classification – T-S Diagram – Thrust, thrust power and propulsion efficiency – Working principles of turbo jet, turbo prop, ram jet, pulse jet engine and rocket engine – Introduction to Rocket propulsion.			
PART-A (2 Marks)			
1.	List out the differences between the open cycle gas turbines and closed cycle gas turbines	BT- 1	Remembering
2.	What are the working differences between the propeller-jet, turbojet and turbo-prop	BT- 5	Evaluating
3.	State the assumptions made for thermal efficiency of a gas turbine plant	BT - 2	Understanding
4.	What are the disadvantages of a closed cycle gas turbine over open cycle gas turbine?	BT - 3	Applying
5.	What are the requirements of a good combustion chamber for a gas turbine?	BT - 3	Applying
6.	Draw the T-s diagram of a reheat gas turbine cycle.	BT - 2	Understanding
7.	Draw the line diagram of a closed cycle gas turbine.	BT - 6	Creating
8.	What are the different rocket propulsion systems?	BT - 3	Applying
9.	Define propulsive efficiency of jet propulsion system.	BT - 1	Remembering
10.	Define Thrust and Proposive efficiency.	BT - 5	Evaluating

PART-B (10 Marks)

1.	A simple gas turbine cycle works with a pressure ratio of 8. The compressor and turbine inlet temperatures are 300 K and 800 K respectively. If the volume flow rate of air is 250 m3/s, compute the power output and thermal efficiency.	BT - 6	Creating
2.	Explain working of turbo prop engine with a neat sketch	BT - 1	Remembering
3.	Define and explain the terms: i. Thrust ii. Thrust power, iii. Effective jet exit velocity, iv. Propulsive efficiency related to turbojet engines.	BT - 5	Evaluating
4.	A jet propulsion system has to create a thrust of 100 tonnes to move the system at a velocity of 700 km/hr. If the gas flow rate through the system is restricted to a maximum of 30 kg/s. find the exit gas velocity and propulsive efficiency.	BT - 1	Remembering
5.	Draw the schematic diagram of closed cycle gas turbine and explain its working.	BT - 2	Understanding
6.	A constant pressure open cycle gas turbine plant works between temperature range of 15ºC and 700ºC and pressure ratio of 6. Find the mass of air circulating in the installation, if it develops 1100 kW. Also find the heat supplied by the heating chamber.	BT - 6	Creating
7.	In a gas turbine plant, air is drawn at 1 bar, 150 C and the pressure ratio is 6. The expansion takes place in two turbines. The efficiency of compressor is 0.82, high pressure turbine is 0.85 and low pressure turbine is 0.84. The maximum cycle temperature is 6250 C. Calculate i) Pressure and temperature of gases entering the low pressure turbine. ii) Net power developed iii) Work ratio iv) Thermal efficiency. Work output of high pressure turbine is equal to compressor work	BT - 3	Applying
8.	What are the different types of combustion chambers in gas turbine engines? Explain them in detail with relevant sketches.	BT-3	Applying
9.	Derive the thermal efficiency of an ideal gas turbine power plant	BT - 6	Creating
10.	Explain the effect of regeneration, inter cooling, and reheating on the performance of Gas turbine plant	BT - 3	Applying