THERMAL ENGINEERING - II (ME505PC)
COURSE PLANER

COURSE OVERVIEW:

This Course provides a simple understanding of the steam and gas power systems. The course contains the analysis of vapour power cycle i.e. Rankine cycle, steam generators and their accessories, Performance of Boilers, flow through steam nozzles, different type of steam turbines for power generation and condensers. The gas turbine cycle, working of gas turbines and a glimpse on jet propulsion and the working principle of rockets.

PREREQUISITE(S):

Students are expected to know the fundamentals of thermodynamics, the laws of thermodynamic and the properties of steam. Students are also expected to have expertise in using steam tables to solve the analytical problems of power cycles.

COURSE OBJECTIVES:

The objectives of the course are to enable the student

- To understand the basic principles of power cycles
- To understand the principles of different components in power cycles
- To analyze the performance of steam and gas turbines
- To understand the working principles of rockets and jet propulsion.

I. COURSE OUTCOMES

Sl.NO	Description	Bloom's Taxonomy level
CO1	Able to explain the working principles of steam and gas power cycles.	L2: Understand
CO2	Able to demonstrate the working of steam boilers and condensers.	L2: Understand
CO3	To analyze the thermodynamic aspects of different power cycles and the velocity diagrams of turbines.	L4: Analyze
CO4	To analyze the performance of steam nozzles.	L4: Analyze
CO5	To estimate maximum efficiency/maximum discharge parameters of different components.	L4: Analyze
CO6	Able to demonstrate the working principles of jet propulsion and rocket engines.	L2: Understand

II. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Level	Proficiency assessed by
PO1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Assignment/ Exam
PO2	**Problem analysis**: Identify, formulate, review research	2	Assignment/

	literature, and analyze engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.		Exam
PO3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	2	Assignment/ Exam
PO4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	Assignment/ Exams
PO5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	4	Exams
PO6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	2	Assignment
PO7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	-	-
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	-	-
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	3	Assignment/ Exams
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Assignment/ Exams
PO11	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	-	-
PO12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	Assignment/ Exams

VI. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Level	Proficiency assessed by
PSO1	The student will be able to apply the knowledge of Mathematics, Sciences and engineering fundamentals to formulate, analyze and provide solutions for the problems related to Mechanical engineering and communicate them effectively to the concerned.	2	Lectures, Assignments
PSO2	Design mechanical systems in various fields such as machine elements, thermal, manufacturing, industrial and inter-disciplinary fields by using various engineering/technological tools to meet the mercurial needs of the industry and society at large.	2	Lectures, Assignments
PSO3	The ability to grasp the latest development, methodologies of mechanical engineering and posses competent knowledge of design process, practical proficiencies, skills and knowledge of programme and developing ideas towards research.	2	Lectures, Assignments

VII. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

CO's	Program Outcomes (PO's)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO.1	2	2	2	1	4	3	--	--	3	2	--	2
CO.2	2	2	2	2	4	3	--	--	3	2	--	2
CO.3	3	2	3	1	--	--	--	--	3	2	--	2
CO.4	3	1	3	1	--	--	--	--	3	2	--	2
CO.5	2	3	3	1	--	--	--	--	3	2	--	2
CO.6	2	1	1	1	--	--	--	--	3	2	--	2
Average	**3**	**2**	**3**	**1**	4	3	--	--	**3**	**2**	--	**2**

Program Specific Outcomes (PSO's)

CO's	PSO1	PSO2	PSO3
CO1.	2	2	3
CO2.	1	2	3
CO3.	2	2	3
CO4.	2	2	1
CO5.	3	2	1
CO6.	1	2	3
Average	2	2	2

VIII. SYLLABUS:

Unit – I	**Steam Power Plant:** Rankine cycle - Schematic layout, Thermodynamic Analysis, Concept of Mean Temperature of Heat addition, Methods to improve cycle performance – Regeneration & reheating. **Boilers** – Classification – Working principles with sketches including H.P.Boilers – Mountings and Accessories – Working principles- Boiler horse power, Equivalent Evaporation, Efficiency and Heat balance – Draught- Classification – Height of chimney for given draught and discharge- Condition for maximum discharge- Efficiency of chimney
Unit – II	**Steam Nozzles :** Stagnation Properties- Function of nozzle – Applications and Types- Flow through nozzles- Thermodynamic analysis – Assumptions -Velocity of nozzle at exit-Ideal and actual expansion in nozzle- Velocity coefficient- Condition for maximum discharge- Critical pressure ratio- Criteria to decide nozzle shape- Super saturated flow, its effects, Degree of super saturation and Degree of under cooling - Wilson line.
Unit – III	**Steam Turbines:** Classification – Impulse turbine; Mechanical details – Velocity diagram – Effect of friction – Power developed, Axial thrust, Blade or diagram efficiency – Condition for maximum efficiency. De-Laval Turbine - its features- Methods to reduce rotor speed- Velocity compounding and Pressure compounding- Velocity and Pressure variation along the flow – Combined velocity diagram for a velocity compounded impulse turbine. **Reaction Turbine:** Mechanical details – Principle of operation, Thermodynamic analysis of a stage, Degree of reaction –Velocity diagram – Parson's reaction turbine – Condition for maximum efficiency.
Unit – IV	**Steam Condensers:** Requirements of steam condensing plant – Classification of condensers – Working principle of different types – Vacuum efficiency and Condenser efficiency – Air leakage, sources and its affects, Air pump- Cooling water requirement. **Gas Turbines:** Simple gas turbine plant – Ideal cycle, essential components – Parameters of performance – Actual cycle – Regeneration, Inter cooling and Reheating –Closed and Semiclosed cycles – Merits and Demerits- Combustion chambers and turbines of Gas Turbine Plant- Brief Concepts.
Unit - V	**Jet Propulsion:** Principle of Operation –Classification of jet propulsive engines – Working Principles with schematic diagrams and representation on T-S diagram - Thrust, Thrust Power and Propulsion Efficiency – Turbo jet engines – Needs and Demands met by Turbo jet – Schematic Diagram, Thermodynamic Cycle, Performance Evaluation Thrust Augmentation – Methods. **Rockets:** Application – Working Principle – Classification – Propellant Type – Thrust, Propulsive Efficiency – Specific Impulse – Solid and Liquid propellant Rocket Engines

SUGGESTED BOOKS/RESOURCES:

TEXT BOOKS:

1. Thermal Engineering / Mahesh M Rathore/ Mc Graw Hill.
2. Gas Turbines – V.Ganesan /Mc Graw Hill.

REFERENCES:

1. Gas Turbine Theory/ Saravanamuttoo, Cohen, Rogers/ Pearson.
2. Fundamentals of Engineering Thermodynamics / Rathakrishnan/ PHI
3. Gas Turbines and Propulsive Systems – P.Khajuria & S.P.Dubey - /Dhanpatrai
4. Thermodynamics and Heat Engines / R. Yadav / Central Book Depot
5. Thermal Engineering / R.K. Rajput / Lakshmi Publications

GATE SYLLABUS:

Thermal sciences: Power Engineering: Air and gas compressors; vapour and gas power cycles, concepts of regeneration and reheat. Turbomachinery: Impulse and reaction principles, velocity diagrams.

IES SYLLABUS:

Turbines, velocity diagrams, Impulse and Reaction principles, Steam and Gas Turbines, Theory of Jet Propulsion – Pulse jet and Ram Jet Engines. Rankine and Brayton cycles with regeneration and reheat, Fuels and their properties, Flue gas analysis, Boilers, steam turbines and other power plant components like condensers, air ejectors, electrostatic precipitators and cooling towers – their theory and design, types and applications.

IX: COURSE PALN

Lecture No.	Unit No.	Topics to be covered	Content to be covered under each topic	Link for PPT	Link for PDF	Link for Small Projects/ Numericals(if any)	Course learning out	Teaching Methodology	Reference
1	I	Steam Power Plant: Rankine cycle	Layout of steam power plant, components in power plant	https://docs.google.com/presentation/d/1rwaj2Jd4uEf9BANIjx51XRbzZTfCjRNY/edit#slide=id.p1		**Case study on Steam power plant, Chimney**	CLO1	Chalk and Talk PPT,Assignments, Videos	**T1, R3**
2		- Schematic layout, Thermodynamic Analysis,	Layout, Analysis, Working of each components and process involved				CLO1		

3		Concept of Mean Temperature of Heat addition	parameters affecting Efficiency		https://drive.google.com/drive/folders/0B77PUweQZVUwfnhaWDRTaXpPRHhaUU9lWk1BcHVBWVpNZzRKSzlVTWhDMGpIVTJKWWlxdTA?resourcekey=0-E6vNAyoez3WYjb_FuSh9Uw		CLO2		
4		Methods to improve cycle performance	Performance evaluation of various cycle	https://docs.google.com/presentation/d/1s0cG2fi8Mek17Y2TbU1uZonO7l0iP6QZ/edit?usp=drive_web&ouid=114809821418212447772&rtpof=true			CLO1		
5		– Regeneration & reheating	Performance evaluation of various cycle				CLO1		
6		Boilers – Classification	working principle of boiler, various types of boilers	https://docs.google.com/presentation/d/1KJQ7-L4OjYf39bGIjSOjztWieAoZ0A-G/edit?usp=drive_web&ouid=114809821418212447772&rtpof=true			CLO5		
7		Working principles with sketches including H.P.Boilers	differentiating different types of boilers based on steam generation, pressure				CLO5		
8		Mountings and Accessories	design and its uses of mounting and accessories				CLO1		
9		Working principles	Working principles of various mounting and accessories				CLO1		
10		Boiler horse power, Equivalent Evaporation, Efficiency and Heat balance	Efficiency calculation of boiler, heat balance sheet of boiler				CLO4		
11		– Draught-Classification – Height of chimney for given draught, discharge	Draught its type and claculation of height of chimney				CLO4		

12		Condition for maximum discharge-Efficiency of chimney.	Calculation of height and discharge				CLO4		
13	**II**	**Steam Nozzles:** Stagnation Properties	Working principle of nozzle, types of nozzle	https://docs.google.com/presentation/d/1D9z9yhvozipiZgPnQn-EdyIN8G-rB6Ws/edit?usp=drive_web&ouid=114809821418212447772&rtpof=true	https://drive.google.com/drive/folders/0B77PUweQZVUwfnhaWDRTaXpPRHhaUU9IWk1BcHVBWVpNZzRKSzlVTWhDMGpIVTJKWWlxdTA?resourcekey=0-E6vNAyoez3WYjb_FuSh9Uw	**Nozzle design**	CLO2	Chalk and Talk PPT,Assignments, Videos	**T1, R2**
14		Function of nozzle – Applications and Types	Function, Application of nozzle				CLO1		
15		Flow through nozzles-Thermodynamic analysis	Analysis of nozzle and velocity calculation				CLO2		
16		Assumptions -Velocity of nozzle at exit-Ideal and actual expansion in nozzle	Friction effecting flow, velocity calculation				CLO2		
17									
18		Velocity coefficient-Condition for maximum discharge-	Velocity coefficient-Condition for maximum discharge-	https://docs.google.com/presentation/d/1D9z9yhvozipiZgPnQn-EdyIN8G-rB6Ws/edit?usp=drive_web&ouid=114809821418212447772&rtpof=true	https://drive.google.com/drive/folders/0B77PUweQZVUwfnhaWDRTaXpPRHhaUU9IWk1BcHVBWVpNZzRKSzlVTWhDMGpIVTJKWWlxdTA?resourcekey=0-E6vNAyoez3WYjb_FuSh9Uw	**Nozzle mass flow calculations**	CLO3	Chalk and Talk PPT, Assignments, Videos	
19		Critical pressure ratio	Critical pressure ratio				CLO2		
20		Criteria to decide nozzle shape	Criteria to decide nozzle shape				CLO1		
21		Super saturated flow, its effects	Various flow through nozzle, super saturation flow				CLO1		
22		Degree of super saturation	Degree of superheating				CLO2		
23		Degree of under cooling - Wilson line	Wilson line, undercooling				CLO2		

24	III	**Steam Turbines:** Classification	Working of steam turbine, Types of turbines	https://docs.google.com/presentation/d/1wh1i0wUMgzZEmFQY7axGbUyVPelSMHhx/edit?usp=drive_web&ouid=114809821418212447772&rtpof=true	https://drive.google.com/drive/folders/0B77PUweQZVUwfnhaWDRTaXpPRHhaUU9IWk1BcHVBWVpNZzRKSzlVTWhDMGpIVTJKWWlxdTA?resourcekey=0-E6vNAyoez3WYjb_FuSh9Uw	**steam turbine types**	CLO3	Chalk and Talk PPT, Assignments, Videos	**T1, R2**
25		Impulse turbine; Mechanical details	working principle of impulse turbine, its components				CLO5		
26		Velocity diagram – Effect ofFriction	calculation of power by Velocity diagram – Effect of Friction				CLO4		
27		Power developed, Axial thrust	calculation of power by Velocity diagram – Effect of Friction				CLO4		
MID EXAM-I									
28	III	Blade or diagram efficiency. Condition for maximum efficiency	Calculation of efficiency and maximum condition derivation	https://docs.google.com/presentation/d/1wh1i0wUMgzZEmFQY7axGbUyVPelSMHhx/edit?usp=drive_web&ouid=114809821418212447772&rtpof=true	https://drive.google.com/drive/folders/0B77PUweQZVUwfnhaWDRTaXpPRHhaUU9IWk1BcHVBWVpNZzRKSzlVTWhDMGpIVTJKWWlxdTA?resourcekey=0-E6vNAyoez3WYjb_FuSh9Uw	**Velocity diagram power evaluation**	CLO4		
29		De-Laval Turbine - its features	Delavel turbine working its feature				CLO1		
30		Methods to reduce rotor speed	Compounding and types				CLO5		
31		Velocity compounding and Pressure compounding-	Working of various compounding turbines				CLO2		
32		Velocity and Pressure variation along the flow	flow through turbine				CLO1		
33		Combined velocity diagram for a velocity,compounded impulse turbine.	Combined velocity diagram for a velocity,compounded impulse turbine.				CLO2		

34		**Reaction Turbine:** Mechanical details – Principle of operation, Thermodynamic analysis of a stage	**Reaction Turbine:** Mechanical details – Principle of operation, Thermodynamic analysis of a stage				CLO1		
35		Degree of reaction – Velocity diagram	Calculation of degree of reaction of turbine				CLO4		
36		Parson's reaction turbine – Condition for maximum efficiency	Calculation of efficiency and maximum condition derivation				CLO4		
37	IV	**Steam Condensers** : Requirements of steam condensing plant	Working principle of Steam Condensers: Requirements of steam condensing plant	https://docs.google.com/presentation/d/130oy-6RcsKrE7hU9l8IqyYD8buGCnngq/edit?usp=drive_web&ouid=114809821418212447772&rtpof=true	https://drive.google.com/drive/folders/0B77PUweQZVUwfnhaWDRTaXpPRHhaUU9lWk1BcHVBWVpNZzRKSzlVTWhDMGpIVTJKWWlxdTA?resourcekey=0-E6vNAyoez3WYjb_FuSh9Uw	**Condenser working and types**	CLO1	Chalk and Talk PPT, Assignments, Videos	**T1,T2, R1,3**
38		Classification of condensers	Various types of condensers, its advantages and disadvantages				CLO1		
39		Working principle of different types – Vacuum efficiency and Condenser efficiency	Calculating Vacuum efficiency and Condenser efficiency				CLO4		
40		Air leakage,sources and its affects, Air pump-Cooling water requirement.	Air leakage,sources and its affects, Air pump-Cooling water requirement.				CLO1		

41		**Gas**	Various types				CLO3			
42		Parameters of performance – Actual cycle	Parameters of performance – Actual cycle				CLO4			
43		Regeneration, Inter cooling and Reheating	calculating efficiency of gas turbine of various cycle				CLO3			
44		Closed and Semi-closedcycles – Merits and Demerits	Closed and Semi-closedcycles – Merits and Demerits				CLO1			
45		Combustion chambers and turbines of Gas Turbine Plant- Brief	Combustion chambers and turbines of Gas Turbine Plant- Brief				CLO2			
46	**V**	**Jet Propulsion:** Principle of Operation – Classification of jet propulsive engines	Jet Propulsion: Principle of Operation – Classification of jet propulsive engines	https://docs.google.com/presentation/d/1D9z9yhvozipiZgPnQn-EdyIN8G-rB6Ws/edit#slide=id.p1	https://drive.google.com/drive/folders/0B77PUweQZVUwfnhaWDRTaXpPRHhaUU9IWk1BcHVBWVpNZzRKSzlVTWhDMGpIVTJKWWlxdTA?resourcekey=0-E6vNAyoez3WYjb_FuSh9Uw	**Jet propulsion types and power calculations**	CLO3	Chalk and Talk PPT, Assignments, Videos	**T2, R1**	
47		Working Principleswith schematic diagrams and representation on T-S diagram	Working Principleswith schematic diagrams and representation on T-S diagram				CLO3			
48		Thrust, Thrust Power and Propulsion Efficiency – Turbo jet engines	Calculation of power, thrust, efficiency of jet engines				CLO4			
49		Needs and Demands met by Turbo jet – Schematic Diagram,	Needs and Demands met by Turbo jet – Schematic Diagram,				CLO4			

50		**Turbines:** Simple gas turbine plant – Ideal cycle, essential components	of gas turbines, its working and components						
51		**Rockets:** Application – Working Principle – Classification – Propellant Type	**Rockets:** Application – Working Principle – Classification – Propellant Type				CLO3		
52		Thrust, Propulsive Efficiency – Specific Impulse – Solid and Liquid propellant Rocket Engines	various fuel propellant used in rocket engines, efficiency				CLO4		
53	**I - V**	Revision	Revision of the topics covered	-	-				

QUESTION BANK:
DESCRIPTIVE QUESTIONS:
UNIT-I

S.NO	Question	Blooms Taxonomy Level	Course Outcome
Short Answer Questions-			
1	What are the methods to increase thermal efficiency of Rankine cycle?	**Application**	**2**
2	What are the advantages and disadvantages of regenerative cycles over simple Rankine cycle?	**Application**	**1**
3	What are the advantages and disadvantages of reheat cycle over simple Rankine cycle?	**Application**	**1**
4	What is reheat factor?	**Apply**	**3**
5	Define Rankine efficiency, efficiency ratio and specific steam consumption?	**KNOWLEDGE**	**4**
6	What is Boiler? Explain the working of boiler?	**Application**	**2**
7	What are the mountings and accessories in boilers? Write various mountings and accessories used in boilers?	**Application**	**1**
8	What is boiler draught? Explain various types of drought in boilers?	**Application**	**1**

9	Write a short note on equivalent evaporation? Also write how we can increase the boiler efficiency?	**Apply**	**3**
Long Answer Question			
10	A steam power cycle uses the following cycle. Steam at boiler outlet 150 bar, 550°C with reheat at 40 bar to 550°C condenser at 0.1 bar. Assuming ideal processes estimate the quality of steam at turbine exhaust and cycle efficiency	**understand**	**2**
11	A simple Rankine cycle works between pressures 28bar and 0.06bar. The initial condition of steam is dry saturated. Calculate cycle efficiency, work ratio and specific steam consumption	**understand**	**2**

UNIT-II

S.NO	Question	Blooms Taxonomy Level	Course Outcome
Short Answer Question			
1	What are the various types of nozzles and their function	**knowledge**	**2**
2	Write down the expression for velocity at exit from steam nozzle.	**Application**	**2**
3	Derive the expression for critical pressure ratio in a steam nozzle	**Application**	**1**
Long Answer Question			
4	A steam nozzle supplied a steam at 15 bar and 350°C, and discharges at 1 bar. The divergent portion of nozzle is 80 mm long and throat diameter is 6 mm. Determine the cone angle between divergent portion. Assume 12% of total enthalpy is lost in friction in divergent portion. Also determine the velocity and condition of steam at throat.	**Apply**	**2**
5	A steam nozzle supplied a steam at 15 bar and 350°C, and discharges at 1 bar. The divergent portion of nozzle is 80 mm long and throat diameter is 6 mm. Determine the cone angle between divergent portion. Assume 12% of total enthalpy is lost in friction in divergent portion. Also determine the velocity and condition of steam at throat	**KNOWLEDGE**	**2**
6	Steam at a pressure of 12 bar and dryness fraction 0.6 is discharged through a convergent divergent nozzle to a aback pressure of 0.1 bar. if the power developed is 220 kW.The mass flow rate is 7kg/kwh. Determine Throat pressure	**Application**	**2**

7	Steam at a pressure of 12 bar and dryness fraction 0.6 is discharged through a convergent divergent nozzle to a aback pressure of 0.1 bar. if the power developed is 220 kW.The mass flow rate is 7kg/kwh. Determine Throat pressure	**Application**	**2**

UNIT-III

S.NO	Question	Blooms Taxonomy Level	Course Outcome
Short Answer Question			
1	Differentiate impulse and reaction turbine	**knowledge**	**1**
2	What is meant by compounding of turbines	**Application**	**2**
3	What is meant by compounding of turbines?	**Application**	**2**
Long Answer Question			
4	At a particular stage of reaction steam turbine the mean blade speed is 60 m/s and steam is at a pressure of 350 kN/m^2 and a temperature of 175°C. Fixed and moving blades at this stage have inlet angles of 30° and exit angles are 20°C. Determine, i. The blade height at this stage if the blade height is one-tenth of the mean blade ring diameter and the steam flow is 13.5 kg/s ii. The power developed by a pair of fixed and moving blade rings at this stage	**Apply**	**2**
5	A stage of an impulse turbine has two rows of moving blades separated by a row of fixed guide blades. The moving blades have tip angles of 38° and the blade speed, nozzle and fixed blade angles are designed on the assumption that the velocity of discharge from the nozzle is 540 m/s. The relative velocity of stream drops by 10% during passage through each ring of blades and the final discharge is axial. Determine the blade speed	**Apply**	**3**

6	Steam with absolute velocity of 300 m/s enters the stage of an impulse turbine provided with a single row wheel. The nozzles are inclined at 20° to the plane of wheel and the rotor blades are equiangular. The rotor with mean diameter of 100 cm rotates with speed of 3000 r.p.m. Estimate the power developed in the blade if the axial thrust in the blade is 145 N. It may be assumed that due to friction in the blade passages the kinetic energy due to outgoing relative velocity is only 67% of the kinetic energy due to incoming relative velocity.	**Apply**	**2**
7	The following particulars refer to a two row velocity compounded impulse steam turbine (wheel): Steam velocity at nozzle exit = 600 m/s, Nozzle angle = 160, Mean Blade Velocity = 120 m/s Exit angles: first row of moving blades = 18°, fixed guide blade = 220, second row of moving blades = 36°, Steam flow rate = 5 kg/s, Blade friction coefficient = 0.85 Determine: (i) the tangential thrust (ii) the axial thrust (iii) the power developed and (iv) the diagram efficiency.	**Apply**	**3**

UNIT-IV

S.NO	Question	Blooms Taxonomy Level	Course Outcome
Short Answer Question			
1	Give the basic concepts of gas turbine unit on block diagram, PV diagram and TS diagram	**knowledge**	**1**
2	What are advantages of closed cycle gas turbine over the open cycle?	**Application**	**2**

3	In a simple gas turbine plant air enters the compressor at 1 bar and 27°C and leaves at 6 bar. It is then heated in the combustion chamber to 700°C then enters in the turbine and expands to 1 bar. The isentropic efficiency of compressor and turbine are 80% and 85% respectively and combustion efficiency is 98%. The pressure drop in the combustion chamber is 0.1 bar. Determine, (i) Thermal efficiency (ii) Work ratio (iii) Specific fuel consumption (iv) Air fuel ratio	**Application**	**2**
Long Answer Question			
4	Explain the method INTER COOLING employed to increase the specific output and thermal efficiency of Gas Turbine plant? Draw the T-S diagram for the same	**understand**	**2**
5	Exhaust steam having a dryness fraction of 0.82 enters a surface condenser where the vacuum is 690 mm of Hg and is condensed to water at 34.8°C. The temperature of the hot well is 31.6°C. The circulating water enters the condenser at 14°C and leaves at 34°C. The barometric pressure is 756 mm of Hg. Calculate, the mass of circulating water required per kg of steam.	**knowledge**	**3**
6	What are the sources of air leakages into a condenser? Explain the affects of air leakage on the performance of a condenser	**Application**	**3**
7	What is the effect of thermal efficiency of open cycle Gas Turbine with the following operating variables (i)Pressure ratio ii)Turbine inlet temperature iii)Compressor inlet temperature	**Application**	**2**

	iv)Efficiency of the turbine v)Efficiency of compressor		

UNIT-V

S.NO	Question	Blooms Taxonomy Level	Course Outcome
1	Define propulsive efficiency	**knowledge**	**1**
2	Differentiate shaft propulsion and Jet propulsion	**Application**	**3**
3	Explain specific thrust as applied to jet engines?	**Application**	**3**
4	A turbo-jet has a speed of 750 km/hr, while flying at an altitude of 10000 m. The propulsive efficiency of the jet is 50% and the overall efficiency of the turbine plant is 16%. The density of air at 10000 m altitude is 0.173 kg/m^3. The drag of the plant is 6250N. The calorific value of the fuel is 48, 000 kJ/kg. Calculate, i. Absolute velocity of the jet ii. Volume of air compressed per minute iii. Diameter of the jet	**Apply**	**2**
5	A turbojet engine flying at a speed of 960km/hour consumes air at the rate of 54.5kg/sec. Calculate i) exit velocity of the jet when the enthalpy change for the nozzle is 200Kj/kg and velocity co-efficient is 0.97. ii) Fuel flow rate in kg/sec, when air fuel ratio is 75:1.	**understand**	**2**
6	Turbojet aircraft is flying at a speed of 287m/sec, where the ambient conditions are A 0.5bar and 200C. The compressor pressure ratio is 8.The maximum cycle temperature is not to exceed 1250K, with fuel of calorific	**understand**	**2**

	value of 44000kJ/kg. The pressure loss in the combustion chamber is 0.1bar. The various efficiencies are listed as : Ram air efficiency is 90%, Isentrophic efficiency of compressor and turbine are 85% and 80%respectively. Combustion efficiency is 98%, nozzle efficiency is 90%. If the outlet area of the nozzle is 0.1m2. Determine the mass flow rate, the thrust developed and specific fuel consumption		
7	For the above problem also calculate i) thrust specific fuel consumption ii) Thermal efficiency of the plant when the combustion efficiency is 90 % and calorific value of the fuel is 45000 kJ/kg. iii) Propulsive power and efficiency	**understand**	**2**

OBJECTIVE QUESTIONS:

JNTUH:

UNIT-1

1. Steam power plants work on _____ cycle.
2. Regenerator _____ the efficiency of the Rankine cycle.
3. For the Analysis of Flue/Exhaust gas _____ is used.
4. 1 Kg of Carbon produces _____ kg of Carbon-dioxide for complete combustion.
5. Air contains _____% of Oxygen on weight basis
6. The efficiency of the steam power plant is about

(a) 30% (b) 45% (c) 60% (d) 100%

7. Rankine cycle efficiency of a good steam power plant may be in the range of:

(*a*) 15 to 20% (*b*) 35 to 45%

(*c*) 70 to 80% (*d*) 90 to 95%

8**.** Rankine cycle operating on low pressure limit of $p1$ and high pressure limit of $p2$

(*a*) has higher thermal efficiency than the Carnot cycle operating between same pressure limits

(*b*) has lower thermal efficiency than Carnot cycle operating between same pressure limits

(*c*) has same thermal efficiency as Carnot cycle operating between same pressure limits

(*d*) may be more or less depending upon the magnitudes of $p1$ and $p2$.

9**.** Rankine efficiency of a steam power plant

(*a*) improves in summer as compared to that in winter

(*b*) improves in winter as compared to that in summer

(*c*) is unaffected by climatic conditions

(*d*) none of the above.

10**.** Rankine cycle comprises of _____.

UNIT-II

1. Benson Boiler produces steam at a rate of

(a) 100 kg/hr (b) 10000 kg/hr (c) 135 ton/hr (d) 10 kg/hr

2. The working pressure of Cornish boiler compared to Lancashire boiler is

(a) same (b) high (c) low (d) medium

3. Stack refers to a chimney which is made of

(a) masonary structure (b) concrete structure (c) metal (d) wood

4. The condition for maximum discharge through a chimney is that height of the chimney should be:

(a) two times the height of the column of the hot gases producing draught

(b) equal to the height of the column of hot gases producing draught

(c) half the height of the column of hot gases producing draught

(d) One and half the height of the column of hot gases producing draught

5. Which safety valve should be used to for portable boilers?

(a) dead weight safety valve (b) spring loaded safety valve

(c) lever safety valve (d) high steam and low water safety valve

6. Which safety valve should be used in portable boilers?

(a) dead weight safety valve (b) spring loaded safety valve

(c) lever safety valve (d) high steam and low water safety valve

7. The mechanical draught produced is _____ than natural draught.

8. A Super heater is used to heat _____.

9. A Heater where circulating water flows through tubes which are surrounded by steam is known as

(a) Closed heater (b) Open heater (c) contact type heater (d) none

10. The function of fusible plug in a boiler is _____.

11. The height of the chimney in a steam power plant is governed mainly by _____.

12. The dryness fraction in the case of gas nozzles is

(a 0 (b) 0.5 (c) 1 (d) 1.

13. Critical pressure ratio for steam flow through the nozzle is given by the expression _____.

14. The frictional losses in the nozzle:

(a) reduces the final dryness fraction of the steam

(b) increases the final dryness fraction of the steam

(c) has no effect on the final dryness fraction of the steam

(d) none of the above

15. Critical pressure ratio for super heated steam flow through a nozzle is:

(a) 0.5457 (b) 0.578 (c) 0.582 (d) 0.565

16. The exit velocity of the steam in a nozzle when inlet velocity is neglected is given by the expression _____

17. Mach number is defined as _____.

UNIT-III

1. A rateau turbine is a:

(a) Velocity compounded impulse turbine (b) Pressure compounded impulse turbine
(c) Velocity compounded reaction turbine (d) Pressure compounded reaction turbine

2. The efficiency of velocity compounded steam turbine as compared to pressure compounded steam turbine is
(a) Less (b) more (c) same (d) not comparable

3. The expression to calculate the axial force on the wheel of an impulse turbine is given by _____.

4. Condition for maximum efficiency of jet condenser is _____.

5. De-Lavel turbine has _____ number of Impulse wheels.

6. Parson's turbine is _____ turbine.

7. Condition for maximum efficiency of a reaction steam turbine _____.

8. Condition for maximum efficiency of impulse steam turbine _____.

9. Velocity compounding is adopted in _____ turbine.

10. Pressure compounding is used in _____ turbine.

11. Pressure velocity compounding is used in_____ turbine.

12. Function of condenser _____ in steam power plant.

13. Which of the following is a type of direct type of condenser?
A) Spray condenser B) Surface condenser C) Water condenser D) Indirect condenser

14. Barometric condenser is _____ type of condenser.

15. Which one of the following condenser type is more efficient?
A) Surface condenser B) Direct type condenser C) Both are equally good D) None of these

UNIT IV

1. Thermal efficiency of closed cycle gas turbine plant increases by
(*a*) Reheating (*b*) intercooling (*c*) Regenerator (*d*) all of the above.

2. With the increase in pressure ratio thermal efficiency of a simple gas turbine plant with fixed turbine inlet temperature
(*a*) Decreases (*b*) increases (*c*) first increases and then decreases (*d*) first decreases and then increases.

3. The thermal efficiency of a gas turbine cycle with ideal regenerative heat exchanger is
(*a*) Equal to work ratio (*b*) is less than work ratio
(*c*) Is more than work ratio (*d*) un-predictable

4. In a two stage gas turbine plant reheating after first stage
(*a*) Decreases thermal efficiency (*b*) increases thermal efficiency
(*c*) does not effect thermal efficiency (*d*) none of the above.

5. In a two stage gas turbine plant, reheating after first stage
(*a*) increases work ratio (*b*) decreases work ratio
(*c*) does not affect work ratio (*d*) none of the above.

6. In a two stage gas turbine plant, with inter-cooling and reheating
(*a*) both work ratio and thermal efficiency improve
(*b*) work ratio improves but thermal efficiency decreases
(*c*) thermal efficiency improves but work ratio decreases
(*d*) both work ratio and thermal efficiency decrease

UNIT-V

1. For a jet propulsion unit, ideally the compressor work and turbine work are:
   (a) equal (*b*) unequal (*c*) not related to each other (*d*) unpredictable.
2. The expression for propulsion efficiently of a Rocket engine use _____.
3. Difference between solid and liquid propellant Rocket engines is _____.
4. Formula for Thrust power of Jet Engine is _____.
5. The principle of jet propulsion is _____.
6. Non-self-propelled airborne explosive devices are generally referred to as shells and usually have a _____ than missiles.
7. A rocket is a missile, spacecraft, aircraft or other vehicle that obtains _____ from rocket engine.
8. Rockets are relatively lightweight and powerful, capable of generating large accelerations and of attaining extremely _____ with reasonable efficiency.
9. A ramjet is also referred to as: A. Pipe jet B. stove pipe jet C. ramjet D. scramjet
10. Ram jet engine consists of intakes, combustor and _____.
    A. nozzle B. jet exhaust C. exhaust D. turbine
11. Rockets combine liquid fuel with _____ to generate thrust.
    (a) liquid nitrogen (b) liquid oxygen (c) liquid hydrazine (d) none
12. A _____ is a type of aircraft engine combining elements of a jet engine and a rocket.
13. The rocket performance is affected by _____.

GATE OBJECTIVE:

1. Consider the following statements regarding a 100% reaction turbine: 1. Change in absolute velocity of steam across the moving blades is zero. 2. Change in absolute velocity of steam across the moving blades is negative. 3. Enthalpy drop in fixed blades is zero. Which of these statements is /are correct?
   a. 1 alone b. 2 alone c. 2 and 3 d. 1 and 3
2. Which one of the following pairs is NOT correctly matched?
   a. Internal efficiency of steam turbine: Product of stage efficiency and reheat factor
   b. Stage efficiency of a turbine: Ratio of adiabatic heat drop to the isentropic heat drop per stage
   c. Dryness fraction of a steam within a stage. : Decreases due to reheating
   d. Steam condensation during expansion through the turbine: Enhances blade erosion
3. Consider the following statements: For supersaturated flow through a steam nozzle, the:
   1. enthalpy drop reduces further
   2. exit temperature increases
   3. flow rate increases
   Which of these statements are correct? a. 1, 2 and 3 b. 1 and 2 c. 2 and 3 d. 1 and 3
4. A gas turbine plant working on Joule cycle produces 4000 kW of power. If its work ratio is 40%, what is the power consumed by the compressor?
   a. 2000 Kw b. 4000 kW c. 6000 kW d. 8000 Kw
5. Consider the following statements in respect of gas turbines: A gas turbine plant with reheater leads to a

1. Considerable improvement in the work output.
2. Considerable improvement in the thermal efficiency.

Which of the statements given above is/are correct?

a. 1 only b. 2 only c. Both 1 and 2 d. Neither 1 nor 2

6. Which one of the following is correct? For the same net power output: a. the turbine used in gas turbine power plants is larger than that used in steam power plants b. the turbine used in gas turbine power plants is smaller than that used in steam power plants c. the same turbine can be used for both plants d. None of the above
7. Which one of the following is the correct statement? Performance of mechanical draft cooling tower is superior to natural draft with: a. increase in air wet bulb temperature b. decrease in air wet bulb temperature c. increase in dry bulb temperature d. increase in recirculation of air
8. Which one of the following fittings is mounted on the boiler to put off the fire in the furnace, when water level falls to an unsafe limit? a. Feed check valve b. Safety valve c. Fusible plug d. Blow off cock
9. The combustion analysis carried out by the Orsat Apparatus renders which one of the following? a. The percentage composition by weight on the dry basis b. The percentage composition by volume on the dry basis c. The percentage composition by weight on the wet basis d. The percentage composition by volume on the wet basis
10. Which one of the following boiler accessories does not need 'flue-gas' for its operation? a. Economizer b. Preheater c. Injector d. Super heater
11. Consider the following: 1. Super heater 2. Economizer 3. Air pre-heater 4. Condenser. Which of the above improve overall steam power plant efficiency? a. Only 1, 2 and 3 b. Only 2 and 3 c. Only 1 and 4 d. 1, 2, 3 and 4
12. In a steam nozzle, to increase the velocity of steam above sonic velocity by expanding steam below critical pressure a. A vacuum pump is added b. Ring diffusers are used c. Divergent portion of the nozzle is necessary d. Abrupt change in cross-section is needed
13. Consider the following: 1. Injector 2. Economizer 3. Blow-off cock 4. Steam stop valve Which of the above is/are not boiler mountings? a. Only 1 b. Only 1 and 2 c. 1, 2 and 3 d. 2 and 4
14. Wilson line is associated with which one of the following? a. Total steam consumption with respect to power output b. Supersonic flow o steam through a nozzle c. Nozzle flow with friction d. Supersaturated flow of steam through a nozzle
15. When is the greatest economy obtained in a regenerative feed heating cycle? a. Steam, is extracted from only one suitable point of a steam turbine b. Steam is extracted only from the last stage of a steam turbine c. Steam is extracted only from the first stage of a steam turbine d. Steam is extracted from several places in different stages of steam turbines
16. In a reaction turbine the enthalpy drop in a stage is 60 units. The enthalpy drop in the moving blades is 32 units. What is the degree of reaction? a. 0.533 b. 0.284 c. 0.466 d. 1.875
17. If the cross-section of a nozzle is increasing in the direction of flow in supersonic flow then in the downstream direction: a. Both pressure and velocity will increase b. Both

pressure and velocity will decrease c. Pressure will increase but velocity will decrease d. Pressure will decrease but velocity will increase

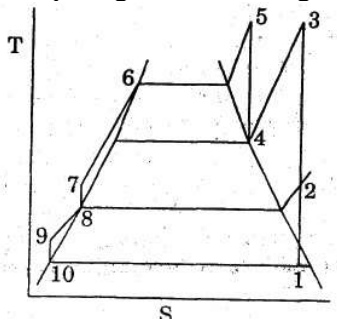
18. Which one of the following is the correct statement? To get supersonic velocity of steam at nozzle exit with a large pressure drop across it, the duct must: a. converge from inlet to exit b. diverge from inlet to exit c. first converge to the throat and then diverge till exit d. remain constant in cross-section
19. A 4-row velocity compounded steam turbine develops total 6400 kW. What is the power developed by the last row? a. 200 kW b. 400 kW c. 800 kW d. 1600 kW
20. Which one of the following is the fire-tube boiler? a. Babcock and Wilcox boiler b. Locomotive boiler c. Sterling boiler d. Benson boiler
21. Consider the following statements: 1. The speed of rotation of the moving elements of gas turbines is much higher than those of steam turbines. 2. Gas turbine plants. are heavier and larger in size than steam turbine plants. 3. Gas turbines require cooling water for its operations. 4. Almost any kind of fuel can be used with gas turbines. Which of the statements given above are correct? a. 1 and 2 b. 1 and 3 c. 1 and 4 d. 3 and 4
22. Consider the following statements regarding waste heat boilers: 1. Waste--heat boilers placed in the path of exhaust gases. 2. These are fire tube boilers. 3. The greater portion of the heat transfer in such boilers is due to convection. Which of the statements given above are correct? a. 1, 2 and 3 b. 1 and 2 c. 2 and 3 d. 1 and 3
23. The air with enthalpy of 100 kJ/kg is compressed by an air compressor to a pressure and Y temperature at which its enthalpy becomes 200 kJ/kg. The loss of heat is 40 kJ/kg from the compressor as the air passes through it. Neglecting kinetic and potential energies, the power required for an air mass flow of 0.5 kJ/s is: a. 30 kW b. 50 kW c. 70 kW d. 90 kW
24. In which one of the following working substances, does the relation T2 / T1 = (p2 / p1) 0.286 hold good if the process takes place with zero heat transfer? a. Wet steam b. Superheat steam c. Petrol vapour and air mixture d. Air
25. When dry saturated steam is throttled from a higher pressure to a lower pressure, the ____. a. pressure decreases and the volume increases. b. temperature decreases and the steam becomes superheated. c. temperature and the dryness fraction increase. d. entropy increases without any change in enthalpy
26. In turbo prop, the expansion of gases takes place approximately: a. 100% in the turbine b. 80% in the turbine and 20% in the nozzle c. 50% in the turbine and 50% in the nozzle d. 100% in the nozzle
27. Assertion (A): With the help of a Bomb calorimeter, the lower calorific value of a solid or liquid fuel can be determined, as the water vapour formed is carried away by the exhaust gases. Reason (R): The lower calorific value of a fuel is the net value of heat available found by subtracting the latent head of the water formed and carried away by exhaust gas from the higher calorific value. a. Both A and R are true and R is the correct explanation of A b. Both A and R are true but R is NOT the correct explanation of A c. A is true but R is false d. A is false but R is true
28. Partial admission steam turbine refers to the situation where: a. steam is admitted partially into the blades through nozzles b. nozzles occupy the complete circumference

leading into the blade annulus c. nozzles do not occupy the complete circumference leading into the blade annulus d. steam is admitted partially into the blades directly

29. Assertion (A): Reaction blading is commonly used in intermediate and low pressure parts of steam turbines. Reason (R): Reaction blading gives higher efficiency than impulse blading. a. Both A and R are true and R is the correct explanation of A b. Both A and R are true but R is NOT the correct explanation of A c. A is true but R is false d. A is false but R is true
30. Consider the following statements: For supersaturated flow through a steam nozzle, the: 1. enthalpy drop reduces further 2. exit temperature increases 3. flow rate increases Which of these statements are correct? a. 1, 2 and 3 b. 1 and 2 c. 2 and 3 d. 1 and 3
31. The efficiency of a simple gas turbine can be improved by using a regenerator, because the: a. work of compression is reduced b. heat required to be supplied is reduced c. work output of the turbine is increased d. heat rejected is increased
32. Which of the following statement(s) is/are relevant to critical flow through a steam nozzle? 1. Flow rate through the nozzle is minimum. 2. Flow rate through the nozzle is maximum 3. Velocity at the throat is supersonic. 4. Velocity at the throat is sonic. Select the correct answer using the codes given below: a. 1 alone b. 1 and 3 c. 2 and 4 d. 4 alone
33. Stoichiometric air-fuel ratio by volume for combustion of methane in air is: a. 15:1 b. 17.16:1 c. 9.52:1 d. 10.58:1
34. The main advantage of a reheat Rankine cycle is: a. Reduced moisture content in L.P. side of turbine b. Increase efficiency c. Reduced load on condenser d. Reduced load on pump
35. Consider the following statements: 1. For the combustion of pulverized coal. 5 to 10% excess air is required. 2. Air contains 21% oxygen by weight. 3. The flue gases from a coal-fired furnace contain around 70% nitrogen by volume. 4. In the combustion of liquid fuels, the number of moles of the reactants. Of these statements, a. 1, 2 and 4 are correct b. 1, 3 and 4 are correct c. 2, 3 and 4 are correct d. 1 and 3 are correct
36. Which of the following statements is/are true in case of one-dimensional flow of perfect gas through a converging diverging nozzle? 1. The exit velocity is always supersonic. 2. the exit velocity can be subsonic or supersonic. 3. If the flow is isentropic, the exit velocity must be supersonic. 4. If the exit velocity is supersonic, the flow must be isentropic. Select the correct answer using the codes given below: a. 2 and 4 b. 2, 3 and 4 c. 1, 3 and 4 d. 2 alone
37. Slowing down of boiler water is the process to: a. Reduce the boiler pressure b. Increase the steam temperature c. Control the solids concentration in the boiler water
38. A device which is used to drain off water from steam pipes without escape of steam is called a. Steam separator b. Steam trap c. Pressure reducing valve d. Injector
39. With increase of pressure, the latent heat of stream a. Remains same b. Increases c. Decreases d. Behaves unpredictably
40. Consider the following statements regarding the throttling process of wet steam: 1. The steam pressure and temperature decrease but enthalpy remains constant. 2. The steam pressure decreases, the temperature increases but entropy remains constant. 3. The entropy, specific volume, and dryness frication increases. 4. The entropy increases but

the volume and dryness fraction decreases. Which of the above statements are correct? a. 1 and 4 b. 2 and 3 c. 1 and 4 d. 2 and 4

41. Consider the following statements in relation to a convergent-divergent steam nozzle operating under choked conditions: 1. In the convergent portion steam velocity is less than sonic velocity. 2. In the convergent portion steam velocity is greater than sonic velocity. 3. In the divergent portion the steam velocity is less than sonic velocity. 4. In the divergent portion the steam velocity is greater than sonic velocity. Which of the above statements are correct? a. 1 and 3 b. 1 and 4 c. 2 and 3 d. 2 and 4
42. Match List I (Components) with List II (Functions) and select the correct answer: List I: A. Steam trap B. Fusible plug C. Blow-off cock D. Feed check valve. List II: 1. Controls steam flow rate 2. Controls rate of water flow to boiler 3. Puts off furnace fire when water level reaches unsafe limit 4. Removes mud and dirt collected at the bottom of boiler 5. Drains off water collected by partial condensation of steam in pipes. Codes: ABCD respectively linked to a. 5 1 4 2 b. 1 3 5 4 c. 5 3 4 2 d. 1 2 5 4
43. 10 kg of water is heated from 300 K to 350 K in an insulated tank due to churning action by a stirrer. The ambient temperature is 300 K. In this context, match List I with list II and select the correct answer: List I: A. Enthalpy change B. Entropy change / kg C. Availability / kg D. Loss of availability. List II: 1. 12.2 kJ/kg 2. 1968 kJ 3. 2090 kJ 4. 656 J /kg – K. Codes: A B C D a. 3 1 4 2 b. 2 4 1 3 c. 3 4 1 2 d. 2 1 4 3
44. Match List I with List II and select the correct answer: List I (Type of Coal): A. Lignite B. Anthracite C. Bituminous D. Coke List II (Coal properties): 1. Artificial fuel derived from coal 2. Contains inflammable gas (volatile matter) and burns with flame 3. Very hard and high heating value 4. High ash content and less volatile matter. Codes: A B C D a. 2 3 4 1 b. 4 1 2 3 c. 2 1 4 3 d. 4 3 2 1
45. For maximum discharge through a convergent nozzle the pressure ratio p2/p1 should be (where n is the isentropic expansion index): (a) $\left(\frac{n}{n+1}\right)^{\frac{2}{n+1}}$ (b) $\left(\frac{2}{n+1}\right)^{\frac{n}{n-1}}$ (c) $\left(\frac{n+1}{2}\right)^{\frac{n}{n-1}}$ (d) $\left(\frac{2}{n+1}\right)^{\frac{n}{n+1}}$
46. The temperature-entropy diagram for a steam turbine power plant, operating on the Rankine cycle with reheat and regenerative feed heating is shown in the given figure. If m denotes the fraction of steam bled for feed heating, the work developed in the turbine per kg steam entering the turbine at state 5 is:



a. (h5 – h4) + (1 – m) (h3 – h1)
b. (h5 – h4) + (h3 – h2) + (1 – m) (h2 – h1)
c. 2h5 – h4 – h1 + (1 – m) (h2 – h1)
d. (h5 – h4) + (1 – m) (h3 – h2)

IES OBJECTIVE:

1. For maximum discharge of hot gases through a chimney, the height of hot column producing draught is: (a) Twice the height of chimney (b) Equal to the height of chimney (c) Half the height of chimney (d) None of the above
2. Considering the flow of steam through a convergent-Divergent nozzle under real conditions, where super saturation occurs, the difference between the saturation temperature corresponding to the pressure and the supersaturated temperature is defined as degree of (a) Under cooling (b) Superheat (c) Reaction (d) Saturation
3. The optimum ratio of blade speed to tangential component of jet speed for the deLaval and Parsons turbine are (a) 1 for both (b) 1/2 for de Laval turbine and 1 for Parsons turbines (c) 1 for de Laval turbine and 1/2 for Parsons turbine (d) 1/2 for both
4. When a converging–diverging nozzle is operated at off–design conditions, a normal shock forms in the diverging portion. The nozzle can be assumed to be perfectly insulated from the surroundings. Then across the shock: (A) The velocity undergoes a jump but pressure and entropy remain unchanged (B) The pressure undergoes a jump but velocity and entropy remain unchanged (C) The velocity and pressure undergo a jump, but entropy remains unchanged because there is no heat transfer (D) Velocity, pressure and entropy all undergo a jump
5. In a two stage gas turbine plant, with inter cooling and reheating: (A) Both work ratio and thermal efficiency increase (B) Work ratio increases but thermal efficiency decreases (C) Thermal efficiency increases but work ratio decreases (D) Both work ratio and thermal efficiency decrease
6. A converging–diverging nozzle is operated at a pressure difference which is not the design value for isentropic flow. As a consequence a normal shock is formed in the diverging portion. In this situation the Mach number at the throat is: (A) Less than 1 (B) More that 1 (C) Exactly 1 (D) Could be less or more than 1 depending on the pressure difference
7. The air pre–heater of a boiler is located between: (A) Forced draft fan and furnace (B) Furnace and economizer (C) Economizer and chimney (D) Super heater and furnace
8. A super critical boiler requires: (A) Only pre heater and super heater (B) Pre heater, evaporator and super heater (C) Only pre heater (D) Only super heater
9. The correct sequence of location of equipment in the flue gas path from furnace exit up to chimney is: (A) Super heater, economizer, air heater, electrostatic precipitator and induced draft fans (B) Super heater, economizer, electrostatic precipitator, induced draft fans and air heater (C) Super heater, electrostatic precipitator, economizer, air heater and induced draft fans (D) Super heater, electrostatic precipitator, induced draft fans, economizer and air heater
10. The main advantage of the water tube boiler over the fire–tube boiler is: (A) The water tube boiler can operate safely at higher pressure (B) Soot deposition in the tubes is avoided (C) Corrosion of the tubes is less (D) Fouling of the tubes is reduced
11. A super critical boiler consists of only economizer and super heater and it does not have an evaporator because: (A) Water temperature can be raised to critical temperature in the economizer itself (B) High evaporation rate is achieved through forced circulation of water through tubes (C) Enthalpy of evaporation becomes zero at critical pressure or above that (D) Flue gas used to run rotary compressor supply high pressure air to the furnace
12. The effect of considering friction in steam nozzle for the same pressure ratio leads to: (A) Increase in dryness fraction of exit steam (B) Decrease in dryness fraction of exit steam (C) No change in the quality of exit steam (D) Decrease or increase of dryness fraction of exit steam depending upon inlet quality
13. In a half–degree reaction Parson's turbine, operating at design conditions, the enthalpy drop of steam in one stage of the turbine occurs: (A) Entirely in the fixed blades (B) Entirely in the moving blades (C) Half in the fixed blades and half in the moving blades (D) None of the above

14. Frictional losses in the nozzle: (A) reduces the enthalpy of the fluid (B) increases the enthalpy of the fluid (C) no effect on enthalpy of the fluid (D) none of the above
15. In a nozzle designed for maximum discharge conditions, the flow velocity in the convergent section of the nozzle is: (A) Subsonic (B) Sonic (C) Supersonic (D) Depends on initial pressure and condition of steam
16. The thermal efficiency of a simple open gas turbine plant is improved by regeneration as this: (A) Decreases the temperature of the gases at the turbine inlet (B) Decreases the quantity of heat supplied in combustion chamber (C) Increases the turbine output (D) Lowers the work input to compressor
17. Consider a gas turbine supplied with gas at 1000 K and 5 bar to expand adiabatically to a 1 bar. The mean specific heat at constant pressure is 1.0425 kJ/kgK and constant volume is 0.7662 kJ/kgK. Calculate power developed in kW/kg of gas per second and exhaust gas temperature: (A) 462 kW/kg and 647 K (B) 362 kW/kg and 653 K (C) 462. KW/kg and 653 K (D) 362 kW/kg and 647 K
18. If absolute jet exit velocity from a jet engine if 2800 m/s and forward flight velocity is 1400 m/s, then propulsive efficiency is: (A) 33.33% (B) 40% (C) 66.66% (D) 90%
19. An air-breathing aircraft is flying at an altitude where the air density is half the value at ground level. With reference to the ground level, the air fuel ratio at this altitude will be: (A) ½ (B) 1 (C) 2 (D) 4
20. A gas turbine operating on Brayton cycle has the maximum temperature of 1200K and the minimum temperature of 300K. The cycle efficiency for the maximum work capacity will be: (A) 75% (B) 60% (C) 50% (D) 25%.
21. Supersaturated condition occurs in a steam expanding through a convergent-divergent nozzle because of the delay in: (A) change of dryness fraction (B) Change of superheat (C) evaporation process (D) condensation process
22. In a nozzle designed to produce a supersonic jet, the flow in the convergent section will always be: (A) subsonic (B) sonic (C) supersonic (D) transonic
23. In an impulse steam turbine, the enthalpy drop of steam takes place in: (A) nozzles (B) rotor blades (C) stator blades (D) exhaust pipe
24. The gas in a cooling chamber of a closed-cycle gas turbine is cooled at: (A) constant volume (B) constant temperature (C) constant pressure (D) None of the above.
25. In a gas turbine power plant, reheating of gases between the high pressure and low pressure turbine stages will: (A) improve turbine output (B) decrease turbine output (C) increase compressor output (D) decrease compressor work
26. In a gas turbine plant, regeneration is done to: (A) increase compression work (B) decrease turbine work (C) limit the maximum temperature (D) improve plant efficiency
27. Turbo prop-engine has the following additional feature over the turbojet: (A) Propeller (B) Diffuser (C) Starting engine (D) Turbine and combustion chamber
28. In modern steam generator, the correct path of gases from boiler furnace to chimney is: (A) Boiler furnace, Economizer, Air pre heater, Super heater and Chimney (B) Boiler furnace, Super heater, Air pre heater, Economizer and Chimney (C) Boiler furnace, Air pre heater, Super heater, Economizer and Chimney (D) Boiler furnace, Super heater, Economizer, Air pre heater and Chimney
29. In a locomotive boiler, the draught is produced by: (A) Chimney (B) ID fan (C) FD fan (D) Steam jet
30. Out of the following impurities generally found in water, which one requires special consideration in case of very high pressure boilers? (A) Hydrogen (B) Ammonia (C) Silica (D) Dissolved salts

31. Willans line represents: (A) Total steam consumption vs. power output with throttle governing (B) Total steam consumption vs. power output with cutoff governing (C) Behaviour of supersaturated steam through nozzles (D) Condensation of steam while flowing through the turbine
32. An isentropic nozzle is discharging steam through critical pressure ratio. If the back pressure is further decreased, the discharge will: (A) Decrease (B) Increase (C) Remain unaffected (D) Come to a dead stop due to shock waves
33. Pertaining to a steam boiler, which of the following statements is correct? (A) Primary boiler heat transfer surface includes evaporator section, economizer and air pre-heater (B) Primary boiler heat transfer surface includes evaporator section, economizer and super heater section (C) Secondary boiler heat transfer surface includes super heater, economizer and air preheater (D) Primary boiler heat transfer surface includes evaporator section, superheater section and reheat section
34. The function of economizer in a boiler is to: (A) Superheat the steam (B) Reduce fuel consumption (C) Increase steam pressure (D) Maintain saturation temperature
35. In rocket propulsion, the oxygen for combustion of its fuel is taken from: (A) Surrounding air (B) The rocket itself (C) Compressed atmospheric air (D) Surrounding air and compressed atmospheric air
36. In which modification of simple gas turbine cycle, is work ratio increased? (1) Regenerative gas turbine cycle (2) Gas turbine cycle with reheating (A) Both 1 and 2 (B) 1 only (C) 2 only (D) Neither 1 nor 2
37. Reheat between multi-stage expansions in Joule cycle increases (1) Overall work output (2) The work ratio (3) The thermal efficiency Which of the above are correct? 1, 2 and 3 (B) 1 and 2 only (C) 2 and 3 only (D) 1 and 3 only
38. Without reducing the fluid flow rate, the speed of an impulse steam turbine can be brought down to practical limits by which of the following methods? (1) Large flywheel (2) Centrifugal governor (3) Velocity compounding (4) Steam bleeding (A) 1, 2 and 3 (B) 2, 3 and 4 (C) 2 only (D) 3 only
39. Reheating of steam in a steam power plant: 1. Increases the cycle efficiency 2. Reduces the turbine speed 3. Reduces blade erosion 4. Increases specific output. Which of the above statements are correct? (A) 1, 2, 3 and 4 (B) 1, 2 and 3 only (C) 2 and 4 only (D) 1, 3 and 4 only
40. Consider the following statements with regard to steam turbines: 1. A single stage impulse turbine has a nozzle angle α. The maximum blade efficiency of the turbine will be $\cos^2\alpha$. 2. For a reaction steam turbine with identical stator and rotor blades, the blade velocity for maximum blade efficiency is equal to inlet steam velocity 3. Velocity compounded impulse steam turbine gives less speed and less efficiency. Which of the above statements are correct? (a) 1 and 2 only (b) 1 and 3 only (c) 2 and 3 only (d) 1, 2 and 3

41. The efficiency of the vapour power Rankine cycle can be increased by 1. Increasing the temperature of the working fluid at which heat is added 2. Increasing the pressure of the working fluid at which heat is added 3. Decreasing the temperature of the working fluid at which heat is rejected. Which of the above statements are correct? (a) 1 and 2 only (b) 1 and 3 only (c) 2 and 3 only (d) 1, 2 and 3
42. Consider the following statements: Isentropic flow through a steam nozzle becomes “choked” when 1. Discharge is maximum 2. Discharge is zero 3. Nozzle pressure ratio is critical pressure ratio less than one 4. Throat velocity reaches sonic value. Which of these statements are correct? (A) 1, 2, 3 and 4 (B) 1, 2 and 3 only (C) 2, 3 and 4 only (D) 1, 3 and 4 only

43. Which of the following statements are correct for turbo-prop powered aircrafts? 1. The propulsion efficiency of turboprop is higher than that of turbo-jet and rockets for low speeds up to about 800 km/hr. 2. For the same thrust the turbine in the turbo-prop aircraft is smaller than in the turbo-jet aircraft 3. For the turbo-prop the flight velocity cannot exceed the jet velocity. (A) 1, 2 and 3 (B) 1 and 2 only (C) 2 and 3 only (D) 1 and 3 only
44. Which of the following statements are correct for rockets? 1. Unlike the turbo-jet aircraft, in rockets the flight velocity can exceed the jet velocity 2. In rockets gases having lower molecular weight increase the specific thrust 3. In rockets the gases are expanded in the nozzle up to the atmosphere pressure. (A) 1, 2 and 3 (B) 1 and 2 only (C) 2 and 3 only (D) 1 and 3 only
45. Consider the following statements: For a velocity-compounded impulse steam turbine stage having two rows of moving blades: 1. The work done in each row of moving blades is equal 2. The efficiency of a velocity-compounded stage is less than that of a pressure-compounded stage 3. The velocity-compounded stage is often used in the first stage of a multistage impulse turbine. Which of the above statements is/are correct? 1 and 3 only (B) 2 only (C) 2 and 3 only (D) 1, 2 and 3

Directions: Each of the next eight (8) items consists of two statements, one labeled as the 'Assertion (A)' and the other as 'Reason (R)'. You are to examine these two statements carefully and select the answers to these items using the codes given below:

Codes:

(A) Both A and R are individually true and R is the correct explanation of A
(B) Both A and R are individually true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

46. **Assertion (A):** In stream turbines, super saturated flow means that the vapour does not condense immediately as it crosses the dry saturated line. **Reason (R):** The mass flow with super saturation flow is greater than the mass flow with isentropic flow.
47. **Assertion (A):** In a modern coal burning steam generator the temperature of exiting flue gases from the chimney should be below 100C. **Reason (R):** The lower the temperature of exiting flue gases from the chimney higher is the heat recovery and therefore higher the efficiency of the steam generator.
48. **Assertion (A):** A major shortcoming of a fire-tube boiler is that the maximum size of the unit and the maximum operating pressure are limited. **Reason (R):** Both large diameters and high pressures lead to prohibitively thick shells resulting in very high cost.
49. **Assertion (A):** The pressure compounded impulse steam turbine is the most efficient type of impulse turbine. **Reason (R):** It is because the ratio of blade velocity to steam velocity remains constant.
50. **Assertion (A):** Rocket engines are used for space research. **Reason (R):** They have high specific impulse.
51. **Assertion (A):** The modern electric power generating plants use only water tube boilers and not fire tube boilers. **Reason (R):** The water tube boilers are comparatively cheaper in first cost than fire tube boilers.
52. **Assertion (A):** Single stage impulse steam turbines are not used in practice. **Reason (R):** Single stage impulse steam turbines have very low revolutions per minute.
53. **Assertion (A):** The performance parameter 'Poly tropic efficiency' is used for axial flow gas turbines and air compressors. **Reason (R):** Poly tropic efficiency is dependent on the pressure ratio

WEBSITES:

1. http://nptel.ac.in/courses/112106166/
2. http://nptel.ac.in/syllabus/syllabus.php?subjectId=112102013
3. *nptel.ac.in/courses/112104117/18*
4. www.iitd.ac.in
5. www.nptel.ac.in
6. www.mit.edu

EXPERT DETAILS

1. Dr. A.V.V.S.S.K Guptha, Professor, JNTU, Hyderabad
2. Dr. R. Yadav, Emeritus Professor, MNNIT, Allahabad
3. Dr. Sanjay, Professor, NIT, Jamshedpur

JOURNALS:

1. ASME Journal of Energy Resource Technology
2. ASME Journal of Engineering for Industry
3. ASME Journal of Solar Energy Engineering
4. Australian Journal of Mechanical Engineering

STUDENTS SEMINARS:

1. Steam Nozzles
2. Steam boilers.
3. Steam Turbines
4. Rocket propulsion
5. Steam Condensers
6. Gas Turbines
7. Jet Propulsion

CASE STUDIES/SMALL PROJECTS:

1. Study of cavitations in steam turbines, BHEL ANNUAL REPORT
2. A demonstration on steam reaction turbine/gas turbine
3. Boilers-models
4. Visit to textile industry/sugar cane industry-write report on it.