SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur– 603 203

DEPARTMENT OF MECHANICAL ENGINEERING

QUESTIONBANK

IV Semester

1909404- APPLIED THERMODYNAMICS

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Prepared by

T.Muthu Krishnan / Asst. Professor Sr.G.

UNIT 1 –GAS AND STEAM POWER CYCLE: Air Standard Cycles - Otto, Diesel and Dual – Calculation of mean effective pressure, and air standard efficiency Comparison of cycles			
PART-A (2 Marks)			
1.	Define a cycle.	BT-1	Remembering
2.	Define Air Standard Efficiency.	BT-1	Remembering
3.	List out the assumptions to be considered for the analysis of all air standard cycles.	BT-1	Remembering
4.	Plot the Otto cycle process by its p-V and T-s planes.	BT-6	Create
5.	Construct the Diesel cycle on p-V and T-s planes.	BT-6	Create
6.	Construct the dual cycle on the p-V plane and mention the five thermodynamic processes involved.	BT-6	Create
7.	Draw the dual cycle on T-s planes and mention the five thermodynamic processes involved.	BT-3	Apply
8.	Define mean effective pressure.	BT-1	Remembering
9.	In an Otto cycle, the compression ratio is 8. Calculate the air standard cycle efficiency.	BT-3	Apply
10	Describe relative efficiency.	BT-2	Understanding
11.	Summarize the compression ratio.	BT-2	Understanding
12.	Define cut-off ratio.	BT-1	Remembering
13.	Define expansion ratio.	BT-1	Remembering
14.	Compare the major differences between Otto and Diesel Cycle.	BT-4	Analyse
15.	List the merits and demerits of the Otto cycle.	BT-1	Remembering
16.	Describe a thermodynamic cycle?	BT-2	Understanding
17.	Name the various gas power cycle.	BT-1	Remembering
18.	Justify the change in compression ratio to affect the air standard efficiency of an ideal Otto cycle.	BT-5	Evaluate
19.	Justify diesel efficiency changes with an increase in the cut-off ratio for the same compression ratio.	BT-5	Evaluate
20.	Label the various Gas Power Cycles.	BT-1	Remembering
21.	List the four thermodynamic processes involved in the Otto cycle	BT-1	Remembering
22.	Lable the four thermodynamic processes involved in the Diesel cycle.	BT-1	Remembering
23.	In an engine working on an Otto cycle, temperatures at the beginning at the end of compression are 27^o C and 327^o C respectively. Find the compression ratio and air standard efficiency of the engine.	BT-2	Understanding
24.	In an Otto cycle, the compression ratio is 11. Calculate the air standard cycle efficiency.	BT-3	Apply
25.	Illustrate the use of air standard cycle analysis.	BT-2	Understanding

PART-B (13 Marks)				
1.	(a) List the Assumptions made for air standard cycles.	(3)	BT-1	Remembering
	(b) Explain the Otto cycle with p-V and T-s diagram and derive the expression for air standard efficiency of the Otto cycle.	(10)	BT-2	Understanding
2.	(a) The efficiency of an Otto cycle is 60% and $\gamma = 1.5$. Calculate the compression ratio.	(5)	BT-3	Applying
	(b) An engine with a 250 mm bore and 375 mm stroke works on the Otto cycle. The clearance volume is 0.00263 m^3. The initial pressure and temperature are 1 bar and 50°C. if the maximum pressure is limited to 25 bar, calculate the following: 1. The air standard efficiency of the cycle. 2. The mean effective pressure for the cycle. Assume the ideal conditions.	(8)	BT-3	Applying
3.	The minimum pressure and temperature in an Otto cycle are 100 kPa and 27° C. the amount of heat added to the air per cycle is 1500 kJ/kg. 1. Calculate the pressure and temperatures at all points of the air standard Otto cycle. 2. Also, calculate the specific work and thermal efficiency of the cycle for a compression ratio of 8:1. Take for air: $c_v = 0.72$ kJ/kg K and $\gamma = 1.4$		BT-3	Applying
4.	In a constant volume Otto cycle the pressure at the end of compression is 15 times that at the start, the temperature of the air at the beginning of compression is 38° C and the maximum temperature attained in the cycle is 1950° C. Solve : 1. Compression ratio. 2. Thermal efficiency of the cycle. 3. Work done. Take γ for air = 1.4.		BT-3	Applying
5.	An engine working on the Otto cycle has a volume of 0.45 m^3, pressure 1 bar and temperature of 30° C at the beginning of the compression stroke. At the end of the compression stroke, the pressure is 11 bar. Heat added during the constant volume process is 210 kJ. Calculate : 1. Pressures, temperatures and volumes at salient points in the cycle. 2. Percentage clearance. 3. Air standard efficiency. 4. Mean effective pressure. 5. Ideal power developed by the engine, if the number of working cycles per minute is 210. Assume the cycle is reversible.		BT-3	Applying
6.	Compose the mean effective pressure of an Otto cycle in terms of compression ratio.		BT-6	Create
7.	Explain the Diesel cycle with p-V and T-s diagrams and compile the expression for air standard efficiency of the Diesel cycle.		BT-6	Create
8.	A diesel engine has a compression ratio of 15 and heat addition at constant pressure takes at 6 % of the stroke. Evaluate the air standard efficiency of the engine. Take γ for air as 1.4		BT-5	Evaluate

9.	An engine with a 200 mm cylinder diameter and 300 mm stroke works on the theoretical Diesel cycle. The initial pressure and temperature of the air used are 1 bar and 27^0C. The cut-off is 8% of the stroke. Evaluate 1. Pressure and temperatures at all salient points. 2. Theoretical air standard efficiency. 3. Mean effective pressure. 4. Power of the engine if the working cycles per minute are 380. Assume that the compression ratio is 15 and the working fluid is air. Consider all conditions to be ideal	BT-5	Evaluate
10.	Explain the Dual cycle with p-v and T-s diagram and develop the expression for air standard efficiency of the Dual cycle.	BT-6	Create
11	The swept volume of a diesel engine working on dual is 0.0053 m^3 and clearance volume is 0.00035 m^3. The maximum pressure is 65 bars. Fuel injection ends at 5 percent of the stroke. The temperature and pressure at the compression are 80^o C and 0.9 bar. Evaluate the air standard efficiency of the cycle. Take γ for air = 1.4.	BT-5	Evaluate
12.	An oil engine working on the dual combustion cycle has a compression ratio 14 and the explosion ratio obtained from an indicator card is 1.4. If the cut-off occurs at 6 percent of stroke, find the ideal efficiency. Take γ for air as 1.4.	BT-3	Applying
13.	The compression ratio for a single–cylinder engine operating on dual cycle is 9. The maximum pressure in the cylinder is limited to 60 bar. The pressure and temperature of the air at the beginning of the cycle is 1 bar and 30^o C. heat is added during constant pressure process up to 4 percent of the stroke. Assuming the cylinder diameter and stroke length as 250 and 300 mm respectively, Calculate : 1. The air standard efficiency of the cycle. 2. The power developed is the number of working cycles is 3 per second. Take for air c_v = 0.71 kJ/kg K and c_p = 1.0 kJ/kg K.	BT-3	Applying
14.	In an engine working on dual cycle, the temperature and pressure at the beginning of the cycle are 90^0 C and 1 bar respectively. The compression ratio is 9. The maximum pressure is limited to 68 bars and total heat supplied per kg of air is 1750 kJ. Solve : 1. Pressure and temperatures at all salient points 2. Air standard efficiency 3. Mean Effective Pressure.	BT-3	Applying
15.	An air standard Otto cycle has a volumetric compression ratio of 6, the lowest cycle pressure of 0.1 MPa and operates between temperature limits of 27^oC and 1569^oC. Calculate the temperature and pressure after the isentropic expansion (ratio of specific heats = 1.4.	BT-3	Applying
16	The minimum pressure and temperature in an Otto cycle are 100 kPa and 30^o C. the amount of heat added to the air per cycle is 1600 kJ/kg. 1. Calculate the pressure and temperatures at all points of the air standard Otto cycle. 2. Also, calculate the specific work and thermal efficiency of the cycle for a compression ratio of 8:1.	BT-3	Applying

	Take for air: c_v = 0.72 kJ/kg K and γ = 1.4		
17	An engine with a 180 mm cylinder diameter and 270 mm stroke works on the theoretical Diesel cycle. The initial pressure and temperature of the air used are 1 bar and 30^0C. The cut-off is 8% of the stroke. Calculate 1. Pressure and temperatures at all salient points. 2. Theoretical air standard efficiency. 3. Mean effective pressure. 4. Power of the engine if the working cycles per minute are 400. Assume that the compression ratio is 15 and the working fluid is air. Consider all conditions to be ideal.	BT-3	Applying
18	The compression ratio for a single–cylinder engine operating on dual cycle is 8. The maximum pressure in the cylinder is limited to 60 bar. The pressure and temperature of the air at the beginning of the cycle is 1 bar and 27^o C. heat is added during constant pressure process up to 5 percent of the stroke. Assuming the cylinder diameter and stroke length as 240 and 310 mm respectively, Calculate : 1. The air standard efficiency of the cycle. 2. The power developed is the number of working cycles is 3 per second. Take for air c_v = 0.71 kJ/kg K and c_p = 1.0 kJ/kg K.	BT-3	Applying

PART-C (15 Marks)			
1.	A Certain quantity of air at a pressure of 1 bar and temperature of 70^oC has compressed adiabatically until the pressure is 7 bar in Otto cycle engine. 465 kJ of heat per kg of air is now added at constant volume. Determine : 1. Compression ratio of the engine 2. Temperature at the end of the compression 3. Temperature at the end of heat addition. Take for air c_p = 1.0 kJ/kg K, c_v = 0.706 kJ/kg K. Show each operation on p-V and T-s diagrams.	BT-3	Applying
2.	The stroke and cylinder diameter of the compression ignition engine are 250 mm and 150 mm respectively. If the clearance volume is 0.0004 m^3 and fuel injection takes place at constant pressure for 5 % of the stroke. Determine the efficiency of the engine. Assume the engine working on the diesel cycle.	BT-3	Applying
3.	The compression ratio and expansion ratio of an oil engine working on the dual cycle are 9 and 5 respectively. The initial pressure and temperature of the air are 1 bar and 30^0 C. The heat liberated at constant pressure is twice the heat liberated at constant volume. The expansion and compression follow the law $pv^{1.25}$ = constant. Calculate : 1. Pressure and temperatures at all salient points 2. Mean effective pressure of the cycle. 3. Efficiency of the cycle. 4. Power of the engine if working cycles per second are 8. Assume: cylinder bore = 250 mm and stroke length = 400 mm.	BT-3	Applying

4.	Compare the Otto, Diesel and Dual Combustion Cycles with the following important variable factors: 1. Efficiency Vs Compression ratio 2. For Constant Maximum pressure and heat supplied 3. For the same Compression ratio and same heat input	BT-4	Analyse
5	A spark ignition engine working on the ideal Otto cycle has a compression ratio of 6. The initial pressure and temperature of air are 1 bar and 37^{o}C. The maximum pressure in the cycle is 30 bar. For unit mass flow, Calculate 1. Pressure and temperatures at all salient points. 2. The ratio of heat supplied to the heat rejected.	BT-3	Applying

UNIT II- INTERNAL COMBUSTION ENGINES AND COMBUSTION:
IC engine – Classification and application IC engine - Different components and their functions of IC engines. Theoretical and actual Valve timing diagrams - Port time diagram - Theoretical and actual p-V diagrams of a four stroke Otto and Diesel cycle engine. Geometric, operating, and performance comparison of SI and CI engines. Combustion in SI– Pre-ignition – Detonation - octane number. Combustion in CI Engines -Delay period- Diesel Knock- Cetane number.

PART-A (2 Marks)			
1.	Define heat engine.	BT-1	Remembering
2.	List the classification of heat engines.	BT-1	Remembering
3.	Label the application of I.C. engines	BT-1	Remembering
4.	List the classification of I.C. engines-based combustion.	BT-1	Remembering
5.	Summarize the eight major parts of I.C. Engines.	BT-2	Understanding
6.	Compare the flywheel and governor	BT-4	Analysing
7.	Label the types of governors.	BT-1	Remembering
8.	Construct a typical valve timing diagram and mention ideal angles.	BT-6	Create
9.	Describe swept volume.	BT-2	Understanding
10.	Describe clearance volume.	BT-2	Understanding
11.	Demonstrate an indicator diagram.	BT-2	Understanding
12.	Discuss the phenomenon of Knocking spark-ignited engines.	BT-2	Understanding
13.	Summarize the cetane number.	BT-2	Understanding
14.	Demonstrate detonation.	BT-2	Understanding
15.	Construct a typical valve timing diagram and mention ideal angles.	BT-6	Create
16.	Discuss mean effective pressure.	BT-2	Understanding
17.	List the types of bearings.	BT-1	Remembering
18.	Analyse rich and lean mixtures.	BT-4	Analysing
19.	List the various components of the engine.	BT-1	Remembering
20.	Define the delay period with respect to a CI engine.	BT-1	Remembering
21.	List the functions of the push rod and rocker’s arm	BT-1	Remembering
22.	Name the function of the engine flywheel.	BT-1	Remembering
23.	State the function of Connecting rod.	BT-1	Remembering
24.	Recall the function of the piston.	BT-1	Remembering
25.	Reproduce the function of the crankshaft	BT-1	Remembering

PART-B (13 Marks)			
1.	Categorize the Classification of IC Engines.	BT-4	Analyse
2.	Discuss the basic idea of the IC engine with a neat sketch and its different parts of IC engines.	BT-2	Understanding
3.	Explain the construction, operation of four stroke petrol engine with a neat sketch	BT-1	Remembering

4.	Discuss the technical terms connected with I.C. engines with a neat sketch.	BT-2	Understanding
5.	Construct the theoretical and actual p-V diagram of four stroke Otto cycle engine.	BT-6	Create
6.	Construct the theoretical and actual p-V diagram of four stroke diesel cycle engine.	BT-6	Create
7.	Construct the actual valve time diagram for four-stroke diesel cycle engine.	BT-6	Create
8.	Describe the Simple carburettor with neat sketches, its limitations, and air-fuel mixtures.	BT-2	Understanding
9.	Explain the construction, operation of two stroke petrol engine with a neat sketch and p-V diagram for the same.	BT-2	Understanding
10.	Summarize the comparison between four-stroke and two-stroke cycle engines.	BT-4	Analysing
11.	Summarize the comparison between S.I. and C.I. engines.	BT-4	Analysing
12.	Summarize the comparison between petrol and diesel engines.	BT-4	Analysing
13.	Explain the combustion phenomenon in S.I. engines.	BT-2	Understanding
14.	Explain the combustion phenomenon in C.I. engines.	BT-2	Understanding
15.	List out the factors affecting normal combustion in S.I. engines.	BT-1	Remembering
16.	List out the factors affecting normal combustion in C.I. engines.	BT-1	Remembering
17.	Describe the Crank and Crank shaft with neat sketch.	BT-2	Understanding
18.	Describe the Piston and connecting rod with neat sketch.	BT-2	Understanding

PART-C (15 Marks)			
1.	Summarize the list of engine parts, material to be used and method of manufacture and its functions	BT-4	Analysing
2.	Construct the typical Port timing diagram and the significance of each angle in the Port timing diagram in Two Stroke Engine	BT-6	Create
3.	Construct the typical theoretical and actual Valve timing diagram for four stroke Otto cycle engine and the significance of each angle in the valve timing diagram.	BT-6	Create
4.	Discuss the desirable properties and qualities of fuels.	BT-2	Understanding
5.	Describe the types of governors in detail.	BT-2	Understanding

UNIT III- INTERNAL COMBUSTION ENGINE PERFORMANCE AND SYSTEMS:

Performance parameters and calculations - Morse and Heat Balance tests. Ignition systems – Magneto and Battery - Fuel Injection system - Electronic fuel injection - Cooling systems - Lubrication systems - Supercharging - Dissociation.

PART-A (2 Marks)

1.	Define the term brake power.	BT-1	Remembering
2.	Define the term Indicated power.	BT-1	Remembering
3.	Describe Air-Fuel ratio.	BT-1	Remembering
4.	List out the measurements are usually undertaken to evaluate the performance of an engine.	BT-1	Remembering
5.	List out the common form of absorption dynamometers	BT-1	Remembering
6.	List out the types of dynamometers.	BT-1	Remembering
7.	What is meant by mean effective pressure?	BT-1	Remembering
8.	Discuss Specific fuel consumption.	BT-2	Understanding
9.	Define thermal efficiency.	BT-1	Remembering
10.	What do you mean by dynamometer?	BT-1	Remembering
11.	List out the methods to determine the frictional power of an engine.	BT-1	Remembering
12.	Describe Specific output.	BT-2	Understanding
13.	Define the phenomenon of Knocking in spark-ignited engines.	BT-2	Understanding
14.	What are all the functions of a flywheel?	BT-1	Remembering
15.	What do you mean by detonation?	BT-1	Remembering
16.	Define the delay period with respect to a CI engine.	BT-1	Remembering
17.	What are the important requirements of a fuel injection system?	BT-1	Remembering
18.	Mention different types of fuel injection systems in CI engines.	BT-1	Remembering
19.	What are the various methods of lubrication	BT-1	Remembering
20.	What are the methods of cooling systems in IC engine?	BT-1	Remembering
21.	State the purpose of providing a radiator in the cooling system	BT-1	Remembering
22.	State any three functions of lubrication.	BT-1	Remembering
23.	What is the purpose of a thermostat in an engine cooling system?	BT-1	Remembering
24.	What is the indicated thermal efficiency of IC engines?	BT-1	Remembering
25.	What are two advantages of the magneto ignition system as compared to the battery ignition system?	BT-1	Remembering

PART-B (13 Marks)				
1.	Discuss the various basic performance parameters used to evaluate the performance of the IC engine.		BT-2	Understanding
2.	Describe the methods to determine the frictional power in detail.		BT-2	Understanding
3.	Discuss the wet sump lubrication system with the help of suitable sketches.		BT-2	Understanding
4.	Discuss the various properties of lubricants.		BT-2	Understanding
5.	Explain the air cooling systems used in I.C engine:		BT -4	Analysing
6.	(a) Explain the thermos-syphon cooling method used in I.C engine: (b) Explain the forced or pump cooling used in I.C engine:	(7) (6)	BT-2	Understanding
7.	(a) State the purposes of lubrication system.	(5)	BT-1	Remembering
	(b) Discuss the dry sump lubrication system with the help of suitable sketches.	(8)	BT-2	Understanding
8.	A 4-cylinder petrol engine has a bore of 60 mm and a stroke of 90 mm. Its rated speed is 2800 rpm and it is tested at this speed against brake which has a torque arm of 0.37 m. The net brake load is 160 N and the fuel consumption is 8.986 lit/hr. The specific gravity of petrol used is 0.74 and it has a lower calorific value of 44100 kJ/kg. A Morse test is carried out and the cylinders are cut out in the order 1,2,3,4 with corresponding brake loads of 110,107,104 and 110 N respectively. Evaluate for this speed:1. The engine torque, 2. B.M.E.P, 3. The brake thermal efficiency, 4. The specific fuel consumption, 5. Mechanical efficiency, 6. I.M.E.P		BT-5	Evaluating
9.	A four cylinder four stroke S.I. engine has a compression ratio of 8 and bore of 100 mm, with stroke equal to the bore. The volumetric efficiency of each cylinder is equal to 75%. The engine operates at a speed of 4800 rpm with an air-fuel ratio 15. Given that the calorific value of fuel = 42 MJ/kg, atmospheric density = 1.12 kg/m^3, mean effective pressure in the cylinder = 10 bar and mechanical efficiency of the engine =80%, determine the indicated thermal efficiency and the brake power.		BT-4	Analysing
10.	Following data relate to 4-cylinder four stroke petrol engine. Air fuel ratio by weight = 16:1, calorific value of the fuel = 45200 kJ/kg, mechanical efficiency = 82%, air-standard efficiency = 52%, relative efficiency = 70%, volumetric efficiency = 78 %, stroke/bore ratio = 1.25, suction conditions = 1 bar & 25°C, r.p.m. = 2400 and power at brakes =72 kW. Evaluating: (1) Compression ratio, (2) Indicated thermal efficiency, (3) Brake specific fuel consumption, (4) Bore and Stroke.		BT-5	Evaluating
11.	Air consumption for a four-stroke petrol engine is measured by means of a circular orifice of diameter 3.2 cm. The co-efficient of discharge for the orifice is 0.62 and the pressure across the orifice is 150 mm of water. The barometer reads 760 mm of Hg. Temperature of air in the room is 20°C. The piston displacement volume is 0.00178 m^3. The compression		BT-5	Evaluating

	ratio is 6.5. The fuel consumption is 0.135 kg/min of calorific value 43900 kJ/kg. The brake power developed at 2500 rpm is 28 kW. Determine: (1) The volumetric efficiency on the basic of air alone. (2) The air-fuel ratio. (3) The brake mean effective pressure. (4) The relative efficiency on the brake thermal efficiency basis.		
12.	In a test on single cylinder four stroke cycle gas engine with explosion in every cycle, the gas consumption given by the metre was 0.216 m^3 per minute; the pressure and temperature of the gas being 75 mm of water and 17^0C respectively. Air consumption was 2.84 kg / min., the temperature being 17^0C and barometer reading 745 mm of mercury. The bore of the engine was 250 mm and stroke 475 mm and rpm 240. Find volumetric efficiency of the engine referred to volume of charge at NTP. Assume R for air as 287 Nm/kg K.	BT-5	Evaluating
13.	The following observations were recorded in a single cylinder oil engine working on four stroke cycle. Bore=300 mm, Stroke=450 mm, Fuel used=8.8 kg, calorific value of fuel=41800 kJ/kg, Average speed=200 rpm, MEP=5.8 bar, Brake friction load=1860 N, Quantity of cooling water=650 kg, temperature rise=22^0C, Diameter of the brake wheel=1.22 m. Calculate mechanical efficiency and brake thermal efficiency. Also draw the heat balance sheet.	BT-5	Evaluating
14.	The following readings were taken during the test of a single cylinder four stroke oil engine: Cylinder diameter = 250 mm Stroke length = 400 mm Gross m.e.p. = 7 bar Pumping m.e.p. = 0.5 bar Engine speed = 250 r.p.m. Net load on the brake = 1080 N Effective diameter of the brake = 1.5 metre Fuel used per hour = 10 kg, Calorific value of fuel = 44300 kJ/kg. Calculate : 1. Indicated power, 2. Brake power, 3. Mechanical efficiency and 4. Indicated thermal efficiency.	BT-4	Analysing
15.	Explain the Battery or coil ignition system	BT-2	Understanding
16.	Explain the Magneto-ignition system	BT-2	Understanding
17.	Explain the thermostat cooling method in IC engine.	BT-2	Understanding
18.	Explain the Evaporative cooling system in IC engine.	BT-2	Understanding

PART-C (15 Marks)			
1.	A six cylinder four stroke SI having a piston displacement of 700 cm^3 per cylinder developed 78 kW at 3200 rpm and consumed 27 kg of petrol per hour. The calorific value of petrol is 44 MJ/kg. Estimate: 1. The volumetric efficiency of the engine if the air-fuel ratio is 12 and intake air is at 0.9 bar, 32^0C. 2. The brake thermal efficiency 3. The brake torque. For air, R=0.287 kJ/kgK.	BT-4	Analysing
2.	During the test of 40 minutes on a single-cylinder gas engine with a 200 mm cylinder bore and 400 mm stroke, working on the four-stroke cycle and governed by hit and miss method of governing, the following readings are taken: The total no of revolutions =9400 Total no of explosions =4200 Area of indicator diagram =550mm^2 Length of indicator diagram =72 mm Spring number =0.8 bar/mm Brake load =540 N Brake wheel diameter =1.6 m Brake rope diameter =2 cm Gas used =8.5 m^3 Calorific value of gas =15900 kJ/m^3 Calculate: i) Indicated power, ii) Brake power, iii) Indicated and brake thermal efficiencies.	BT-5	Evaluating
3.	What do you mean by the performance of the IC engine? Discuss briefly the basic performance parameters. And also discuss with a suitable sketch the brake rope dynamometer.	BT-2	Understanding
4.	The following data refer to an oil engine working on an Otto four-stroke cycle: Brake power =14.7 kW Suction pressure =0.9 bar Mechanical efficiency =80% Ratio of compression =5 Index of compression curve =1.35 Index of expansion curve =1.3 Maximum explosion pressure =24 bar Engine speed =1000 RPM Ratio of stroke: bore =1.5 Find the diameter and stroke of the piston.	BT-5	Evaluating
5.	What are the different factors that affect the knock and explain the process of pinking or detonation and how to control it.	BT-2	Understanding

UNIT IV- RECIPROCATING AIR COMPRESSOR Classification of Air compressor - Reciprocating compressor - construction and working. Equation of work with and without clearance - Free air delivered - Volumetric efficiency, Isothermal efficiency, mechanical efficiency and overall isothermal efficiency - Multistage air compressor with Inter-cooling.			
PART-A (2 Marks)			
1.	List out the compressed air used in diversified fields.	BT – 1	Remembering
2.	Describe the function of a compressor.	BT – 2	Understanding
3.	Discuss the need for a booster in an air or gas compressor.	BT – 2	Understanding
4.	Illustrate the effective swept volume.	BT – 1	Remembering
5.	Discuss the advantage of a multistage compressor over a single-stage compressor.	BT – 2	Understanding
6.	Construct the actual compressor p-V diagram.	BT – 6	Creating
7.	List out the conditions that will lower the volumetric efficiency.	BT – 1	Remembering
8.	Categorize the various types of air compressors.	BT – 4	Analyse
9.	Describe the volumetric efficiency of a reciprocating compressor.	BT – 2	Understanding
10.	List out any two examples of positive displacement rotary compressors.	BT – 1	Remembering
11.	Explain the necessity of clearance in reciprocating compressors.	BT – 2	Understanding
12.	What do you mean by perfect intercooling?	BT – 1	Remembering
13.	Define the Degree of reaction in a compressor.	BT – 2	Understanding
14.	Discuss the disadvantages of the multi-stage compressor with an intercooler.	BT – 2	Understanding
15.	Interpret slip factor in the compressor.	BT – 3	Applying
16.	List out two merits of the rotary compressor over the reciprocating compressor.	BT – 1	Remembering
17.	Identify the compression process in which work done is minimum in reciprocating air compressors.	BT – 1	Remembering
18.	Construct the p-V diagram of a single-stage reciprocating air compressor.	BT – 6	Creating
19.	Define isothermal efficiency in air compressors.	BT – 1	Remembering
20.	Define the Mechanical efficiency of a reciprocating compressor.	BT – 1	Remembering
21.	Discuss free air delivery in an air compressor.	BT – 2	Understanding
22.	Construct the p-V diagram of a two-stage reciprocating air compressor.	BT – 6	Creating
23.	What do mean by Air Turbine?	BT – 1	Remembering
24.	Name the expression for work done for a two-stage compression with prefect intercooling.	BT – 1	Remembering

25.	Name the expression for the equation of work for a single-stage compressor.	BT – 1	Remembering

PART-B (13 Marks)				
1.	Explain the construction and working of a single-stage reciprocating compressor with a neat sketch.		BT - 2	Understanding
2.	Derive the work done for a single-stage air compressor with and without clearance volume.		BT - 2	Understanding
3.	Derive the expression for the volumetric efficiency of a reciprocating air compressor.		BT - 2	Understanding
4.	An air compressor takes in air at 1 bar and 20°C and compresses it according to law $pv^{1.2}$ = constant. It is then delivered to a receiver at a constant pressure of 10 bar. Take R = 0.287 kJ/kg K. Calculate 1. The temperature at the end of the compression. 2. Work done and heat transferred during compression per kg of air.		BT -3	Applying
5.	A single-stage double-acting air compressor is required to deliver 14 m^3 of air per minute measured at 1.013 bar and 15°C. The delivery pressure is 7 bar and the speed is 300 rpm. Take the clearance volume as 5% of the swept volume with the compression and expansion index n=1.3. Calculate: 1. The swept volume of the cylinder 2. The delivery temperature 3. Indicated power		BT -3	Applying
6.	A single-stage, the double-acting compressor has a free air delivery (F.A.D) of 14 m^3/min measured at 1.013 bar and 15°C. The pressure and temperature in the cylinder during induction are 0.95 bar and 32°C. The delivery pressure is 7 bar and the index of compression and expansion is n=1.3. The clearance volume is 5% of the swept volume. Calculate: 1. Indicated power required. 2. Volumetric efficiency.		BT -3	Applying
7.	(a) Explain the Actual p-V diagram for single-stage compressor.	(8)	BT - 2	Understanding
	(b)Explain the concept of multi-stage compression.	(5)	BT - 2	Understanding
8.	Air at 103 kPa and 27°C is drawn in the L.P. cylinder of a two–stage air compressor and is isentropically compressed to 700 kPa. The air is then cooled at constant pressure to 37°C in an intercooler and is then again compressed isentropically to 4 MPa in the H.P. cylinder, and is delivered at this pressure. Determine the power required to run the compressor if it has to deliver 30 m^3 of air per hour measured at inlet conditions.		BT -3	Applying

9.	A trial on a two stage single acting reciprocating air compressor gave the following data: Free air delivered = 6 m^3/min. Atmospheric pressure and temperature = 1 bar 27°C Delivery pressure = 40 bar Speed = 400 r.p.m. Intermediate pressure = 6 bar Temperature at the inlet to the second stage = 27°C Law of compression = $pV^{1.3}$ = constant Mechanical efficiency = 80% Stroke of L.P. = diameter of L.P. = stroke of H.P. Calculate: 1. Cylinder diameter 2. Power required (neglect clearance).	BT -3	Applying
10.	A two-stage single-acting reciprocating compressor takes in air at the rate of 0.2 m^3/s. The intake pressure and temperature of air are 0.1 Mpa and 16°C. The intermediate pressure is ideal and the intercooling is perfect. The intermediate pressure is ideal and the intercooling is perfect. The compression index in both the stages is 1.25 and the compressor runs at 600 rpm. Neglecting clearance, take c_p= 1.005 kJ/Kg K and R = 0.287 kJ/kg K. Determine: 1. The intermediate pressure, 2. The total volume of each cylinder, 3. The power required to drive the compressor, and 4. The rate of heat rejection in the intercooler.	BT -3	Applying
11.	A two-stage air compressor with complete inter-cooling delivers air to the mains at a pressure of 30 bar, the suction conditions being 1 bar and 15°C. If both cylinders have the same stroke, find the ratio of cylinder diameters, for the efficiency of compression to be a maximum. Assume the index of compression to be 1.3.	BT -3	Applying
12.	In a single-acting two- Stage reciprocating air compressor 4.5 kg of air per min are compressed from 1.013 bar and 15°C through a pressure ratio, and the law of compression and expansion in both stages is $pV^{1.3}$= constant. If the intercooling is complete, assume that the clearance volume of both stages are 5% of their respective swept volume and that the compressor runs at 300 rpm. Calculate: 1. The Indicated power 2. The cylinder swept volume is required.	BT -3	Applying
13.	Categorize the comparison between reciprocating and centrifugal compressors	BT - 4	Analysing
14.	Categorize the comparison between reciprocating and axial flow compressors.	BT - 4	Analysing
15.	Develop the condition of minimum work for a compressor.	BT - 6	Create
16.	Describe the Actual p-V (Indicated) diagram for two stage compressor.	BT - 2	Understanding

17.	Describe the free air delivered and displacement in air compressor.	BT - 2	Understanding
18.	Discuss the arrangements of reciprocating compressor with neat sketch	BT - 2	Understanding

PART-C (15 Marks)			
1.	A single stage single acting air compressor delivers 0.6 kg of air per minute at 6 bar. The temperature and pressure at the end of suction stroke are 30^{o}C and 1 bar. The bore and stroke of the compressor are 100 mm and 150 mm respectively. The clearance is 3% of the swept volume. Assuming the index of compression and expansion to be 1.3, Calculate: 1. Volumetric efficiency of the compressor, 2. Power required if the mechanical efficiency is 85%, 3. Speed of the compressor in rpm.	BT - 3	Applying
2.	Explain the construction and working of Multi-stage reciprocating compressor with neat schematic diagram, discuss the perfect and imperfect inter cooling with neat a sketch of p-V diagram and analyze the effect of intercoolers in multi stage compression.	BT - 4	Analysing
3.	Explain the construction and working principle of Centrifugal compressor and analyze the variations of pressure and velocity of air passing through impeller and diffuser.	BT -4	Analysing
4.	Categorize the methods are employed to increase isothermal efficiency of reciprocating compressor.	BT -4	Analysing
5.	Describe the clearance and effect of clearance volume in air compressor.	BT - 2	Understanding

UNIT V GAS TURBINES:

Brayton Cycle - Classification of Gas turbine, Merits of gas turbine- Constant pressure combustion gas turbine – open cycle gas turbine - Methods for improvement of thermal efficiency of open cycle turbine plant- Effect of operating variables on thermal efficiency - Closed cycle gas turbine - Constant volume Combustion turbines - Performance of gas turbine - Power developed, Thermal efficiency and work ratio.

PART-A (2 Marks)

1.	Name the three major components of a gas turbine engine.	BT-1	Remembering
2.	Sketch a schematic diagram of a simple open cycle gas turbine engine	BT-6	Create
3.	Sketch a schematic diagram and a T-s diagram of an open cycle gas turbine	BT-6	Create
4.	Name the various fuels used in the gas turbine.	BT-1	Remembering
5.	What are the applications of gas turbines?	BT-1	Remembering
6.	Classify the types of gas turbines.	BT-2	Understanding
7.	Discuss the merits of closed cycle gas turbine.	BT-2	Understanding
8.	Discuss the demerits of closed cycle gas turbine.	BT-2	Understanding
9.	Describe the Gaseous fuels in gas turbine.	BT-2	Understanding
10.	Describe the liquid fuels in gas turbine.	BT-2	Understanding
11.	Describe the solid fuels in gas turbine.	BT-2	Understanding
12.	Define back work ratio.	BT-1	Remembering
13.	List out the effect of operating variables on thermal efficiency	BT-1	Remembering
14.	Define work ratio.	BT-1	Remembering
15.	What is the effect of regeneration on the performance of an open cycle gas turbine?	BT-1	Remembering
16.	What are three major effects on the performance of an open cycle gas turbine with regeneration caused by the addition of an intercooler and a re-heater?	BT-1	Remembering
17.	How is the performance of a gas turbine engine increased by water injection?	BT-1	Remembering
18.	What are three methods of improving the part load performance of a gas turbine engine?	BT-1	Remembering
19.	Enumerate the five advantages of gas turbines over steam turbine.	BT-1	Remembering
20.	What do you understand by regeneration?	BT-2	Understanding
21.	Discuss the effect of pressure ratio of simple Brayton cycle.	BT-2	Understanding
22.	What are the variables affecting the thermal efficiency of a gas turbine?	BT-6	Creating
23.	Write down the expression for overall efficiency of the gas turbine.	BT-1	Remembering

24.	Discuss the merits of Gas turbines over IC engines.	BT-1	Remembering
25.	Write down the expression for thermal efficiency of the open cycle gas turbines.	BT-6	Creating

PART-B (13 Marks)			
1.	A gas turbine set takes in air at 15°C, the pressure ratio is 4:1 and the maximum temperature is 560°C. Assuming efficiencies of 0.86 and 0.83 for the turbine and compressor respectively, evaluate the overall efficiency, (a) without heat exchanger, and (b) with heat exchanger making use of 75% of the heat available. Assume that pressure drops in the connecting pipes, etc. can be neglected and that the specific heats of air are constant.	BT-5	Evaluating
2.	Describe the gaseous fuels, liquid fuels and solid fuels.	BT-2	Understanding
3.	Air enters the compressor of an open cycle constant pressure gas turbine at a pressure of 1 bar and temperature 20^0C. The pressure of the air after compression is 4 bar. The isentropic efficiencies of compressor and turbine are 80% and 85% respectively. The air-fuel ratio used is 90:1. If the flow rate of air is 3kg/s, find a)Power developed, b)Thermal efficiency of the cycle. Assume C_p=1kJ/kg K and γ=1.4 of air and gases calorific value of fuel=41800kJ/kg	BT-2	Understanding
4.	In a constant pressure open cycle gas turbine air enters at 1 bar and 20^0C and leaves the compressor at 5 bar. Using the following data: Temperature of the gas entering the turbine =680^0C, the pressure loss in the compression chamber =0.1 bar, $\eta_{compressor}$ = 85%, $\eta_{turbine}$ = 80%, $\eta_{combustion}$ = 85%, γ=1.4, C_p=1.024 kJ/kg K for air and gas, Find a) The quantity of air circulation if the plants develops 1065 kW b)Heat supplied per kg of air circulation c)The thermal efficiency if the cycle, mass of the fuel may be neglected.	BT-5	Evaluating
5.	In a gas turbine the compressor is driven by the high pressure turbine. The exhaust from the high pressure turbine goes to free low pressure turbine which runs the load. The air flow rate is 20kg/s and the minimum and maximum temperature respectively 300K and 1000K. The compressor ratio is 4. Calculate the pressure ratio of low pressure turbine and temperature of exhaust gas from the unit. The compressor and turbine are isentropic. C_p of air and exhaust gases =1kJ/kg K and γ=1.4	BT-5	Evaluating
6.	A gas turbine unit has a pressure ratio of 6:1 and maximum cycle temperature of 610^0C. The isentropic efficiencies of compressor and turbine are 80% and 82% respectively. Evaluate the power output in KW of an electric generator geared to the turbine when the air enters the compressor at 15^0C at the rate of 16kg/s. Take C_p=1.005kJ/kg K and γ=1.4 for the compression process, and take C_p=1.11kJ/kg K and γ=1.333 for the expansion process	BT-5	Evaluating

7.	Explain the closed-cycle gas turbine with a neat sketch	BT-2	Understanding
8.	Air is drawn in a gas turbine unit at 15^0C and 0.01 bar and the pressure ratio is 7:1. The compressor is driven by the HP turbine LP turbine drives a separate power shaft. The isentropic efficiencies of the compressor and the HP and LP turbines are 0.82, 0.85 and 0.85 respectively. If the maximum cycle temperature is 610^0C, Evaluate (a) The pressure and temperature of the gases entering the power turbine b) The net power developed by the unit per kg/s mass flow c) The work ratio d) The thermal efficiency of the unit. Neglect the mass of fuel and assume the following: For compression process: C_{pa}=1.005kJ/kg K and γ=1.4.For combustion and expansion process: C_{pg}=1.15kJ/kg K and γ=1.333.	BT-5	Evaluating
9.	The pressure ratio of an open cycle gas turbine power plant is 5.6. Air taken as 30^0C and 1 bar. The compression is carried out in two stages with perfect inter cooling in between. The maximum temperature of the cycle is limited to 700^0C. Assuming the isentropic efficiency of each compressor stage as 85% and that of turbine as 90%, determine the power developed and efficiency of the power plant, if the air flow is 1.2kg/s. The mass of fuel may be neglected, and it may be assumed that C_p = 1.02kJ/kg K andγ = 1.41.	BT-3	Applying
10.	A gas turbine plant consists of two turbines. One compressor turbine to drive compressor and other power turbine to develop power output and both are having their own combustion chamber which are served by air directly from the compressor. Air enters the compressor at 1 bar and 288K and is compressed to 8 bar with an isentropic efficiency of 76%. Due to heat added in the combustion chamber, the inlet temperature of the gas to both turbines is 86% and mass flow rate of air at the compressor is 23kg/s. The calorific value of the fuel is 4200kJ/kg. Calculate the output of the plant and the thermal efficiency if mechanical efficiency is 95%and generator efficiency is 96%. Take c_p =1.005kJ/kg K and γ=1.4 for air and C_{pg} = 1.128kJ/kg K and γ=1.34 for gases.	BT-3	Applying
11.	A gas turbine unit receives air at 1 bar and 300K and compresses it adiabatically to 6.2 bar. The compressor efficiency is 88%.The fuel has a heating value of 44186kJ/kg and the fuel air ratio is 0.017kJ/kg of air. Take turbine internal efficiency is 90%.Calculate the work of turbine and compressor per kg of air compressed and thermal efficiency. For product of combustion, c_p =1.147kJ/kg K and γ=1.333.	BT-3	Applying
12.	In a gas turbine cycle, air at atmosphere pressure is compressed adiabatically from 27°C and 1.01325bar to 5.741 bar and then the air absorbs heat from the exhaust gases at constant pressure at a rate of 84kJ per kg. The air is further expanded at constant pressure by the combustion of 0.012 kg of fuel per kg of air. The calorific value of fuel is 42000kJ/kg. The products of combustion are expanded adiabatically in the turbine to 1.01325 bar. Being exhausted with negligible velocity after yielding some of their heat to the air leaving the compressor. Cp for air = 1 kJ/kg K	BT-3	Applying

13.	In an air standard regenerative gas turbine cycle the pressure ratio is 5. Air enters the compressor at 1 bar, 300 K and leaves at 490 K. The maximum temperature in the cycle is 1000K. Calculate the cycle efficiency, given that efficiency of the regenerator and adiabatic efficiency of the turbine are each 80%. Assume for air, the ratio for specific heats is 1.4. Also, show the cycle on T-S diagram.	BT-3	Applying
14.	Find the required air fuel ratio in a gas turbine whose turbine and compressor efficiencies are 85% and 80% respectively. Maximum cycle temperature is 875^0C. Working fluid is taken as air (C_p=1kJ/kgK and γ=1.4) which enters the compressor at 1 bar and 27^0C. The pressure ratio is 4. The fuel used has a calorific value of 42000kJ/kg. There is a loss of 10% of calorific value in the combustion chamber.	BT-3	Applying
15.	Explain the open-cycle gas turbine with a neat sketch	BT-2	Understanding
16.	Explain the Inter cooling methods for improvement of thermal efficiency of open cycle gas turbine plant with neat sketch and T-s diagram.	BT-2	Understanding
17.	Explain the reheating methods for improvement of thermal efficiency of open cycle gas turbine plant with neat sketch and T-s diagram.	BT-2	Understanding
18.	Explain the regeneration methods for improvement of thermal efficiency of open cycle gas turbine plant with neat sketch and T-s diagram.	BT-2	Understanding

PART-C (15 Marks)			
1.	A gas turbine employs a HE with a thermal ratio of 72%. The turbine operates between the pressure of 1.01bar and 4.04bar and the ambient temperature of 20°C. Isentropic efficiencies of the compressor and turbine are 80% and 85% respectively. The pressure drop on each side of the HE is 0.05 bar and in the combustion chamber is 0.14 bar. Assume combustion efficiency to be unity and calorific value of the fuel to be 41800kJ/kg. evaluate the increase in efficiency due to the HE over that for simple cycle. Assume p is constant throughout and is equal to 1.024kJ/kg K and assume γ =1.4. For simple cycle the air fuel ratio is 90:1 and for the HE cycle the turbine entry temperature is same as for simple cycle.	BT-5	Evaluating
2.	A 4500 kW gas turbine generating set operates with two compressor stages, the overall pressure ratio 9:1, a high-pressure turbine is used to drive the compressor and a LP turbine drives the generator. The temperature of the gas at the entry to an HP turbine is 625°C and the gases are reheated to 625°C after expansion in the first turbine. The exhaust gases leaving the LP turbine are passed through a heat exchanger to heat air leaving the HP stage compressor. The compressors have equal pressure ratio and the inter cooling is complete between the stages. The air inlet temperature to the unit is 20°C. The isentropic efficiency of each compressor stage is 0.8, and the isentropic efficiency of the each turbine stage is 0.85, and the HE thermal ratio is 0.8. A mechanical efficiency of 95% can be assumed for both the power shaft and compressor turbine shaft. Neglecting all the pressure losses	BT-5	Evaluating

	and change in KE evaluate, (i) The thermal Efficiency (ii) Work ratio of the plant (iii) Mass flow in kg/s.		
3.	In a gas turbine the compressor takes in air at a temperature of 15°C and compresses it four times the initial pressure with an isentropic efficiency of 82%. The air is then passed through the HE heated by the turbine exhaust before reaching the combustion chamber. In the HE 78% of the available heat is given to the air. The maximum temperature after constant pressure combustion is 600°C and the efficiency of the turbine is 70%. Neglecting all the losses except those mentioned and assuming the working fluid throughout the cycle to have the characteristics of air and evaluate the efficiency of the cycle. Assume R= 0.287kJ/kg K and γ = 1.4 for air and constant specific heats throughout.	BT-5	Evaluating
4.	In a closed cycle gas turbine there is a two stage compressor and a two stage turbine. All the components ate mounted on the same shaft. The pressure and temperature at the inlet of the first stage compressor are 1.5 bar and 20°C. The maximum cycle temperature and pressure are limited to 750°C and 6bar. A perfect intercooler is used between the two stage compressors and a re-heater is used between the two turbines. Gases are heated in the re-heater to 750°C before entering in to the LP turbine. Assuming the compressor and turbine efficiencies are 0.82, Evaluate, (i) Efficiency of the cycle without regenerator (ii) the efficiency of the cycle with regenerator whose effectiveness is 0.70. (iii) The mass of the fluid circulated if the power developed by the plant is 350kW. The Working fluid used in the cycle is air. For air γ=1.4 and C_p=1.005 kJ/kg K.	BT-5	Evaluating
5.	Compile the effect of operating variables on thermal efficiency.	BT-6	Creating