JEPPIAAR ENGINEERING COLLEGE

Jeppiaar Nagar, Rajiv Gandhi Salai – 600 119

DEPARTMENT OF MECHANICAL ENGINEERING

QUESTION BANK

Subject : **ME6404 – THERMAL ENGINEERING**

Year / Sem : II / IV

UNIT I GAS POWER CYCLES				
Otto, Diesel, Dual, Brayton cycles, Calculation of mean effective pressure, and air standard efficiency - Comparison of cycles.				
PART-A				
CO Mapping : C406.1				
Q.No.	**Questions**	**BT Level**	**Competence**	**PO**
1	**Define Thermodynamic cycle**	BTL-1	Remembering	PO1, PO6
2	**Define air standard cycle.**	BTL-1	Remembering	PO1
3	**Draw the p-V & T-S diagram for Otto cycle.**	BTL-1	Remembering	PO1, PO6
4	**Draw the p-V & T-S diagram for Diesel cycle**	BTL-1	Remembering	PO1
5	**Mention the various processes of the Brayton cycle**	BTL-1	Remembering	PO1, PO6
6	**Mention the four thermodynamic processes involved in Diesel cycle**	BTL-1	Remembering	PO1, PO2
7	**Mention the various process of Dual cyale.**	BTL-1	Remembering	PO1, PO2
8	What **are the assumptions made on air standard cycles?**	BTL-1	Remembering	PO1
9	**Define air standard efficiency of Diesel cycle**	BTL-1	Remembering	PO1
10	**What are the functions of a flywheel?**	BTL-1	Remembering	PO1, PO2
11	**Define compression ratio.**	BTL-1	Remembering	PO1, PO2
12	**Define cut-off ratio**	BTL-1	Remembering	PO1, PO2
13	**Which cycle is more efficient with respect to the same compression ratio?**	BTL-1	Remembering	PO1
14	**For the same compression ratio and heat supplied, state the order of decreasing air standard efficiency of Otto, Diesel and Dual cycle.**	BTL-1	Remembering	PO1
15	**Name the factors that affect air standard efficiency of Diesel cycle**	BTL-1	Remembering	PO1
16	**What is the effect of cut-off ratio on the efficiency of diesel cycle when the compression ratio is kept**	BTL-1	Remembering	PO1

	constant?			
17	**Define the term actual thermal efficiency and relative efficiency**	BTL-1	Remembering	PO1, PO2
18	**Define Mean Effective Pressure of an I.C Engine.**	BTL-1	Remembering	PO1, PO2
19	**Name the various Gas power cycles.**	BTL-1	Remembering	PO1
20	**Define air standard efficiency.**	BTL-1	Remembering	PO1
21	**Define specific air consumption**	BTL-1	Remembering	PO1
22	**Define cylinder bore, stroke**	BTL-1	Remembering	PO1
23	**Define clearance volume.**	BTL-1	Remembering	PO1
24	**Define swept volume.**	BTL-1	Remembering	PO1
25	**What is the expression for efficiency of Otto & Diesel cycle?**	BTL-1	Remembering	PO1
26	**Compare Otto and Diesel cycles. Same Compression Ratio And Same Heat Input:**	BTL-1	Analysing	PO1, PO2
27	**What is the expression for efficiency of Dual cycle?**	BTL-1	Remembering	PO1
28	**What is the expression for efficiency of Diesel cycle?**	BTL-1	Remembering	PO1, PO2
29	**What are all the modifications are carried out in Brayton cycle? Why?**	BTL-1	Remembering	PO1
30	**What is the difference between otto and diesel cycle?**	BTL-1	Remembering	PO1
31	**What is meant by Atkinson cycle?**	BTL-1	Remembering	PO1, PO2
	PART-B			
1	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 are 1 bar and 30^{O}C. Heat is added during constant pressure process upto 4 percent of the stroke. Assuming cylinder diameter and stroke length as 250mm and 300mm. Determine (i) The air standard efficiency of the cycle (ii) The power developed if the number of working cycles is 3 per second.	BTL-5	Evaluating	PO1, PO2
2	The swept volume of a diesel engine working on dual cycle is 0.0053m^3 and clearance volume is 0.00035m^3. The maximum pressure is 65 bar. Fuel injection ends at 5 percent of the stroke. The temperature and pressure at the start of the compression are 80^{O}C and 0.9 bar. Determine the air standard efficiency of the cycle. Take γ for air as 1.4.	BTL-5	Evaluating	PO1, PO2, PO6
3	In a gas turbine plant working on the Brayton cycle	BTL-5	Evaluating	PO1, PO2

	the air at the inlet is at 27^{O}C, 0.1 MPa. The pressure ratio is 6.25 and the maximum temperature is 800^{O}C, The turbine and compressor efficiencies are each 80%. Find (i) the compressor work per kg of air (ii) the turbine work per kg of air (iii) the heat supplied per kg of air (iv) the cycle efficiency and (v) the turbine exhaust temperature.			
4	An engine with 200mm cylinder diameter and 300mm stroke works on theoretical diesel cycle. The initial pressure and temperature of sir used are 1 bar and 27^{O}C. The cut-off is 8% of stroke. Determine (i) Pressures and Temperatures at all salient points (ii) Theoritical air standard efficiency (iii) Mean effective pressure (iv) Power of the engine if the working cycles per minute are 380. Assume that compression ratio is 15 and working fluid is air.	BTL-5	Evaluating	PO1
5	Air enters the compressor of a gas turbine plant operating on Brayton cycle at 1 bar and 27^{O}C. The pressure ratio in the cycle is 6. If W_T =2.5 W_C where W_T and W_C are the turbine and compressor work respectively. Calculate the maximum temperature and the cycle efficiency.	BTL-5	Evaluating	PO1, PO2
6	An air standard dual cycle has a compression ratio of 10. The pressure and temperature at the beginning of compression are 1 bar and 27^{O}C. The maximum pressure reached is 42 bar and the maximum temperature is 1500^{O}C. Determine (i) The temperature at the end of constant volume heat addition (ii) cut-off ratio (iii) workdone per kg of air (iv) the cycle efficiency. Assume C_p=1.004 kJ/kg K and C_v= 0.717 kJ/kg K for air.	BTL-5	Evaluating	PO1
7	The following data refers to the theoretical diesel cycle during air as the working fluid. Pressure at the end of the suction stroke = 1bar, Temperature at the end of the suction stroke = 30°C, Temperature at the end of the constant pressure heat addition = 1500°C, Compression ratio = 16, Specific heat at constant pressure =1.005 kJ/kgK, Specific heat at constant volume = 0.718 kJ/kgK. Find : i) The percentage of stroke at which cutoff place ii) Temperature at the end of the expansion iii) The ideal thermal efficiency.	BTL-5	Evaluating	PO1, PO2
8	A diesel engine operating on the air-standard Diesel cycle has six cylinders of 100 mm bore and 120 mm stroke. The engine speed is 1800 rpm. At the beginning of compression the pressure and temperature of air are 1.03 bar and 35°C. If the clearance volume is 1/8th of the stroke volume, Calculate i) The pressure and temperature at the	BTL-5	Evaluating	PO1

	salient points of the cycle, ii) The compression ratio, iii) The efficiency of the cycle and iv) The power output if the maximum temperature of the cycle is 1500°C. Assume C_p and C_v of air to be 1.004 kJ/kg K and 0.717 kJ/kg K respectively.			
9	An engine working on Otto cycle has a volume of 0.45m^3, pressure 1 bar and temperature 30°C at the beginning of compression stroke. At the end of compression stroke, the pressure is 11 bar and 210 kJ of heat is added at const ant volume. Determine i) pressure, temperature and volumes at salient points in the cycle ii) efficiency, Percentage of clearance, mean effective pressure, ideal power developed by the engine if the number of working cycle per minute is 210.	BTL-5	Evaluating	PO1
10	Derive an expression for the ideal efficiency of Diesel cycle, using ideal air as the working fluid with the aid of P-v and T-s diagrams. Sketch the Diesel cycle on P-V and T-S diagrams and derive the expression for its mean effective pressure.	BTL-2	Understanding	PO1
11	An air standard dual cycle has a compression ratio of 18, and compression begins at 1 bar, 40°C. The maximum pressure is 85 bar. The heat transferred to air at constant pressure is equal to that at constant volume. Estimate: i) The pressure and temperatures at the cardinal points of the cycle ii) The cycle efficiency and iii) The mean effective pressure of the cycle.	BTL-5	Evaluating	PO1
12	An an air standard dual cycle, the pressure and temperature at the beginning of compression are 1 bar and 57°C respectively. The heat supplied in the cycle is 125 kJ/kg, two third of this being added at constant volume and rest at constant pressure. If the compression ratio is 16, determine the maximum pressure, temperature in the cycle, thermal efficiency and mean effective pressure.	BTL-5	Evaluating	PO1
13	In a gas turbine power plant, the air at inlet is at 35°C, 0.1 MPa. The pressure ratio is 8 and the maximum temperature is 1050°C. The turbine and compressor efficiencies are each 80%. Find compressor work, turbine work, heat supplied, cycle efficiency and turbine exhaust temperature. Mass of air may be considered 1 kg. Draw the T-s diagram. (16 Marks)	BTL-5	Evaluating	PO1, PO2
14	Derive an expression for the ideal efficiency of dual combustion cycle, using ideal air as the working fluid with the aid of P-V and T-S diagrams.	BTL-2	Understanding	PO1, PO2
15	i) A diesel engine has a compression ratio of 20	BTL-5	Evaluating	PO1

	and cutoff takes place 5%of the stroke. Find the air standard efficiency. Assume γ=1.4. (6 Marks) ii) In an engine working on the diesel cycle the ratios of the weights of air and fuel supplied is 50:1, the temperature of air at the beginning of the compression is 333 K and the compression ratio used is 14:1. What is the ideal efficiency of the engine? Calorific value of the fuel used is 42000 kJ/kg. Assume Cp=1.004 kJ/kg K and Cv =0.717 kJ/kg K for air.			
16	In an engine working on dual cycle, the temperature and pressure at the beginning of the cycle are 90°C and 1 bar respectively. The compression ratio is 9. The minimum pressure is limited to 68 bar and the total heat supplied per kg of air is 1750 kJ. Determine, i) Pressure and temperature at all salient points ii) Cut-off ratio iii) Work-done per kg of air and iv) net work output per kg vi) Cycle efficiency	BTL-5	Evaluating	PO1

UNIT II *INTERNAL COMBUSTION ENGINES*

Classification - Components and their **function. Valve timing diagram and port timing diagram - actual and theoretical p-V diagram of four stroke and two stroke engines. Simple and complete Carburettor. MPFI, Diesel pump and injector system. Battery and Magneto Ignition System - Principles of Combustion and knocking in SI and CI Engines. Lubrication and Cooling systems. Performance calculation.**

PART-A

CO Mapping : C406.2

Q.No.	Questions	BT Level	Competence	PO
1	**What is meant by scavenging in I.C. Engines?**	BTL-1	Remembering	PO1
2	**Differentiate between ideal and actual valve timing diagrams of a petrol engine.**	BTL-1	Remembering	PO1
3	**What are the important requirements of fuel injection system?**	BTL-1	Remembering	PO1
4	**Mention different types of fuel injection systems in IC Engines**	BTL-1	Remembering	PO1, PO2
5	**What is the purpose of a thermostat in an engine cooling system?**	BTL-2	Understanding	PO1, PO2
6	**What is meant by ignition delay?**	BTL-1	Remembering	PO1, PO2

7	**What is Cetane number?**	BTL-1	Remembering	PO1
8	**Explain the phenomenon of detonation in S.I Engine.**	BTL-1	Remembering	PO1
9	**What are the effects of knocking?**	BTL-1	Remembering	PO1
10	**Define the terms: (i) Indicated Power. (ii) Brake Power. (iii) Friction Power (or)Differentiate between Brake power and Indicated power.**	BTL-1	Remembering	PO1
11	**Differentiate between SFC and TFC in engine performance**	BTL-1	Remembering	PO1
12	**What is meant by IC Engine?**	BTL-1	Remembering	PO1
13	**What is meant by highest useful compression ratio?**	BTL-1	Remembering	PO1
14	**Compare the thermal efficiency of petrol engines with diesel engines. Give reasons**	BTL-1	Remembering	PO1, PO2
15	**Which is better efficient two stroke or four stroke engines? Why?**	BTL-1	Remembering	PO1
16	**. What is carburetor? State some functions of carburetor.**	BTL-1	Remembering	PO1
17	**What is meant by compensation in carburetor?**	BTL-1	Remembering	PO1
18	**List the various circuits available in the solex carburetor?**	BTL-1	Remembering	PO1
19	**What is the fuel injector?**	BTL-1	Remembering	PO1
20	**Define governing. State functions of governing.**	BTL-1	Remembering	PO1, PO2
21	**List out the advantages of electronic ignition system over the conventional systems.**	BTL-1	Remembering	PO1, PO2
22	**What is meant by lubrication system? State the methods of lubrication.**	BTL-1	Remembering	PO1
23	**What is meant by scavenging in I.C. Engines?**	BTL-1	Remembering	PO1
Q.No.	**Questions**	**BT Level**	**Competence**	**PO**
24	**How fuels are rated? Explain.**	BTL-1	Remembering	PO1, PO2
25	**What is "super charging" in diesel engine? And state its use.**	BTL-1	Remembering	PO1, PO2
26	**What are the different factors which influence knocking in petrol engines?**	BTL-1	Remembering	PO1, PO2
27	**What are the advantages of supercharging?.**	BTL-1	Remembering	PO1, PO6
28	**What is pre – ignition? How can be detected?**	BTL-1	Remembering	PO1, PO2
29	**. List out the factors affects the ignition lag.**	BTL-1	Remembering	
30	**What is auto ignition and why it occurs in SI engine?**	BTL-1	Remembering	
	PART-B			
1	Describe with suitable sketches the following system of a modern carburetor. (i) main metering system (ii) idling system (iii) economizer system (iv) accelerating pump system (v) choke.	BTL-2	Understanding	PO1, PO2

2	(i) With a neat sketch, explain the principle of work of diesel fuel injector (ii) A four-stroke, four-cylinder gasoline engine has a bore of 60mm and a stroke of 100 mm. On test it develops a torque of 66.5 N-m when running at 3000rpm. If the clearance volume in each cylinder is 60cc, the relative efficiency with respect to brake thermal efficiency is 0.5 and the calorific value of fuel is 42MJ/kg, determine the fuel consumption in kg/h and the brake mean effective pressure.	BTL-1 BTL-5	Remembering Evaluating	PO1
3	(i) Explain the pressure lubrication system with a neat sketch. Explain the bosch fuel injector with a neat sketch	BTL-2	Understanding	PO1
4	Air consumption for a four stroke petrol engine is measured by means of a circular orifice of diameter 3.5 cm. The coefficient of discharge for the orifice is 0.6 and the pressure across the orifice is 14 cm of water. The barometer reads 760 mm of Hg. The temperature of air in the room is $24^{O}C$. The piston displacement volume is 1800 cm^3. The compression ratio is 6.5. The fuel consumption is 0.13 kg/min and calorific value is 44000kJ/kg. The brake power developed at 2500 rpm is 28 kW. Determine (i) Air-Fuel ratio (ii) Volumetric efficiency on the basis of air alone (iii) Brake mean effective pressure (iv) Relative efficiency on brake thermal efficiency basis.	BTL-5	Evaluating	PO1
5	Discuss the difference between theoretical and actual valve timing diagrams of a diesel engine.	BTL-2	Understanding	PO1
6	Explain the phenomena of knocking in diesel engines. What are the different factors which influence knocking?	BTL-2	Understanding	PO1
7	A four-cylinder, four-stroke oil engine 10 cm in diameter and 15 cm in stroke develops a torque of 185 Nm at 2000 rpm. The oil consumption is 14.5 lit/hr. The specific gravity of the oil is 0.82 and calorific value of oil is 42,000 kJ/kg. If the IMEP taken from the indicator diagram is 6.7 bar, find (i) mechanical efficiency (ii) brake thermal efficiency (iii) brake mean effective pressure (iv) specific fuel consumption in litres on brake power basis. (16 Marks)	BTL-5	Evaluating	PO1
8	Write a note on lubrication system for an IC engine in detail with relevant sketches of various types.	BTL-2	Understanding	PO1, PO2
9	Explain how knocking taking place in S.I. engines and discuss the various factors which affect knocking in S.I engines	BTL-2	Understanding	PO1

10	i) Compare four stroke and two stroke cycle engine ii) Explain with a sketche the non-exhaust emission from a vehicle	BTL-2	Understanding	PO1
11	i During the test of 40 minutes on a single cylinder gas engine of 200 mm bore and 400 mm stroke, working on the four stroke cycle, the following readings were taken; total no of revolutions 9400, total no of explosion 4200 and area of indicator diagram 72 mm, spring number 0.8 bar/mm, brake load 540 N, brake diameter 2 cm, gas used 8.5 m^3, and calorific value 15900 kJ/m^3. Calculate i) Indicated power ii) Brake power and iii) Indicated and brake thermal efficiency. ii) Write short notes on SI and CI engine emissions	BTL-5	Evaluating	PO1

UNIT III *STEAM NOZZLES AND TURBINES*

Flow of steam through nozzles, shapes of nozzles, effect of friction, critical pressure ratio, supersaturated flow. Impulse and Reaction principles, compounding, velocity diagram for simple and multi-stage turbines, speed regulations –Governors.

PART-A

CO Mapping : C406.3

Q.No.	Questions	BT Level	Competence	PO
1	**What are the main classifications of steam turbine?**	BTL-1	Remembering	PO1
2	**What is meant by carry over loss?**	BTL-1	Remembering	PO1, PO2
3	**State the function of fixed blades.**	BTL-1	Remembering	PO1
4	**State the function of moving blades.**	BTL-1	Remembering	PO1, PO2
5	**Differentiate between impulse and reaction turbines**	BTL-2	Understanding	PO1, PO6
6	**Give examples of impulse turbine and reaction turbine?**	BTL-1	Remembering	PO1, PO6, PO7
7	**What is meant by degree of reaction?**	BTL-1	Remembering	PO1, PO6
8	**What are the three methods compounding?**	BTL-1	Remembering	PO1
9	**What is hypothetical indicator diagram?**	BTL-1	Remembering	PO1, PO6, PO7
10	**Explain pressure compounding**	BTL-1	Remembering	PO1, PO6, PO7

11	**Define diagram factor.**	BTL-1	Remembering	PO1, PO6, PO7
12	**Briefly explain the working of steam turbine.**	BTL-1	Remembering	PO1, PO6, PO7
13	**Define pure substance.**	BTL-1	Remembering	PO1, PO6, PO7
14	**Give the classification of steam turbine.**	BTL-1	Remembering	PO1
15	**Give the classification of steam turbines according to number of stages**	BTL-4	Analyzing	PO1
16	**Define impulse turbine.**	BTL-1	Remembering	PO1
17	**Define reaction turbine**	BTL-1	Remembering	PO1
18	**Define compounding of steam turbines**	BTL-1	Remembering	PO1
19	**Define velocity diagram.**	BTL-1	Remembering	PO1
20	**Define speed ratio.**	BTL-1	Remembering	PO1
21	**Define degree of Reaction (Rd).**	BTL-1	Remembering	PO1
22	**What are the assumptions required to derive maximum efficiency?**	BTL-1	Remembering	PO1
23	**What are the classifications of steam turbine on the basis of method of steam expansion?**	BTL-1	Remembering	PO1, PO6
24	**What are the classifications of steam turbine on the basis of number of blades?**	BTL-1	Remembering	PO1
25	**What are the classifications of steam turbine on the basis of steam flow direction?**	BTL-1	Remembering	
26	**What are the classifications of steam turbine on the basis of pressure of steam?**	BTL-1	Remembering	
27	**What are the external loses in turbine?**	BTL-1	Remembering	
28	**What are the internal loses in turbine?**	BTL-1	Remembering	
29	**What are the main constructional features of a turbine?**	BTL-1	Remembering	PO1
30	**What is supersaturated flow?**	BTL-1	Remembering	PO1
PART-B				
1	i)Define critical pressure ratio of a nozzle and discuss why attainment of sonic velocity determines the maximum discharge through steam nozzle. (10 Marks) ii)Explain the metastable expansion of steam in a nozzle with help of h-s diagram. (6 Marks)	BTL-6	Creating	PO1, PO6, PO7
2	A simple impulse turbine has one ring of moving	BTL-5	Evaluating	PO1, PO6, PO7

	blades running at 150 m/sec. The absolute velocity of steam at exit from the stage is 85 m/sec at angle of 80^{O} from the tangential direction. Blade velocity co-efficient is 0.82 and the rate of steam flowing through the stage is 2.5 kg/sec. If the blades are equiangular, determine (i) Blade angles (ii) Nozzle angle (iii) Absolute velocity of steam issuing from the nozzle (iv) Axial thrust.			
3	A convergent divergent nozzle required to discharge 2 kg of steam per second. The nozzle is supplied with steam at 7 bar and 180^{O}C and discharge takes place against a back pressure of 1 bar. The expansion up to throat is isentropic and the frictional resistance between the throat and the exit is equivalent to 63 kJ/kg of steam. Take approach velocity of 75 m/s and throat pressure 4 bar. Estimate (i) suitable areas for the throat and the exit (ii) overall efficiency of the nozzle based on the enthalpy drop between the actual inlet pressure and the temperature and the exit pressure	BTL-5	Evaluating	PO1, PO6, PO7
4	In a stage of impulse reaction turbine operating with 50% degree of reaction, the blades are identical in shape. The outlet angle of the moving blade is 19^{O} and the absolute discharge velocity of steam is 100m/s in the direction 70^{O} to the bottom of the blades. If the rate of flow through the turbine is 15000 kg/hr, calculate the power developed by the turbine.	BTL-5	Evaluating	PO1, PO6, PO7
5	Dry saturated steam at a pressure of 11 bar enters a convergent divergent nozzle and leaves at a pressure of 2 bar. If the flow is adiabatic and frictionless, determine (i) the exit velocity of steam (ii) ratio of cross section of exit and that at throat.	BTL-5	Evaluating	PO1, PO2, PO6
6	In a De Laval turbine steam issues from the nozzle with a velocity of 1200 m/s. The nozzle angle is 20^{O}, the mean blade velocity is 400 m/s and the inlet and outlet angles of blades are equal. The mass of steam flowing through the turbine per hour is 1000kg. Calculate (i) blade angles (ii) relative velocity of steam entering the blades (iii) Tangential force on blades (iv) power developed (v) blade efficiency. Take blade velocity co-efficient as 0.8.	BTL-5	Evaluating	PO1, PO2, PO6, PO7
7	Dry saturated steam at a pressure of 8 bar enters a convergent-divergent nozzle and leaves it at a pressure of 1.5 bar. If the flow is isentropic, and the corresponding expansion index is 1.133; find the ratio of cross-sectional area at exit and throat for maximum discharge.	BTL-5	Evaluating	PO1
8	The steam at 4.9 bar and 160^{O}C is supplied to a	BTL-5	Evaluating	PO1

	single stage impulse turbine at a mass flow rate of 30 kg/min, from where it is exhausted to a condenser at a pressure of 19.6 kPa. The blade speed is 300 m/s. The nozzles are inclined are inclined as 25^{O} to the plane of wheel and the outlet blade angle is 35^{O}. Neglecting friction losses, determine (i) theoretical power developed by the turbine (ii) diagram efficiency and (iii) stage efficiency.			
9	Steam enters a convergent divergent nozzle at 2 MPa and 400°C with a negligible velocity and a mass flow rate of 2.5 kg/s and it exits at a pressure of 300 kPa. The flow is isentropic between the nozzle entrance and throat and overall nozzle efficiency is 93 %. Determine i) throat area and ii) exit area	BTL-5	Evaluating	PO1
10	A gas expands in a **convergent divergent nozzle** from 5 bar to 1.5 bar, the initial temperature being 700°C and the nozzle efficiency is 90%. All the losses take place after the throat. For 1 kg/s mass flow rate of the gas, find throat and exit areas. Take n=1.4, R=287 J/kgK	BTL-5	Evaluating	PO1, PO2

UNIT IV AIR COMPRESSOR

Classification and working principle of various types of compressors, work of compression with and without clearance, Volumetric efficiency, Isothermal efficiency and Isentropic efficiency of reciprocating compressors, Multistage air compressor and inter cooling –work of multistage air compressor.

PART-A

CO Mapping : C803.4

Q.No.	Questions	BT Level	Competence	PO
1	List out the components of reciprocating air compressor.	BTL-1	Remembering	PO1
2	List out the types of air compressors.	BTL-1	Remembering	PO1, PO2
3	Define single acting compressor.	BTL-1	Remembering	PO1
4	Define double acting compressor.	BTL-1	Remembering	PO1
5	Define single stage compressor?	BTL-1	Remembering	PO1
6	Define multistage compressor?	BTL-1	Remembering	PO1
7	Define ratio of compression.	BTL-1	Remembering	PO1
8	Define free air delivered (FAD?	BTL-1	Remembering	PO1
9	Define displacement of the compressor.	BTL-1	Remembering	PO1
10	Define actual capacity of the compressor.	BTL-1	Remembering	PO1
11	List out the parts of a centrifugal compressor.	BTL-1	Remembering	PO1
12	Distinguish between rotary and reciprocating compressor.	BTL-1	Remembering	PO1

13	Define volumetric efficiency.	BTL-1	Remembering	PO1
14	Define clearance ratio?	BTL-1	Remembering	PO1, PO2
15	Define Isothermal Efficiency of air compressor.	BTL-1	Remembering	PO1
16	Define isentropic efficiency.	BTL-1	Remembering	PO1
17	Explain how flow of air is controlled in a reciprocating compressor.	BTL-1	Remembering	PO1
18	Mention the important applications of compressed air?	BTL-1	Remembering	PO1
19	What factors limit the delivery pressure in a reciprocating compressor	BTL-1	Remembering	PO1
20	Why clearance is necessary and what is its effect on the performance of reciprocating compressor.	BTL-1	Remembering	PO1
21	. Define mean effective pressure.	BTL-1	Remembering	PO1
22	Name the methods adopted for increasing isothermal efficiency of reciprocating air compressor.	BTL-1	Remembering	PO1
23	Which type of compression is the best in reciprocating compressor?	BTL-1	Remembering	PO1
24	What are the factors that affect the volumetric efficiency of a reciprocating compressor?	BTL-1	Remembering	PO1
25	Discuss the effect of clearance upon the performance of an air compressor?	BTL-1	Remembering	PO1, PO2
PART-B				
1	A two-stage air compressor consists of three cylinders having the same bore and stroke. The delivery pressure is 7 bar and the free air delivery is 4.3 m^3/min. Air is drawn in at 1.013 bar , and 15^OC and an intercooler cools the air to 38^OC. The index of compression is 1.3 for all three cylinders. Neglecting clearance calculate, (i) the intermediate pressure (ii) the power required to drive the compressor (iii) the isothermal efficiency	BTL-5	Evaluating	PO1
2	With a neat sketch, describe the construction and working of a single stage acting reciprocating air compressor. Also derive the equation for work done with clearance and without clearance.	BTL-2	Understanding	PO1
3	The FAD (free air delivered) of a single cylinder single stage air compressor is 2.5 m^3/min. The ambient is at 20C and 1.013 bar and delivery pressure is 7 bar. The clearance volume is 5% of the stroke volume and law of compression and expansion is $PV^{1.25}$=C. Stroke length is 20% more than that of the bore.Compressor runs at 150 rpm. Determine the mass of air per second, indicated power, indicated mean effective pressure and bore and stroke of the cylinder.	BTL-5	Evaluating	PO1

4	Explain the construction and working principle of centrifugal compressor and axial flow compressor with neat sketches.	BTL-2	Understanding	PO1
5	A single acting, single stage 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 swept volume. Assuming the index of compression and expansion to be 1.3. Find (i) volumetric efficiency of the compressor (ii) power required if the mechanical efficiency is 85% and (iii) speed of compressor (rpm).	BTL-5	Evaluating	PO1
6	In a single acting two stage reciprocating air compressor 4.5 kg of air per min. are compressed from 1.013 bar and 15^{O}C through a pressure ratio of 9 to 1. Both stage have the same pressure ratio, and the law of compression and expansion in both stages is $pV^{1.3}$=C. Calculate (i) the indicated power (ii) the cylinder swept volume required. Assume that the clearance volume of both stages are 5% of their respective swept volumes and that the compressor runs at 300 rpm.	BTL-5	Evaluating	PO1
7	A single acting air compressor takes in atmospheric air (atm condition 101.325 kPa, 27^{O}C) and delivers it at 1.4 MPa. The compressor runs at 300 rpm and has cylinder diameter of 160 mm and stroke 200 mm. Clearence volume is 5% of stroke volume. If the pressure and temperature of air at the end of suction stroke are 100kPa and 47^{O}C, and law of compression and expansion is $pV^{1.2}$=C, determine (i) mass of the sir delivered per minute (ii) volumetric efficiency (iii) driving power required, if mechanical efficiency is 85%.	BTL-5	Evaluating	PO1
8	A three stage air compressor with perfect intercooling takes 15 m^3 of air per minute at 95 kPa and 27^{O}C, delivers the air at 3.5 MPa. If compression process is polytropic ($pV^{1.3}$=C), determine (i) Power required if mechanical efficiency is 90% (ii) heat rejected in the intercoolers per minute (iii) isothermal efficiency (iv) heat rejected through cylinder walls per minute.	BTL-5	Evaluating	PO1
9	Derive an expression for the **minimum work required** for a two stage reciprocating air compressor with perfect inter-cooling and prove that the intercooler pressure is the geometric mean of the initial and final pressure.	BTL-2	Understanding	PO1
10	Write working principle of multi-stage reciprocating air compressor. Derive the condition for minimum	BTL-1	Remembering	PO1

	work output of two stage reciprocating air compressor and work output relation for multi stage reciprocating air compressor.			
11	A single –acting two stage air compressor deals with 4 m^3/min of air at 1.013 bar and 15° C with a speed of 250 rpm. The delivery pressure is 80 bar. Assuming, complete inter-cooling. Find the maximum power required by the compressor and the bore and stroke of the compressor. Assume a piston speed of 3 m/s, mechanical efficiency of 75% and volumetric efficiency of 80% per stage. Assume the polytropic index of compression in both the stage to be n=1.25 and neglect clearance.	BTL-5	Evaluating	PO1
12	A single stage single acting reciprocating air compressor has a bore of 20 cm and a stroke of 30 cm. The compressor runs at 600 rpm. The clearance volume is 4% of the swept volume and index if expansion and compression is 1.3. The suction conditions are 0.97 bar and 27°C and delivery pressure is 5.6 bar. The atmospheric conditions are at 1.01 bar and 17°C. Determine i) the free air delivered in m^3/min ii) the volumetric efficiency referred to the free air conditions iii) the indicated power.	BTL-5	Evaluating	PO1
13	i) A single stage single acting compressor delivers 15 m^3 of free air per minute from 1 bar to 8 bar. The speed of the compressor is 300 rpm. Assuming that compression and expansion follows the law $PV^{1.3}$ = Constant and clearance is 1/16th of swept volume, find the diameter and stroke of the compressor. Take L/D = 1.5. The temperature and pressure of air at the suction are same as atmospheric air. ii) For the same pressure ratio, discuss the advantages of multistage compression with inter cooling over single stage compression.	BTL-5	Evaluating	PO1
14	Explain with neat sketch the construction and working of Roots blower with two lobe and three lobe rotor and vane type compressor.	BTL-1	Remembering	PO1
15	2 kg/s of air enter the L.P cylinder of a two stage, reciprocating air compressor. The overall pressure ratio is 9. The air at inlet to the compressor is at 100 kPa and 35°C. The index of compression in each cylinder is 1.3. Find the inter-cooler pressure for perfect inter-cooling Also find the minimum power required for compression. Take R=0.287 kJ/kgK and Cp=1 kJ/kg K.	BTL-5	Evaluating	PO1

UNIT V REFRIGERATION AND AIR CONDITIONING

Refrigerants - Vapour compression refrigeration cycle- super heat, sub cooling – Performance calculations - working principle of vapour absorption system, Ammonia –Water, Lithium bromide – water systems (Description only) . Air conditioning system - Processes, Types and Working Principles. - Concept of RSHF, GSHF, ESHF- Cooling Load calculations.

PART-A

CO Mapping : C803.5

Q.No.	Questions	BT Level	Competence	PO
1	Define C.O.P. of a refrigeration system.	BTL-1	Remembering	PO1, PO5
2	Define refrigerator.	BTL-1	Remembering	PO1
3	Define heat pump.	BTL-1	Remembering	PO1, PO5
4	Define DPT and Degree of saturation.	BTL-1	Remembering	PO1
5	Define Relative humidity (RH) and Specific humidity.	BTL-1	Remembering	PO1
6	What are the classifications of air conditioning system?	BTL-1	Remembering	PO1
7	How does humidity affect human comfort?	BTL-1	Remembering	PO1, PO5
8	Define: RSHF, RTH.	BTL-1	Remembering	PO1
9	What are the various sources of heat gain of an air conditioned space?	BTL-1	Remembering	PO1, PO5
10	Define apparatus dew point (ADP) of cooling coil	BTL-1	Remembering	PO1
11	Define bypass factor (BPF) of a coil.	BTL-1	Remembering	PO1
12	What is psychrometry ?	BTL-1	Remembering	PO1
13	Define DPT and Degree of saturation.	BTL-1	Remembering	PO1
14	Define Relative humidity (RH) and Specific humidity.	BTL-1	Remembering	PO1, PO2
15	How does humidity affect human comfort?	BTL-1	Remembering	PO1, PO5
16	What are the various sources of heat gain of an air conditioned space?	BTL-1	Remembering	PO1, PO5
17	State the effects of very high and a very low bypass factor.	BTL-1	Remembering	PO1
18	What factors affect BPF?	BTL-1	Remembering	PO1, PO5
19	What are the requirements of comfort air conditioning?	BTL-1	Remembering	PO1, PO2
20	Define Effective Temperature (ET).	BTL-1	Remembering	PO1
21	What are the general comfort conditions during summer and winter?	BTL-1	Remembering	PO1
22	Differentiate between heat pump and refrigerator.	BTL-1	Remembering	PO1
23	What is dew point temperature?	BTL-1	Remembering	PO1, PO5
24	What is effective temperature?	BTL-1	Remembering	PO1
25	Define dew point depression.	BTL-1	Remembering	PO1

26	Define Dew point,Tdp	BTL-1	Remembering	PO1
27	What is meant by Absolute humidity?	BTL-1	Remembering	PO1
28	What is Humidity Ratio?	BTL-1	Remembering	PO1
PART-B				
1	Describe the following refrigeration systems with layout (i) Ammonia water system (ii) Lithium-bromide water system.	BTL-2	Understanding	PO1
2	(i) Describe the working principle of centralized air conditioning system and enumerate the need for it. (ii) List the loads that contribute to the overall cooling load.	BTL-2	Understanding	PO1
3	A food storage locker requires a refrigeration capacity of 50 kW. It works between a condenser temperature of 35^{O}C and an evaporator temperature of -10^{O}C. The refrigerant is ammonia. It is sub-cooled by 5^{O}C before entering the expansion valve by the dry saturated vapour leaving the evaporator. Assuming a single cylinder, single acting compressor operating at 1000 rpm with stroke equal to 1.2 times the bore. Determine (i) the power required (ii) the cylinder dimensions.	BTL-5	Evaluating	PO1, PO2, PO6
4	(i) Explain the centralized air conditioning system with a neat sketch 100 m^3 of air per minute at 15^{O}C DBT 80% RH is heated until its temperature is 22^{O}C. Calculate heat added to air per minute, RH of the heated air and wet bulb temperature of the heated air.	BTL-5	Evaluating	PO1, PO2, PO6
5	An ammonia refrigerator operates between evaporating and condensing temperatures of -16^{O}C and 50^{O}C respectively. The vapour is dry saturated at the compressor inlet, the compression process is isentropic and there is no undercooling of the condensate. Calculate (i) The refrigerator effect per kg (ii) The mass flow and power input per kw of refrigeration and (iii) COP.	BTL-5	Evaluating	PO1
6	. Saturated air leaving the cooling section of an air conditioning system at 14^{O}C at a rate of 50 m^3/min is mixed adiabatically with the outside air at 32^{O}C and 60% relative humidity at a rate of 20 m^3/min. assuming that the mixing process occurs at a pressure of 1 atm, determine the specific humidity, the relative humidity, the dry-bulb temperature and the volume flow rate of the mixture.	BTL-5	Evaluating	PO1
7	An air conditioning plant is required to supply 50 m^3 of air per minute at a DBT of 22^{O}C and 50% RH. The atmospheric condition is 32^{O}C with 65% RH. Determine the mass os moisture removed and	BTL-5	Evaluating	PO1

	capacity og cooling coil, if the required effect is obtained by dehumidification and sensible cooling process. Also calculate sensible heat factor.			
8	i) Explain the construction and working of vapour absorption refrigeration system with neat sketch. ii) Write the advantages and disadvantages of vapour absorption and vapour compression refrigeration system.	BTL-2	Understanding	PO1
9	i) Explain the working principle of vapour absorption refrigeration system and compare it with vapour compression refrigeration system. ii) A Freon vapour compression system operating at a condenser temperature of 40°C and an evaporator temperature of -5°C develops 15 tons of refrigeration. Using the p-h diagram for Freon 12, determine i) The mass flow rate of the refrigerant circulated. ii) the theoretical piston displacement of the compressor and piston displacement per ton of refrigeration. ii) The theoretical horse power of the compressor and horse power per ton of refrigeration iv) The heat rejected in the condenser.	BTL-5	Evaluating	PO1
10	i) Compare vapour compression and vapour absorption refrigeration system. ii) For a hall to be air-conditioned the following conditions are given: Outdoor condition 40°C DBT,20°C WBT, Required comfort condition 20°C DBT,60% RH, Seating capacity of hall-1500, Amount of outdoor air supply 0.3 m3/min per person, if the required condition is achieved first by adiabatic humidification and then by cooling, estimate a) the capacity of the cooling coli in tones and ii) The capacity of humidifier in kg/hr.	BTL-5	Evaluating	PO1, PO5

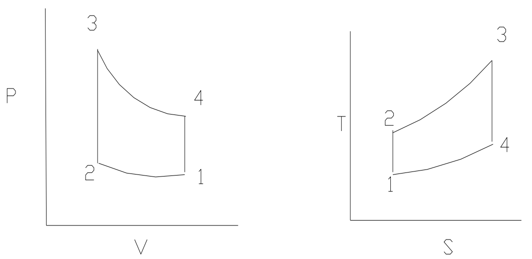
UNIT I GAS POWER CYCLES
Otto, Diesel, Dual, Brayton cycles, Calculation of mean effective pressure, and air standard efficiency - Comparison of cycles.
PART-A
1. Define Thermodynamic cycle. (OCT' 97)

Thermodynamic cycle is defined as the series of operations which takes place in a certain order and restore the initial conditions.

2. Define air standard cycle. (May'14, Dec'12, May'11)

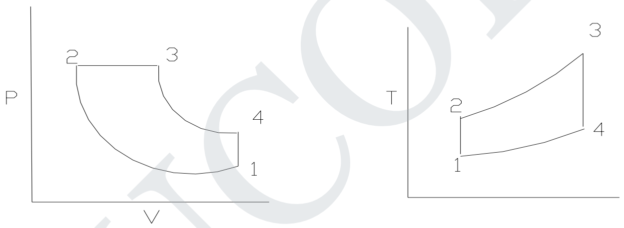
The theoretical cycle or air cycle approximation which is used to calculate conditions in an internal combustion engines is known as air standard cycle.

3. Draw the p-V & T-S diagram for Otto cycle. (APR'04)



1-2	Isentropic compression
2-3	Constant Volume Heating
3-4	Isentropic Expansion
4-1	Constant Volume Cooling

4. Draw the p-V & T-S diagram for Diesel cycle. (MAY'07)



1-2	Isentropic compression
2-3	Constant pressure Heating
3-4	Isentropic expansion
4-1	Constant volume Cooling

5. Mention the various processes of the Brayton cycle. (OCT'96)

1. Isentropic compression
2. Constant pressure heat supplied
3. Isentropic expansion
4. Constant pressure heat rejection.

6. Mention the four thermodynamic processes involved in Diesel cycle. (APR'08)

1. One reversible adiabatic compression
2. One constant pressure process
3. One reversible adiabatic expansion
4. One constant volume

7. Mention the various process of Dual cyale. (APR'96)

1. Isentropic compression
2. Constant volume heat addition
3. Isentropic expansion
4. Constant volume heat rejection

8. What are the assumptions made on air standard cycles? (MAY'16, NOV'16, MAY'15, MAY'13, May'11, JUNE'09)

The assumptions made are,

(i) Air is the working fluid, assumed to be a perfect gas.
(ii) Effect of colorific values of fuels is neglected by using hot and cold body contacts with the engine cylinder head for addition and rejection of heat respectively.
(iii) Frictionless.
(iv) No heat is either gained or lost during the cycle except during the contact of hot body and cold body with the cylinder head.

9. Define air standard efficiency of Diesel cycle. (DEC'08)

Air standard efficiency is defined as the ratio of work done by the cycle to the heat supplied to the cycle.

10. What are the functions of a flywheel? (MAY'15)

Flywheel serves as an energy reservoir. It stores energy during power stroke and releases energy during remaining strokes.

11. **Define compression ratio. (NOV'10, MAY'14)**

Compression ratio is defined as the ratio of volume fluid occupied when the piston reaches bottom dead centre position to the volume of fluid occupied when the piston reaches the top dead centre position.

$$R_C = 1 + \frac{V_S}{V_C}$$

12. Define cut-off ratio. (MAY'14)

Cut-off ratio is defined as the ratio of volume after the heat addition to the volume before the heat addition.

13. Which cycle is more efficient with respect to the same compression ratio? (OCT'95)

For the same compression ratio, Otto cycle is more efficient than Diesel cycle.

14. For the same compression ratio and heat supplied, state the order of decreasing air standard efficiency of Otto, Diesel and Dual cycle. (APR'98, OCT'98)

$\eta_{otto} > \eta_{Dual} > \eta_{Diesel}$

15. Name the factors that affect air standard efficiency of Diesel cycle. (APR'97)

Compression ratio and cut-off ratio

16. What is the effect of cut-off ratio on the efficiency of diesel cycle when the compression ratio is kept constant? (NOV'15, APR'03)

When the cut-off ratio of diesel cycle increases, the efficiency of cycle is decreased when the compression ratio kept constant and vice versa.

17. Define the term actual thermal efficiency and relative efficiency. (DEC'12)

Actual efficiency is defined as the ratio of work output by the cycle to the heat input to the cycle.

Relative efficiency is defined as the ratio between actual efficiency and air standard efficiency.

18. Define Mean Effective Pressure of an I.C Engine. (MAY'16, NOV'07)

Mean effective pressure is defined as the constant pressure acting on the piston during the working stroke. It is also defined as the ratio of work done to the stroke volume or piston displacement volume.

19. Name the various Gas power cycles.

1. Carnot cycle	2.Otto cycle	3.Diesel cycle
4. Brayton cycle	5.Dual combustion cycle	6.Atkinson cycle.

20. Define air standard efficiency.

It is defined as the ratio of net work transfer during the cycle to the net heat transfer to the cycle. It is also known as thermal efficiency.

$$\eta_a = \frac{Q_s - Q_r}{Q_s}$$

21. Define specific air consumption.

Specific air consumption is the quantity of working substance required for doing unit work transfer.

22. Define cylinder bore, stroke.

Bore: the cylinder diameter is known as cylinder bore.

Stroke: the distance through which the piston can travel between top dead center position and bottom dead centre is known as stroke.

23. Define clearance volume.

Clearance volume is defined as the volume occupied by the fluid when the piston reaches top dead centre. It is denoted by V_c

24. Define swept volume.

It is defined as the volume swept by the piston. When it moves between top dead centre and bottom dead centre. It is denoted by V_s

25. What is the expression for efficiency of Otto & Diesel cycle?

For Otto cycle,

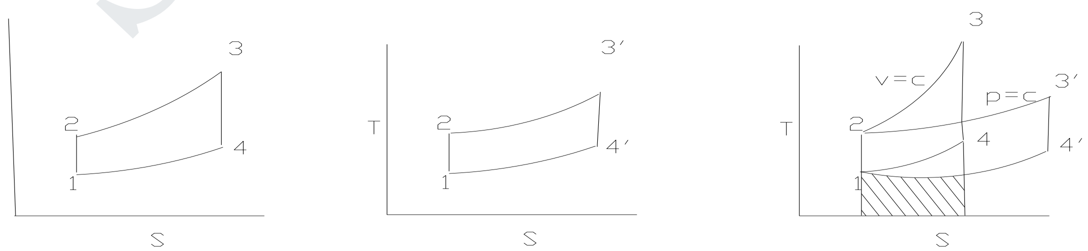
Efficiency, $\eta_{cy} = 1 - \left[\frac{1}{(r)^{\gamma-1}}\right]$ where $r = \frac{V_1}{V_2} = compression \quad ratio$

For Diesel cycle,

Efficiency, $\eta_{cy} = \left\{1 - \frac{\left[r_c^{\gamma} - 1\right]}{\gamma r^{\gamma-1}\left[r_c - 1\right]}\right\}$, *where* r_c=*Cut-off ratio*

26. Compare Otto and Diesel cycles.

Same Compression Ratio And Same Heat Input:



$\eta_D < \eta_O$ Same

Compression ratio $\frac{V_1}{V_2}$ = C

i.e., For same T_1, T_2 should be same for both the cycles.

Heat input is same

$$mC_v(T_3 - T_2) = mC_v(T_3^{'} - T_2)$$

we know that $C_p > C_v$

$(T_3^{'} - T_2) < (T_3 - T_2)$

$$\eta_o = 1 - \frac{(T_4 - T_1)}{(T_3 - T_2)}$$

$$\eta_o = 1 - \frac{(T_4^{'} - T_1)}{\gamma(T_3^{'} - T_2)}$$

27. What is the expression for efficiency of Dual cycle?

$$\eta_{cy} = \left\{ 1 - \frac{\left[r_c^{\gamma} r_p - 1 \right]}{r^{\gamma-1}\left\{ (r_p - 1) + \gamma r_p \left[r_c - 1 \right] \right\}} \right\}$$

Where r = Compression Ratio

r_c = *Cut-off ratio*

r_p = *Pressure ratio*

28. What is the expression for efficiency of Diesel cycle?

$$\eta = \left[1 - \frac{1}{(r_p)^{\frac{\gamma-1}{\gamma}}} \right]$$

Where r_p=*Pressure ratio*

29. What are all the modifications are carried out in Brayton cycle? Why? (APR/MAY 2015)

In Brayton cycles, the devices can be incorporated to increase its thermal efficiency such as (i) Regenerator (ii) Re heater and (iii) Intercooler, because of increasing thermal efficiency of the cycle.

30. What is the difference between otto and diesel cycle? (NOV'16, NOV'15)

Otto cycle	Diesel cycle
1. Otto cycle consist of two adiabatic and two constant volume process.	1. It consists of two adiabatic one constant volume and one constant pressure process.
2. Compression ratio is equal to expansion ratio	2. Compression ratio is greater than expansion ratio
3. Heat addition takes place at constant volume	3. Heat addition takes place at constant pressure.
4. Compression ratio is less. It is varies from 6 to 8.	4. Compression ratio is more. It varies from 12 to 18.

PART-B

1. 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 are 1 bar and 30^{O}C. Heat is added during constant pressure process upto 4 percent of the stroke. Assuming cylinder diameter and stroke length as 250mm and 300mm. Determine (i) The air standard efficiency of the cycle (ii) The power developed if the number of working cycles is 3 per second.(May/June 2016)

Refer: "Kothandaraman.C.P., Domkundwar. S,Domkundwar. A.V., "A course in thermal Engineering", Fifth Edition, " by Dhanpat Rai & sons , 2002

2. The swept volume of a diesel engine working on dual cycle is 0.0053m^3 and clearance volume is 0.00035m^3. The maximum pressure is 65 bar. Fuel injection ends at 5 percent of the stroke. The temperature and pressure at the start of the compression are 80^{O}C and 0.9 bar. Determine the air standard efficiency of the cycle. Take γ for air as 1.4. (MAY/JUNE 2016)

Refer: "Kothandaraman.C.P., Domkundwar. S,Domkundwar. A.V., "A course in thermal Engineering", Fifth Edition, " by Dhanpat Rai & sons , 2002

3.In a gas turbine plant working on the Brayton cycle the air at the inlet is at 27^{O}C, 0.1 MPa. The pressure ratio is 6.25 and the maximum temperature is 800^{O}C, The turbine and compressor efficiencies are each 80%. Find (i) the compressor work per kg of air (ii) the turbine work per kg of air (iii) the heat supplied per kg of air (iv) the cycle efficiency and (v) the turbine exhaust temperature.(NOV/DEC 2016)

Refer: "Kothandaraman.C.P., Domkundwar. S,Domkundwar. A.V., "A course in thermal Engineering", Fifth Edition, " by Dhanpat Rai & sons , 2002

4. Air enters the compressor of a gas turbine plant operating on Brayton cycle at 1 bar and 27^{O}C. The pressure ratio in the cycle is 6. If W_T =2.5 W_C where W_T and W_C are the turbine and compressor work respectively. Calculate the maximum temperature and the cycle efficiency (APRIL/MAY 2015)

Refer: "Kothandaraman.C.P., Domkundwar. S,Domkundwar. A.V., "A course in thermal Engineering", Fifth Edition, " by Dhanpat Rai & sons , 2002

5.An air standard dual cycle has a compression ratio of 10. The pressure and temperature at the beginning of compression are 1 bar and 27^{O}C. The maximum pressure reached is 42 bar and the maximum temperature is 1500^{O}C. Determine (i) The temperature at the end of constant volume heat addition (ii) cut-off ratio (iii) workdone per kg of air (iv) the cycle efficiency. Assume C_p=1.004 kJ/kg K and C_v= 0.717 kJ/kg K for air. (NOV/ DEC 2015)

Refer: "Kothandaraman.C.P., Domkundwar. S,Domkundwar. A.V., "A course in thermal Engineering", Fifth Edition, " by Dhanpat Rai & sons , 2002

6. The following data refers to the theoretical diesel cycle during air as the working fluid. Pressure at the end of the suction stroke = 1bar, Temperature at the end of the suction stroke = 30°C, Temperature at the end of the constant pressure heat addition = 1500°C, Compression ratio = 16, Specific heat at constant pressure =1.005 kJ/kgK, Specific heat at constant volume = 0.718 kJ/kgK. Find : i) The percentage of stroke at which cutoff place ii) Temperature at the end of the expansion iii) The ideal thermal efficiency. (Nov-Dec 2010)

Refer: "Kothandaraman.C.P., Domkundwar. S,Domkundwar. A.V., "A course in thermal Engineering", Fifth Edition, " by Dhanpat Rai & sons , 2002 "

7.A diesel engine operating on the air-standard Diesel cycle has six cylinders of 100 mm bore and 120 mm stroke. The engine speed is 1800 rpm. At the beginning of compression the pressure and temperature of air are 1.03 bar and 35°C. If the clearance volume is 1/8th of the stroke volume, Calculate i) The pressure and temperature at the salient points of the cycle, ii) The compression ratio, iii) The efficiency of the cycle and iv) The power output if the maximum temperature of the cycle is 1500°C. Assume C_p and C_v of air to be 1.004

kJ/kg K and 0.717 kJ/kg K respectively. (Nov/Dec 2011)   *Refer:* "Kothandaraman.C.P., Domkundwar. S,Domkundwar. A.V., "A course in thermal Engineering", Fifth Edition, " by Dhanpat Rai & sons , 2002 "
8.An engine working on Otto cycle has a volume of 0.45m^3, pressure 1 bar and temperature 30°C at the beginning of compression stroke. At the end of compression stroke, the pressure is 11 bar and 210 kJ of heat is added at const ant volume. Determine i) pressure, temperature and volumes at salient points in the cycle ii) efficiency, Percentage of clearance, mean effective pressure, ideal power developed by the engine if the number of working cycle per minute is 210. (May/June 2007 May/June 2011)   *Refer:* "Kothandaraman.C.P., Domkundwar. S,Domkundwar. A.V., "A course in thermal Engineering", Fifth Edition, " by Dhanpat Rai & sons , 2002 "
9. Derive an expression for the ideal efficiency of Diesel cycle, using ideal air as the working fluid with the aid of P-v and T-s diagrams. Sketch the Diesel cycle on P-V and T-S diagrams and derive the expression for its mean effective pressure. (Nov/Dec 2008 Nov/Dec 2011)   *Refer:* "Kothandaraman.C.P., Domkundwar. S,Domkundwar. A.V., "A course in thermal Engineering", Fifth Edition, " by Dhanpat Rai & sons , 2002 "
10. An air standard dual cycle has a compression ratio of 18, and compression begins at 1 bar, 40°C. The maximum pressure is 85 bar. The heat transferred to air at constant pressure is equal to that at constant volume. Estimate: i) The pressure and temperatures at the cardinal points of the cycle ii) The cycle efficiency and iii) The mean effective pressure of the cycle. (Nov-Dec 2012)   *Refer:* "Kothandaraman.C.P., Domkundwar. S,Domkundwar. A.V., "A course in thermal Engineering", Fifth Edition, " by Dhanpat Rai & sons , 2002 "

UNIT II INTERNAL COMBUSTION ENGINE
Classification - Components and their function. Valve timing diagram and port timing diagram - actual and theoretical p-V diagram of four stroke and two stroke engines. Simple and complete Carburettor. MPFI, Diesel pump and injector system. Battery and Magneto Ignition System - Principles of Combustion and knocking in SI and CI Engines. Lubrication and Cooling systems. Performance calculation.
PART-A
1. What is meant by scavenging in I.C. Engines? (MAY'13, NOV'10, APR'03)   The process of removing burnt exhaust gases from the combustion chamber of the engine cylinder using the fresh incoming charge is known as scavenging.
2. Differentiate between ideal and actual valve timing diagrams of a petrol engine. (OCT'01)

Theoretical valve timing diagram:

In theoretical valve timing diagram, inlet and exhaust valves open and close at both at dead centers. Similarly, all the process sharply completed at the TDC or BDC.

Actual valve timing diagram:

The inlet valve opens 10-30^o before the TDC. The air fuel mixture is sucked into the cylinder till the inlet valve closes.

The inlet valve closes 30-40^o or even 60^o after BDC. The charge is compressed till the spark occurs.

The spark is produced 20-40^o before the TDC. This gives sufficient time for fuel to burn. The pressure and temperature increase. The burnt gases expand till the exhaust valve opens.

The Exhaust valve opens 30-60^o before the BDC. The exhaust gases are forced out from the cylinder till the exhaust valve closes.

The exhaust valve closes 8-20^o after the TDC. Before it closes, again the inlet valve opens 10-30^o before TDC.

3. What are the important requirements of fuel injection system? (NOV'15, NOV'07)

- The beginning as well as end of injection should take place sharply.
- Inject the fuel at correct time in the cycle throughout the speed range of the engine.
- The injection of fuel should occur at the correct rate and in correct quantity as required by the varying engine load.
- Atomize the fuel to the required degree
- Distribute the fuel throughout the combustion chamber for better mixing.

4. Mention different types of fuel injection systems in IC Engines. (APR'99)

a. Air injection systems
b. Airless injection system
   1. Common rail system
   2. Individual pump system

5. What is the purpose of a thermostat in an engine cooling system? (NOV'15, APR'03)

A Thermostat valve is used in the water cooling system to regulate the circulation of water in system to maintain the normal working temperature of the engine parts during the different operating conditions.

6. What is meant by ignition delay? (NOV'03)

In the actual engine cylinder, there is a certain time interval between the instant of spark and the instant of pressure rise due to combustion. This time interval or time lay is known as "*Ignition Lag*" or "*Ignition Delay*" or "*Delay Period*".

7. What is Cetane number? (APR'03)

The property that quantities the ignition delay is called cetane number.

8. Explain the phenomenon of detonation in S.I Engine. (MAY'16, NOV'10)

If the temperature of the un burnt mixture exceeds the self ignition temperature during the ignition delay period, auto ignition occurs at various locations in the cylinder. This will generate pressure pulses. These high pressure pulses can cause damage to the engine and quite often are in the audible frequency range. This phenomenon is often called knocking or detonation.

9. What are the effects of knocking? (MAY'07)

The Impact on the engine components and structures may cause failures and creates undesirable noise which is always objectionable.

The lack of control of combustion process leads to pre ignition and local overheating. Therefore piston may be damaged by overheating.

The pressure differences in the combustion chamber cause the gas to vibrate and scrub the chamber walls causing increased loss of heat to the coolant.

Detonation results in increased carbon deposits on the wall of the cylinder.

Due to increase in the rate of heat transfer, the power outputs as well as efficiency of the engine will decreases.

10. Define the terms: (i) Indicated Power. (ii) Brake Power. (iii) Friction Power (or) Differentiate

between Brake power and Indicated power. (APR'03)

(i) Indicated power is defined as the power actually developed by the engine in the engine cylinder.

(ii) Brake power is defined as the power available at the crankshaft. It is always less than the indicated power.

(iii) Friction power is the difference between indicated power and the brake power. Actually friction power is the power lost due to engine friction.

i.e FP = IP – BP

11. Differentiate between SFC and TFC in engine performance. (NOV'03)

SFC is defined as the amount of fuel consumed of fuel consumed per brake power hour of work.

12. What is meant by IC Engine?

The internal combustion engine (IC Engine) is a heat engine that converts chemical energy in a fuel into mechanical energy. Chemical energy of a fuel is first converted into thermal energy by means of energy of a fuel is first converted into thermal energy by means of combustion or oxidation with air inside the engine. This thermal energy is converted into useful work through mechanical mechanism of the engine.

13. What is meant by highest useful compression ratio?

The compression ratio which gives maximum efficiency is known as highest useful compression ratio.

14. Compare the thermal efficiency of petrol engines with diesel engines. Give reasons.

Thermal efficiency of diesel engine is greater than petrol engine. This is due to high compression ratio.

15. Which is better efficient two stroke or four stroke engines? Why?

Two stroke engine gives always lesser efficiency than four stroke engine due to incomplete combustion and poor scavenging.

16. What is carburetor? State some functions of carburetor.

A carburetor is a device which vaporizes the fuel and mixed it with the air.

a. It maintains a small reserve of petrol in the float chamber at a constant head.
b. It atomizes and vaporizes the fuel.
c. It prepares a mixture of petrol and air in correct proportion.
d. It supplies a fine spray of petrol.

17. What is meant by compensation in carburetor?

The process of providing additional air or fuel when it requires maintaining the correct air fuel mixture is called compensation in carburetor.

18. List the various circuits available in the solex carburetor?

a. Starting circuits.
b. Normal running circuits
c. Acceleration circuit
d. Idling circuit and slow running circuit.

19. What is the fuel injector?

Fuel injector is used in diesel engine to inject and atomize the diesel at the compression stroke into the combustion chamber.

20. Define governing. State functions of governing.

Governing is the process of varying the fuel supply. It is done to maintain constant speed through the load is changed.

21. List out the advantages of electronic ignition system over the conventional systems. (NOV'03)

The parts such as reluctor, magnetic pick up and electronic control module are not subjected to wear and tear as a mechanical contact breaker.

a. Periodic adjustment of engine timing is not necessary.
b. It gives very accurate control of timing.

22. What is meant by lubrication system? State the methods of lubrication.

The process of reducing the friction between moving parts is known lubrication.

- Petrol lubrication or mist lubrication system

- Wet sump and
- Dry sump

23. What is meant by scavenging in I.C. Engines?

The process of removing burnt exhaust gases from the combustion chamber of the engine cylinder using the fresh incoming charge is known as scavenging.

24. How fuels are rated? Explain.

The rating of a SI engine fuel is done by comparing its performance with that of a standard reference fuel which is usually a combination of iso – octane and n-heptane called octane number.

The rating of a SI engine fuel is established by compounding the test fuel to two standard reference fuels. The fuel component n-cetane number value of 100, while alpha methylnaphthalene, $C_{11}H_{10}$, is given the value of 0 called cetane numbers.

25. What is "super charging" in diesel engine? And state its use.

Supercharging is the process of forcing of air fuel mixture or air alone into the engine cylinder during the suction stroke at a pressure greater than that of atmospheric pressure. It is done to increase the density of air fuel mixture. Or air admitted into the engine cylinder.

26. What are the different factors which influence knocking in petrol engines?

Temperature factors, density factors, time factors, and composition factors.

27. What are the advantages of supercharging?

- Complete combustion of mixture takes place inside the combustion of mixture takes place inside the combustion chamber which increases the power output of the engine.
- The turbulence caused by supercharging assist in better mixing of fuel and air particles.
- Possibility of knocking is reduced in C.I. Engines.
- Specific fuel consumption is less due to complete combustion of air fuel mixture.
- Mechanical and thermal load carrying capacity of the engine increases with increase in supercharging.
- The exhaust gas temperature us reduced and there will be better scavenging.

28. What is pre – ignition? How can be detected?

Pre ignition is defined as phenomenon of ignition of the charge before the ignition spark occurs. Carbon particles in the combustion chamber are over heated under certain operating conditions.

PART-B

1	Describe with suitable sketches the following system of a modern carburetor. (i) main metering system (ii) idling system (iii) economizer system (iv) accelerating pump system (v) choke.	**May/June 2016**

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2	(iii) With a neat sketch, explain the principle of work of diesel fuel injector (iv) A four-stroke, four-cylinder gasoline engine has a bore of 60mm and a stroke of 100 mm. On test it develops a torque of 66.5 N-m when running at 3000rpm. If the clearance volume in each cylinder is 60cc, the relative efficiency with respect to brake thermal efficiency is 0.5 and the calorific value of fuel is 42MJ/kg, determine the fuel consumption in kg/h and the brake mean effective pressure.	**May/June 2016**

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3	(i) Explain the pressure lubrication system with a neat sketch. (ii) Explain the bosch fuel injector with a neat sketch.	**Nov/Dec 2016**
Refer:"Thermal Engineering" by Dr.R.K.Rajput Page No:		
4	Discuss the difference between theoretical and actual valve timing diagrams of a diesel engine.	**Apr/May 2015**
Refer:"Thermal Engineering" by Dr.R.K.Rajput Page No:		
5	Compare SI and CI engines with respect to i) Basic cycle ii) Introduction of fuel iii) Fuel used iv) ignition v) Compression ratio vi) Speed vii) efficiency viii) Weight (16 Marks)	Nov-Dec 2012
Refer:"Thermal Engineering" by Dr.R.K.Rajput Page No:		
6	Explain the phenomena of knocking in diesel engines. What are the different factors which influence knocking?	**Apr/May 2015**
Refer:"Thermal Engineering" by Dr.R.K.Rajput Page No:		
7	A four-cylinder, four-stroke oil engine 10 cm in diameter and 15 cm in stroke develops a torque of 185 Nm at 2000 rpm. The oil consumption is 14.5 lit/hr. The specific gravity of the oil is 0.82 and calorific value of oil is 42,000 kJ/kg. If the IMEP taken from the indicator diagram is 6.7 bar, find (i) mechanical efficiency (ii) brake thermal efficiency (iii) brake mean effective pressure (iv) specific fuel consumption in litres on brake power basis. (16 Marks)	**Nov/Dec 2015**
Refer:"Thermal Engineering" by Dr.R.K.Rajput Page No:		
8	Write a note on lubrication system for an IC engine in detail with relevant sketches of various types. (16 Marks)	**Nov/Dec 2015**
Refer:"Thermal Engineering" by Dr.R.K.Rajput Page No:		
9	Explain how knocking taking place in S.I. engines and discuss the various factors which affect knocking in S.I engines. (16 Marks)	Nov-Dec 2010 Nov/Dec 2006 (1)
Refer:"Thermal Engineering" by Dr.R.K.Rajput Page No:		
10	i) Compare four stroke and two stroke cycle engine ii) Explain with a sketche the	May/June

	non-exhaust emission from a vehicle. (9+7 marks)	2009

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UNIT III - STEAM NOZZLES AND TURBINES

Flow of steam through nozzles, shapes of nozzles, effect of friction, critical pressure ratio, supersaturated flow. Impulse and Reaction principles, compounding, velocity diagram for simple and multi-stage turbines, speed regulations –Governors.

PART-A

1. What are the main classifications of steam turbine?

1. On the basis of method of steam expansion
   a. Impulse turbine.
   b. Reaction turbine.
   c. Combination of impulse and reaction turbine
2. On the basis of number of stages.
   a. Single stage turbines
   b. Multi stage turbines
3. On the basis of steam flow directions
   a. Axial turbine.
   b. Radial turbine
   c. Tangential turbine.
   d. Mixed flow turbine.
4. On the basis of pressure of steam
   a. High pressure turbine
   b. Low pressure turbine
   c. Medium pressure turbine

2. State the function of fixed blades.

The function of fixed blades is that they guide the steam as well as allow it to expand a larger velocity

3. State the function of moving blades.

- It converts the kinetic energy of the steam into useful mechanical energy.
- The steam expands while flowing over the moving blades and thus gives reaction to the moving blades. Hence the turbine is called as reaction turbine.
- The velocity of the steam decreases as the kinetic energy of the steam absorbed.

4. Differentiate between impulse and reaction turbines. (MAY'16, MAY'11, DEC'10, APR'04)

Si. No.	Impulse Turbine	Reaction Turbine
1.	It consists of nozzle and moving blades.	It consists of fixed blades and moving blades.
2.	Pressure drops occurs only in nozzles not in moving blades.	Pressure drop occurs in fixed as well as moving blades.
3.	Steam strikes the blade with kinetic energy.	Steam passes over the moving blades with pressure and kinetic energy.
4.	It has constant blade channels area.	It has varying blade channels area.
5.	Due to more pressure drop per blade, number of stages required is less.	Number of stages required is more due to more pressure drop.

5. Give examples of impulse turbine and reaction turbine?

Impulse turbine – De level, curties and rateau

Reaction turbine – Parson

6. What is meant by degree of reaction?

Degree of reaction is defined as the ratio of enthalpy drop in moving blades to total enthalpy in the fixed and moving blades (stage)

.

7.What are the three methods compounding?

1. Velocity compounding 2. Pressure compounding 3.Pressure – velocity compounding

.

8. What is hypothetical indicator diagram?

The theoretical cycle of the steam engine work on the Rankine cycle. The hypothetical indicator diagram is the theoretical indicator diagram of a steam engine when there is no loss during the cycle.

9.Explain pressure compounding. (MAY'15)

The steam from the boiler is passed through the nozzle rings and moving blade rings alternately. When the steam expands through nozzle, pressure of the steam decreases and velocity increases. When the steam flows over moving blades, velocity of steam decrease and pressure remain constant. Then the steam again expanded in the nozzle. This process is continued till the pressure of the steam is reduced from boiler pressure to condenser pressure. The pressure of steam is reduced in each stage of nozzle ring and hence it is known as pressure compounding.

10. Define diagram factor.

The ratio of the actual indicator diagram to the hypothetical indicator diagram is known as diagram factor.

i.e., $k = \dfrac{\text{Area of actual indicator diagram}}{\text{Area of hypothetical indicator diagram}}$

11. Briefly explain the working of steam turbine.

Steam turbine consists of a nozzle and a rotary blade wheel. In the nozzle, the steam is expanded from a high pressure to a low pressure. Due to this fall in pressure, a certain amount of heat energy is converted into kinetic energy which causes the increase in velocity of steam. The steam with high velocity flows over a curved blades and its direction of motion changed. This causes a change of momentum and force. This constitutes the rotation of turbine shaft.

.

12. Define pure substance.

A pure substance is defined as a homogeneous material which retains its chemical composition even though there may be a change of phase.

13.Give the classification of steam turbine. Steam turbines are classified as :

a. Impulse turbine b. Reaction turbine

.

14. Give the classification of steam turbines according to number of stages.

According to the numberof stages, steam turbines are classifed as :

a. Single stage turbine.

b. Multi stage turbine

15. Define impulse turbine. (DEC'11)

If at the inlet of the turbine, the energy available is only kinetic energy, then the turbine is known as impulse turbine. eg: curties turbine

.

16. Define reaction turbine. (DEC'11)

If at the inlet of the turbine, the water possesses kinetic energy as well as pressure energy , then the turbine is known as reaction turbine. eg. parson's turbine.

.

17. Define compounding of steam turbines. (NOV'15, NOV'10)

Compounding is defined as the method used for reducing rotor speed and sharing the loss of kinetic energy in stages in an impulse turbine is known as compounding.

18.Define velocity diagram.

Velocity diagrams are defined as diagrams drawn to determine rate of change of momentum of steam during the flow, through the moving blade in order to find force on the blades.

19. Define speed ratio.

Speed ratio (ρ) is defined as the ratio of tangential velocity of the blade (V) to absolute velocity of steam at inlet of moving blade (Va_l).

$\rho = V / Va_l$

.

20. Define degree of Reaction (Rd). (MAY'14, APR'04)

The degree of reaction in an impulse reaction turbine is defined as the ratio of enthalpy drop in moving

blades to enthalpy drop in the stage. $$R_d = \frac{\text{Enthalpy drop in moving blades}}{\text{Enthalpy drop in the stage}}$$
21. What are the assumptions required to derive maximum efficiency? The assumptions are, i. The degree of reaction is 50% ii. The moving and fixed blades are of the same shape iii. The velocity of steam at exit from the proceeding stage is same as the velocity of steam at the entrance to the succeeding stage.
22. What are the classifications of steam turbine on the basis of method of steam expansion? Impulse turbine. Reaction turbine. Combination of impulse and reaction turbine .
23. What are the classifications of steam turbine on the basis of number of blades? Single stage turbines Multi stage turbines .
24. What are the classifications of steam turbine on the basis of steam flow direction? Axial turbine. Radial turbine Tangential turbine. Mixed flow turbine. .
25. What are the classifications of steam turbine on the basis of pressure of steam? High pressure turbine Low pressure turbine Medium pressure turbine
26. What are the external loses in turbine? ESV & strainer losses Governing losses (throttling losses) Leaving Energy Losses (Latent heat of exhaust steam in condenser) Radiation Loss to the surroundings .
27. What are the external loses in turbine?

28.What are the internal loses in turbine?

Blade losses

Primary Losses:

Friction loss due to profile surface finish

Secondary Losses:

Impingement loss

.

29. What are the main constructional features of a turbine?

Casing, Rotor and Control stage

30. What is supersaturated flow? (MAY'15)

When the supersaturated steam is expanded in the nozzle, the condensation should occur in the nozzle. Since the steam has a great velocity, the condensation does not take place at the expected rate. So, the equilibrium between liquid and vapour phase is delayed and the steam continues to expand in a dry state. The steam in such set of condition is said to be supersaturated or metastable flow.

31. What is the effect of friction on the flow through a steam nozzle? (NOV'15)(NOV'16)

(i) The dryness fraction of the steam is increased
(ii) Entropy and specific volume of the steam are increased
(iii) Exit velocity of the steam is reduced
(iv) Mass of steam discharged is increased

PART-B

1..i)Define critical pressure ratio of a nozzle and discuss why attainment of sonic velocity determines the maximum discharge through steam nozzle. (10 Marks) ii)Explain the metastable expansion of steam in a nozzle with help of h-s diagram. (6 Marks)	**May/June 2016**

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2.

A simple impulse turbine has one ring of moving blades running at 150 m/sec. The absolute velocity of steam at exit from the stage is 85 m/sec at angle of 80^{O} from the tangential direction. Blade velocity co-efficient is 0.82 and the rate of steam flowing through the stage is 2.5 kg/sec. If the blades are equiangular, determine (i) Blade angles (ii) Nozzle angle (iii) Absolute velocity of steam issuing from the nozzle (iv) Axial thrust.	**May/June 2016**

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	(i) Explain the pressure lubrication system with a neat sketch. e xplain the bosch fuel injector with a neat sketch.	**Nov/Dec 2016**
	Refer: "Thermal Engineering" by Dr.R.K.Rajput Page No:	
4	Air consumption for a four stroke petrol engine is measured by means of a circular orifice of diameter 3.5 cm. The coefficient of discharge for the orifice is 0.6 and the pressure across the orifice is 14 cm of water. The barometer reads 760 mm of Hg. The temperature of air in the room is $24^{O}C$. The piston displacement volume is 1800 cm^3. The compression ratio is 6.5. The fuel consumption is 0.13 kg/min and calorific value is 44000kJ/kg. The brake power developed at 2500 rpm is 28 kW. Determine (i) Air-Fuel ratio (ii) Volumetric efficiency on the basis of air alone (iii) Brake mean effective pressure (iv) Relative efficiency on brake thermal efficiency basis.	**Nov/Dec 2016**
	Refer: "Thermal Engineering" by Dr.R.K.Rajput Page No:	
5	Discuss the difference between theoretical and actual valve timing diagrams of a diesel engine.	**Apr/May 2015**
	Refer: :"Thermal Engineering" by Dr.R.K.Rajput , Page No:	
6	Explain the phenomena of knocking in diesel engines. What are the different factors which influence knocking?	**Apr/May 2015**
	Refer: "Thermal Engineering" by Dr.R.K.Rajput , Page No:	
7	A four-cylinder, four-stroke oil engine 10 cm in diameter and 15 cm in stroke develops a torque of 185 Nm at 2000 rpm. The oil consumption is 14.5 lit/hr. The specific gravity of the oil is 0.82 and calorific value of oil is 42,000 kJ/kg. If the IMEP taken from the indicator diagram is 6.7 bar, find (i) mechanical efficiency (ii) brake thermal efficiency (iii) brake mean effective pressure (iv) specific fuel consumption in litres on brake power basis. (16 Marks)	**Nov/Dec 2015**
	Refer: "Thermal Engineering" by Dr.R.K.Rajput , Page No:	
8	Write a note on lubrication system for an IC engine in detail with relevant sketches of various types. (16 Marks)	**Nov/Dec 2015**

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9. Explain how knocking taking place in S.I. engines and discuss the various factors which affect knocking in S.I engines. (16 Marks)	Nov-Dec 2010 Nov/Dec 2006 (1)	Nov-Dec 2010 Nov/Dec 2006 (1)

Refer :"Thermal Engineering" by Dr.R.K.Rajput, Page No:

10 i) Compare four stroke and two stroke cycle engine ii) Explain with a sketche the non-exhaust emission from a vehicle. (9+7 marks)	May/June 2009

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UNIT IV – AIR COMPRESSOR

Classification and working principle of various types of compressors, work of compression with and without clearance, Volumetric efficiency, Isothermal efficiency and Isentropic efficiency of reciprocating compressors, Multistage air compressor and inter cooling –work of multistage air compressor

.

PART-A

1.List out the components of reciprocating air compressor.

The components of reciprocating air compressor are,

i. Cylinder ii. Outlet valve iii. Piston
iv. Connecting rod v. Inlet valve

2.List out the types of air compressors.

The types of air compressors are,

i. Single acting compressor ii. Double acting compressor
iii. Single stage compressor iv. Multistage compressor.

2. Define single acting compressor.

Single acting compressor is a reciprocating compressor in which suction, compression and delivery of the air takes place on one side of the piston only. It has only one delivery stroke per revolution of crankshaft.

3. Define double acting compressor.

Double acting compressor is a reciprocating compressor in which sqction, compression and delivery of the air takes place on both sides of the piston. It has two delivery stroke per revolution of the crankshaft.

4. Define single stage compressor.

Single stage compressor is a compressor in which compression of air from initial pressure to final pressure is carried out in one cylinder only. It is used when pressure ratio is low.

5. Define multistage compressor.

When the compression of air from initial pressure to final pressure is carried out in more than one cylinder arranged in series, then the compressor is known as multistage compressor. It is necessary when the pressure ratio is high.

6. Define ratio of compression.

Ratio of compression is the ratio of absolute discharge pressure to absolute inlet pressure. It is also known as pressure ratio.

7. Define displacement of the compressor.

The swept volume of the piston is known as displacement of the compressor

8. Define actual capacity of the compressor.

The actual free air delivered per cycle (or) per minute is known as actual capacity of the compressor. The actual capacity is always less than displacement. It is expressed in cubic meter of free air per minute.

9. List out the parts of a centrifugal compressor.

The parts of a centrifugal compressor are

i. Rotating impeller ii. Diffuser iii. Casing

10. Distinguish between rotary and reciprocating compressor.

Rotary compressor	Reciprocating compressor
1. the maximum free air delivered is 3000 m^3 / min	The maximum free air delivered is 300 m3 / min.
2. These are smaller in size for the same discharge.	These are larger in size for the same discharge.
3. Lubricating system is simple.	Lubricating system is complicated.
4. There is no balancing	Balancing is the major problem
5. The air delivered is clean because it does not come in contact with lubricating oil.	The air delivered is not clean as it has contact with lubricating oil.
6. The speed is high.	The speed is low.

11. Define volumetric efficiency. **(MAY'16, MAY'15)**

Volumetric efficiency is defined as the ratio of volume of free air sucked into the compressor per cycle to the stroke volume of the cylinder.

12. Define clearance ratio.

It is defined as the ratio of clearance volume to swept volume (or) stroke volume.

13.Define Isothermal Efficiency of air compressor.

It is defined as the ratio of isothermal work to Indicated work.

14. Compare the petrol and LPG?

PETROL	LIQUIED PETROLEM GAS
Octane rating of petrol is 81	Octane rating of LPG is 110.
Petrol has odours	LPG is odourless.
In order to increase octane number	LPG is lead free with high Octane number.

15. Define isentropic efficiency.

16. Explain how flow of air is controlled in a reciprocating compressor.

The flow of air is controlled by centrifugal governor, or by maintaining the speed of motor constant or by providing the air pocket advancement to the cylinder.

17. Mention the important applications of compressed air.

Compressed air used in,

1. Pneumatic brakes
2. Pneumatic drills
3. Spray painting
4. Pneumatic Jacks
5. Air conditioning
6. Refrigeration

18. What factors limit the delivery pressure in a reciprocating compressor

1. To obtain high delivery pressure the size of the cylinder will be large.
2. Temperature of Air.

19. Why clearance is necessary and what is its effect on the performance of reciprocating compressor.

When the piston reaches top dead center in the cylinder, there is a dead space between piston top and cylinder head. This space is known as clearance space and the volume occupied by this space is known as clearance volume.

21. Define mean effective pressure.

Mean effective pressure is defined as hypothetical pressure, which is considered to be acting on the piston IP throughout the power stroke.

22. **Name the methods adopted for increasing isothermal efficiency of reciprocating air compressor.**

Isothermal efficiency is increased by perfect internal cooling.

. Which type of compression is the best in reciprocating compressor?

Isothermal compression.

24. What are the factors that affect the volumetric efficiency of a reciprocating compressor? (MAY'16)

1.Clearance volume. 2.Compression ratio.

25. Discuss the effect of clearance upon the performance of an air compressor.

The volumetric efficiency of air compressor increases with decreasing the clearance of the compressor. The free air delivered by the compressor is increased by decreasing the clearance volume.

26. What is meant by inter cooler?

An inter cooler is a simple heat exchanger. It exchanges the heat of compressed air from the low pressure compressor to the circulating water before the air enters to the high pressure compressor. The purpose of inter cooling is to minimize the work of compression.

27. What are the the classification of reciprocating compressors?

In-line compressors, "V"-shaped compressors, Tandem Piston compressors. Single-acting compressors, Double-acting compressors, and Diaphragm compressors.

28. What are the types of rotary compressors?

Screw compressors, Vane type compressors, Lobe and scroll compressors and other types.

29. What are the types Under the Roto-dynamic compressors?

Centrifugal compressors, and the Axial flow compressors.

31. How compressors are classified based on other aspects?

Number of stages, Cooling method and medium, Drive types Lubrication method and Service Pressure

PART-B

1	A two-stage air compressor consists of three cylinders having the same bore and stroke. The delivery pressure is 7 bar and the free air delivery is 4.3 m^3/min. Air is drawn in at 1.013 bar , and 15^{O}C and an intercooler cools the air to 38^{O}C. The index of compression is 1.3 for all three cylinders. Neglecting clearance calculate, (i) the intermediate pressure (ii) the power required to drive the compressor (iii) the isothermal efficiency	**May/June 2016**

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2	With a neat sketch, describe the construction and working of a single stage acting reciprocating air compressor. Also derive the equation for work done with clearance and without clearance.	**May/June 2016**

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3	The FAD (free air delivered) of a single cylinder single stage air compressor is 2.5 m^3/min. The ambient is at 20C and 1.013 bar and delivery pressure is 7 bar. The clearance volume is 5% of the stroke volume and law of compression and expansion is $PV^{1.25}$=C. Stroke length is 20% more than that of the bore.Compressor runs at 150 rpm. Determine the mass of air per second, indicated power, indicated mean effective pressure and bore and stroke of the cylinder. (16 Marks)	**Nov/Dec 2016**

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4	Explain the construction and working principle of centrifugal compressor and axial flow compressor with neat sketches.	**Nov/Dec 2016**

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5	A single acting, single stage 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 swept volume. Assuming the index of compression and expansion to be 1.3. Find (i) volumetric efficiency of the compressor (ii) power required if the mechanical efficiency is 85% and (iii) speed of compressor (rpm).	**April/May 2015**

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6	In a single acting two stage reciprocating air compressor 4.5 kg of air per min. are compressed from 1.013 bar and 15^{O}C through a pressure ratio of 9 to 1. Both stage have the same pressure ratio, and the law of compression and expansion in both stages is $pV^{1.3}$=C. Calculate (i) the indicated power (ii) the cylinder swept volume required. Assume that the clearance volume of both stages are 5% of their respective swept volumes and that the compressor runs at 300 rpm.	**April/May 2015**

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7	A single acting air compressor takes in atmospheric air (atm condition 101.325 kPa, 27^{O}C) and delivers it at 1.4 MPa. The compressor runs at 300 rpm and has cylinder diameter of 160 mm and stroke 200 mm. Clearence volume is 5% of stroke volume. If the pressure and temperature of air at the end of suction stroke are 100kPa and 47^{O}C, and law of compression and expansion is $pV^{1.2}$=C, determine (i) mass of the sir delivered per minute (ii) volumetric efficiency (iii) driving power required, if mechanical efficiency is 85%.	**Nov/Dec 2015**

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8	A three stage air compressor with perfect intercooling takes 15 m^3 of air per minute at 95 kPa and 27^{O}C, delivers the air at 3.5 MPa. If compression process is polytropic ($pV^{1.3}$=C), determine (i) Power required if mechanical efficiency is 90% (ii) heat rejected in the intercoolers per minute (iii) isothermal efficiency (iv) heat rejected through cylinder walls per minute.	**Nov/Dec 2015**

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9	Derive an expression for the **minimum work required** for a two stage reciprocating air compressor with perfect inter-cooling and prove that the intercooler pressure is the geometric mean of the initial and final pressure. (16 Marks)	Nov-Dec 2010

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10	Write working principle of multi-stage reciprocating air compressor. Derive the condition for minimum work output of two stage reciprocating air compressor and work output relation for multi stage reciprocating air compressor. (16 Marks)	Nov/Dec 2011

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UNIT V - REFRIGERATION AND AIR CONDITIONING

Refrigerants - Vapour compression refrigeration cycle- super heat, sub cooling – Performance ca Types and Working Principles. - Concept of RSHF, GSHF, ESHF- Cooling Load calculations.

1. **Define C.O.P. of a refrigeration system.**
   C.O.P. of a refrigeration system is the ratio of heat removed from the low temperature system to the work supp
   C.O.P = Q / W
   Where, W = Work supplied in kJ per unit time, Q = Heat removed in kJ per unit time, C.O.P. -Coef

2. **Define refrigerator.**
   A refrigerator is equipment which is used to remove heat continuously from space and maintain temperature be

3. **Define heat pump.**
   A heat pump is equipment used to supply heat continuously to space and maintain the temperature above atmo

4. **Define DPT and Degree of saturation.**
   DPT (Dew Point Temperature) is the temperature to which moist air is to be cooled before it starts condensing.
   Degree of saturation is the ratio of specific humidity of moist air to the specific humidity of saturated air at tem

5. **Define Relative humidity (RH) and Specific humidity.**
   RH is the ratio of mass of water vapour (mv) in a certain volume of moist air at a given temperature to the mas
   Specific humidity (ώ) is the ratio of mass of water vapour (mv) to the mass of dry air in the given volume of m

6. **What are the classifications of air conditioning system?**
   I. Based on construction of components:
   - Unitary system
   - Central system
   - Package system
   - Split units

   II. Based on fluid flow methods:
   - Direct expansion system

- Chilled water system
- Chilled water air washer system.

7. How does humidity affect human comfort?

If the humidity is above a certain level, water vapour from human body moisture cannot be absorbed by atmos

8. Define: RSHF, RTH.

RSHF (Room Sensible Heat Factor) is the ratio of room sensible heat (RSH) to room total heat.

RSHF = RSH / RTH

RTH (Room Total Heat) is the sum of room sensible heat and room latent heat.

RTH = RSH+RLH

9. What are the various sources of heat gain of an air conditioned space?

- Solar gain through glass plates
- Solar gain through roof and walls
- Heat gain from occupants
- Heat gain from appliances and lights.
- Duck leakage
- Infiltration
- Vapour transmission

10. Define apparatus dew point (ADP) of cooling coil.

For dehumidification, the cooling coil is to be kept at a mean temperature which is below the dew point temper

11. Define bypass factor (BPF) of a coil.

The ratio of the amount of air which does not contact the cooling coil (amount of bypassing air) to the amount i.e. BPF = amount of air bypassing the coil / Total amount of air passed.

12. What is psychrometry ?

Psychrometry is a study of properties of moist air. It deals with the state of atmosphere with respect to moistu commodities and the human comforts.

13. Define DPT and Degree of saturation.

DPT (Dew Point Temperature) is the temperature to which moist air is to be cooled before it starts condensing.

Degree of saturation is the ratio of specific humidity of moist air to the specific humidity of saturated air at tem

14. Define Relative humidity (RH) and Specific humidity.

It is the ratio of the actual partial pressure of water vapour in the moist air to the Saturation pressure of water vapour corresponding to the dry-bulb temperature, i.e.,

$$\varphi = \frac{\text{Existing partial pressure of water vapour, Pv}}{\text{The saturation pressure of pure water vapour at the same temperature, Ps}}$$

15. How does humidity affect human comfort?

If the humidity is above a certain level, water vapour from human body moisture cannot be absorbed by atmos

16. What are the various sources of heat gain of an air conditioned space?

1. Solar gain through glass plates
2. Solar gain through roof and walls
3. Heat gain from occupants
4. Heat gain from appliances and lights.
5. Duck leakage
6. Infiltration
7. Vapour transmission

17. State the effects of very high and a very low bypass factor.

Very high BPF:

a. Requires lower ADP. Refrigerant plant should be of larger capacity.
b. Requires more air. Larger fan and motor required.
c. Less heat transfer area.
d. Requires more chilling water. Larger piping required.

Very low BPF:

a. Higher ADP is to be employed.
b. Requires less air. Fan and motor size reduced.

18. What factors affect BPF?

a. Pitch of fins.
b. Number of coil tubes
c. Air velocity over the coil.
d. Direction of air flow.

19. What are the requirements of comfort air conditioning?

a. Supply of O_2 and removal of CO_2.
b. Removal of heat of occupants.
c. Removal of moisture of occupants.
d. Good air distribution.
e. Maintaining air purity.

20. Define Effective Temperature (ET).

ET is defined as that temperature of saturated air at which the subject would experience the same feeling of co

21. What are the general comfort conditions during summer and winter?

Summer:

Inside temperature	$24^o \pm 1^oC$
RH	50 – 60 %

Air movement	4.5 – 7.5 m / min.

Winter:

Inside temperature	$20^{o}\pm1^{o}C$
RH	35 – 40%

22. Differentiate between heat pump and refrigerator. (AU' MAY 2003)

Refrigeration may be defined as the process by which the temperature of a given space or a substance is lowere

23. What is dew point temperature? (AU' MAY 2004)

Dew point temperature is temperature to which moist air is to be cooled before it starts condensing.

24. What is effective temperature? (AU' MAY 2004)

Effective temperature is defined as that temperature of saturated air at which the subject would experience the

25. Define dew point depression.

It is the difference between dry bulb temperature and dew point temperature of air vapour mixture.

26. Define Dew point,Tdp :

It is the temperature at which the liquid droplets just appear when the moist air is Cooled continuously

27. What is meant by Absolute humidity?

It is the amount of water vapour per unit volume of the gas.

28. What is Humidity Ratio?

It is also called the specific humidity. It is defined as the amount of water vapour in the moist air per unit mass

29. What is Saturated air?

A mixture of dry air and water vapour in which the patial pressure of the vapour is equal to saturation

30. What is Degree of saturation, μ?

It is defined as a ratio of the mass of the water vapour at a given temperature associated with the unit mass of d

μ =mv/mvs

1	Describe the following refrigeration systems with layout (i) Ammonia water system (ii) Lithium-br

Refer: "Thermal Engineering" by Dr.R.K.Rajput Page No:

2	(i) Describe the working principle of centralized air conditioning system and enumerate the ne (ii) List the loads that contribute to the overall cooling load.

Refer: "Thermal Engineering" by Dr.R.K.Rajput Page No:	
3	A food storage locker requires a refrigeration capacity of 50 kW. It works between a condenser t saturated vapour leaving the evaporator. Assuming a single cylinder, single acting compressor ope
Refer: "Thermal Engineering" by Dr.R.K.Rajput Page No:	
4	(i) Explain the centralized air conditioning system with a neat sketch (ii) 100 m^3 of air per minute at 15^OC DBT 80% RH is heated until its temperature is 22^OC. Calcul
Refer: "Thermal Engineering" by Dr.R.K.Rajput Page No:	
5	An ammonia refrigerator operates between evaporating and condensing temperatures of -16^OC a Calculate (i) The refrigerator effect per kg (ii) The mass flow and power input per kw of refrigerati
Refer: "Thermal Engineering" by Dr.R.K.Rajput Page No:	
6	Saturated air leaving the cooling section of an air conditioning system at 14^OC at a rate of 50 m^3/m atm, determine the specific humidity, the relative humidity, the dry-bulb temperature and the volur
. *Refer: "Thermal Engineering" by Dr.R.K.Rajput Page No:*	
7	An air conditioning plant is required to supply 50 m^3 of air per minute at a DBT of 22^OC and 50% dehumidification and sensible cooling process. Also calculate sensible heat factor.
Refer: "Thermal Engineering" by Dr.R.K.Rajput Page No:	
8	i) Explain the construction and working of vapour absorption refrigeration system with neat sketch
Refer: "Thermal Engineering" by Dr.R.K.Rajput Page No:	
9	i) Explain the working principle of vapour absorption refrigeration system and compare it with vapour compressi diagram for Freon 12, determine i) The mass flow rate of the refrigerant circulated. ii) the theoretical piston disp condenser. (16 Marks)
Refer: "Thermal Engineering" by Dr.R.K.Rajput Page No:	
10	Explain the construction and working of summer and winter air conditioning systems. (16 Marks)
Refer: "Thermal Engineering" by Dr.R.K.Rajput Page No:	