ME2301 THERMAL ENGINEERING
UNIT I GAS POWER CYCLES
Part-A

1. What is thermodynamic cycle?
2. List out the assumptions made for the analysis of thermodynamic air cycles.
3. Sketch the Otto cycle on P-V and T-S planes and name all the processes.
4. Define air standard cycle efficiency of an Otto Cycle.
5. How does the change in compression ratio affect the air standard efficiency of an ideal Otto cycle?
6. Define MEP as applied to gas power cycles. What is its significance?
7. Write the expression for MEP for an Otto cycle in terms of compression ratio and other parameters.
8. In an Otto cycle, pressure ratio during compression is 11. Calculate the air standard cycle efficiency.
9. A Carnot cycle works between the temperatures 300K and 700K. Find the maximum work possible per kg of air.
10. Sketch the Diesel cycle on P-V and T-S planes and mention the four thermodynamic processes involved.
11. A Diesel engine has a compression ratio of 14 and cut-off takes place at 6% of the stroke. Find the air standard efficiency.
12. Draw the actual p-v diagram for four stroke SI Engine.
13. Define air standard cycle efficiency of a diesel Cycle.
14. Name the factors that affect the air standard efficiency of diesel cycle.
15. Define the terms compression ratio and cutoff ratio.
16. What is the effect of cut-off ratio on the efficiency of diesel cycle when the compression ratio is kept constant?
17. Sketch the Dual cycle on P-V and T-S planes and mention the various processes.
18. Sketch the PV & TS diagram for Otto cycle and Diesel cycle and Dual cycle for the same compression ratio and heat rejection, compare the efficiency.
19. For the same compression ratio and heat supplied, state the order of decreasing air standard efficiency of Otto, Diesel and Dual cycles.
20. Sketch the Brayton cycle (Limited pressure cycle) on P-V and T-S planes and mention the various processes.

Part-B

Otto Cycle:

1. Derive an expression for air standard efficiency of an Otto cycle. Obtain an expression for mean effective pressure of an Otto cycle.

2. In an engine working on constant volume cycle, the pressure, temperature and volume at the beginning of the cycle are 1.2 bar, 35oC and 0.5 m3 respectively. At the end of compression stroke, the pressure is 12 bar. 315 kJ of heat is added per kg of gas during constant volume heating process. Calculate the pressure, temperature and volume at all points. Also find the air standard efficiency of the cycle.

3. A six cylinder petrol engine has a compression ratio of 5:1. The clearance volume of each cylinder is 110CC. It operates on the four stroke constant volume cycle and the indicated

efficiency ratio referred to air standard efficiency is 0.56. At the speed of 2400 rpm, it consumes 10kg of fuel per hour. The calorific value of fuel is 44000KJ/kg. Determine the average indicated mean effective pressure.

Diesel Cycle:

4. Derive an expression for mean effective pressure of a Diesel cycle in terms of pressure ratio, cutoff ratio and compression ratio.

5. An air standard Diesel cycle has a compression ratio of 12 and cutoff takes place at 6% of the stroke. Calculate the air standard efficiency of the cycle.

6. 1kg of air is taken through a diesel cycle. Initially the air is at 25oC and 1 bar. The compression ratio is 14 and the heat added is 1850KJ. Calculate the ideal cycle efficiency and the mean effective pressure.

Dual Cycle:

7. In a dual cycle the air is compressed isentropically to 1/14th of its initial volume. At the end of compression heat is added at constant volume till its pressure increases to twice the pressure at the end of compression. Then heat is added at constant pressure till its volume increases to twice the volume after compression. Find the efficiency of the cycle.

8. In engine working on Dual cycle, the temperature and pressure at the beginning of cycle are 90oC and one bar. The compression ratio is 9. The maximum pressure is limited to 68bar and total heat supplied per kg of air is 1750kJ. Determine air standard efficiency and mean effective pressure.

Brayton Cycle:

9. Derive an expression for air standard efficiency of a Brayton cycle in terms of pressure ratio and compression ratio. Also prove that the pressure ratio for maximum work is a function of limiting temperature ratio.

10. The extreme of pressure and temperature in an open circuit constant pressure gas turbine plant are 1 bar, 5.25bar and 25oC and 560oC respectively. The isentropic efficiency of the turbine is 88% and that of the compressor is 84%. Determine the efficiency of the plant.

UNIT II INTERNAL COMBUSTION ENGINES

Part-A

1. Write any two major differences between 'SI engine' and 'CI engine'.
2. Compare two stroke and four stroke engines.
3. Why diesel engines are more efficient than petrol engines?
4. Which is better efficient two stroke or four stroke engines? Why?
5. What is the function of camshaft and crankshaft?
6. What is the function of pushrod and rocker arm?
7. What are the functions of piston rings?

8. Name the basic thermodynamic cycles of two types of internal combustion reciprocating engines.
9. What is meant by highest useful compression ratio?
10. Why compression ratio of a petrol engine is low while diesel engines have high compression ratio?
11. Compare the thermal efficiency of petrol engines with diesel engines. Give reasons.
12. Why the actual cycle efficiency is much lower than the air-standard cycle efficiency? List and explain the major losses in an actual engine.
13. State the air-fuel ratio requirements of SI engine under various operating conditions.
14. Differentiate between ideal and actual valve timing diagram of a petrol engine.
15. Draw port-timing diagram of petrol engine.
16. What is scavenging in IC engines?
17. What is the function of a carburettor? What is carburetion?
18. Why a choke is used in carburettor and what is meant by automatic chocking?
19. What are the limitations of simple carburettor?
20. During peak power operation, why petrol engine requires rich mixture?

Part-B

1. (a) Explain any four types of classification of internal combustion engines.
   (b) Draw the valve timing diagram for a 4 stroke SI Engine.

2. (a) Explain any four types of classification of Internal Combustion engines.
   (b) With a neat sketch explain any one type of ignition system.

3. Explain the working of 4-stroke cycle Diesel engine. Draw theoretical and actual valve-timing diagram for the engine. Explain the reasons for the difference.

4. Explain why cooling is necessary in I.C. engine. With neat sketches describe the working of water cooling system used for multi-cylinder engine. Why should a pump and thermostat be provided in the cooling system of an engine?

5. Explain with neat sketches the method of lubrication of the following parts of the I.C. Engines. (i) Piston and cylinder
   (ii) Crank-pin and Gudgeon pin
   (iii) Cam-shaft.

6. (i) Explain with neat sketch Air Cooling of Engines.
   (ii) Explain any one lubrication system adopted in multi cylinder SI engines.

7. Explain the principle of Magneto ignition system. Enumerate its advantages and disadvantages?

8.(a) What are the various factors influencing the flame speed in SI Engines?

(b) Explain the combustion phenomenon in SI Engines.

9. (a) What is the purpose of cooling an I.C. Engine?
(b) What are the ill effects of improper cooling?
(c) With neat sketches, describe how a fuel injection pump supplies fuel to a diesel engine for different load conditions.
(d) Explain the normal combustion and knocking in a diesel engine with pressure-crank angle diagram

10. (i) Explain the function of a fuel injection pump with a simple sketch. (8)
(ii) What are the advantages and disadvantages of Magneto ignition system over Batter ignition system? (8)

UNIT III STEAM NOZZLES AND TURBINES

Part-A

1. What are the various types of nozzles and their function?
2. Write down the expression for velocity at exit from steam nozzle.
3. Derive the expression for critical pressure ratio in a steam nozzle.
4. What are the effects of friction on the flow through a steam nozzle?
5. Write the general energy equation for a steady flow system and from this obtain the energy equation for nozzle.
6. Define nozzle efficiency.
7. Define critical pressure ratio.
8. What is meta stable flow?
9. What is supersaturated flow?
10. What are the conditions that produce super saturation of steam in nozzles?
11. What are the effects of super saturation in a steam nozzle?
12. Draw the T-S and H-S plot of super saturated expansion of steam in a nozzle.
13. Differentiate supersaturated flow and isentropic flow.
14. Differentiate impulse and reaction turbine.
15. What are the different losses involved in steam turbines?
16. What is Curtis turbine?
17. Define degree of reaction
18. What is bladding efficiency?
19. Define stage efficiency.
20. Define Diagram efficiency.

Part-B

1. (a) Steam at a pressure of 15 bar saturated is discharged through a convergent-divergent nozzle to a back pressure of 0.2 bar. The mass flow rate is 9 kg/kW-hr, if the power developed is 220 kW, determine number nozzles required if each nozzle has a throat of rectangular cross section of 4mm x 8mm. If 12% of overall isentropic enthalpy drop occurs in the divergent portion due to friction, find the cross section of the exit rectangle?
(b) Explain the supersaturated expansion of steam in a nozzle.

2. (a) Derive the expression for critical pressure ratio in terms of index of expansion.

(b) A convergent divergent adiabatic steam nozzle is supplied with steam at 10bar and 2500C. The discharge pressure is 1.2bar. Assuming the nozzle efficiency as 100% and initial velocity of steam is 50m/s, find the discharge velocity.

3. (a) Derive an expression for the critical pressure ratio in terms of the index of expansion.

(b) Dry saturated steam enters a steam nozzle at a pressure of 15 bar and is discharged at a pressure of 2.00 bar. If the dryness fraction of discharge steam is 0.96, what will be the final velocity of steam. Neglect initial velocity of steam. If 10% of heat drop is lost in friction, find the percentage reduction in the final velocity.

4. Steam at a pressure of 15 bar with 50° C of superheat is allowed to expand through a convergent-divergent nozzle. The exit pressure is 1 bar. If the nozzle is required to supply 2 kg/sec. of steam to the turbine, then calculate

(i) The velocities at throat and exit.

(ii) Areas at throat and exit Assume 10% frictional loss in divergent part only and percentage taken as % of, total heat drop.

5. The blade speed of a single ring of an impulse turbine is 300 m/s and the nozzle angle is 20°. The isentropic heat drop is 473 kJ/kg and the nozzle efficiency is 0.85. Given that the blade velocity coefficient is 0.7 and the blades are symmetrical, draw the velocity diagrams and calculate for a mass flow of 1 kg/s:

(i) Axial thrust on the blading.

(ii) Steam consumption per B.P. hour if the mechanical efficiency is 90 per cent.

(iii) Blade efficiency and stage efficiency

6. In a 50 percent reaction turbine stage running at 50 revolutions per second, the exit angles are 30° and the inlet angles are 50°. The mean diameter is 1m. The steam flow rate is 10000 kg/mm and the stage efficiency is 85%. Determine

(i) The power output of the stage

(ii) The specific enthalpy drop in the stage and

(iii) The percentage increase in the relative velocity of steam when it flows over the moving blades.

7. A 50% reaction turbine running at 400 rpm has the exit angle of the blades as 20° and the velocity of steam relative to the blades at the exit is 1.35 times the mean speed of the blade. The steam flow rate is 8.33 kg/s and at a particular stage the specific volume is 1.381 m3/Kg. Calculate for this stage.

(i) A suitable blade height, assuming the rotor mean diameter 12 times the bladeheight, and

(ii) The diagram work

8. (a) Define the following terms for reaction turbines:
(i) Diagram efficiency and (ii) Stage efficiency.
(b) Determine the condition for maximum efficiency of a 50% reaction turbine and show that the maximum efficiency for such a turbine is [2cos2 α1/(1+cos2α1)],where αl is the angle at which the steam enters the blades.

9. A single row impulse turbine develops 132.4 kW at a blade speed of 175 m/s, using 2 kg of steam per sec. Steam leaves the nozzle at 400 m/s. Velocity coefficient of the blades is 0.9. Steam leaves the turbine blades axially. Determine nozzle angle, blade angles at entry and exit, assuming no shock.

10. A single-stage impulse turbine is supplied steam at 4 bar and 160°C and it is exhausted at a condenser pressure of 0. 1 bar at the rate (if 60 kg/mm. The steam expands in a nozzle with an efficiency of 90°c. The blade speed is 250 m/s and nozzle are inclined at 20° to the plane of the wheel. The blade angle at the exit of the moving blade is 30°. Neglecting friction losses in the moving blade, determine (i) Steam Jet Velocity (ii) Power developed (iii) Blade efficiency (iv) Stage efficiency

UNIT IV AIR COMPRESSOR

Part-A

1. Classify the various types of air-compressors.
2. Define the term applied to air compressor: Volumetric efficiency and Isothermal efficiency.
3. What is meant by free air delivered?
4. Give two merits of rotary compressor over reciprocating compressor.
5. Name the compression process in which work done is minimum in reciprocating air compressor.
6. Draw the PV diagram of a two stage reciprocating air compressor.
7. Indicate the applications of reciprocating compressors in industry.
8. What are the advantages of multistage compression with inter-cooling over single stage compression for the same pressure ratio?
9. Define the terms as applied to reciprocating compressor: Mechanical efficiency, isothermal efficiency, isentropic efficiency.
10. What factors limit the delivery pressure in a reciprocating compressor?
11. Name the methods adopted for increasing isothermal efficiency of reciprocating air compressor.
12. What are the factors that affect the volumetric efficiency of a reciprocating compressor?
13. Discuss the effect of clearance upon the performance of an air compressor.
14. Differentiate between prefect inter cooling and imperfect inter cooling.
15. Compare reciprocating and rotary compressor.
16. What is the main advantage of inter cooling in multistage reciprocating compressor?
17. Why clearance is necessary in reciprocating compressor?
18. Differentiate positive and non positive displacement compressor?
19. What is the effect of clearance volume on the power required and work done in a reciprocating air compressor?
20. A multistage air compressor is to be designed to elevate the pressure from 1 bar to 120

Part-B

1. A multi stage air compressor is to be designed to evaluate the pressure from 1 bar to 120 bar. Such that the single stage pressure ratio not to exceed 4. Find (i) Number of stages (ii) Exact stage pressure ratio (iii) Inter stage pressure.

2. Consider a single acting two stage reciprocating air compressor running at 300rpm. Air is compressed at a rate of 4.5kg/min from 1.013bar and 288K through a pressure ratio of 9 to 1. Both the stages have same pressure ratio and the index of expansion in both stages is 1.3. Assume a complete inter-cooling, find the indicated power and the cylinder swept volume required. Assume that the clearance volumes of both stages are 5% of their respective swept volumes.

3. A two stage air compressor compresses air from 1 bar and 20°C to 42 bar. If the law of compression is pv1.3= constant and the inter cooling is perfect. Find per kg of air
(i) the work done in compression
(ii) the mass of cooling water necessary for abstracting the heat in the intercooler ,
if the temperature rise of the cooling water is 25°C.

4. (i) With a neat sketch describe any one type of rotary compressor.
(ii) A single stage single acting reciprocating air compressor delivers 14 m3 of free air per minute from 1 bar to 7 bar. The speed of compressor is 310rpm.Assuming that compression and expansion follow the law pv1.35 = constant and clearance is 5% of the swept volume, find the diameter and stroke of the compressor. Take stroke length is 1.5 times the bore diameter.

5. (i) Explain with suitable sketches the working of two stage air compressor with actual p-v diagram.
(ii) A single acting single stage compressor is belt driven from an electric motor at 400rpm. The cylinder diameter is 15 cm and the stroke is 17.5 cm. The air is compressed from 1 bar to 7 bar and the law of compression PV1.3 = constant. Find the power of the motor, if transmission efficiency is 97% and the mechanical efficiency of the compressor is 90%. Neglect clearance effects. (10)

6. A three-stage air-compressor delivers 5.2 m3 of free air per minute. The suction pressure and temperature are 1 bar and 30°C. The ambient pressure and temperature are 1.03 bar and 20°C. The air is cooled to 30°C after each stage of compression. The delivery pressure of the compressor is 150 bar. The RPM of the compressor is 300. The clearances of LP, I.P and H.P cylinders are 5% of the respective strokes. The index of compression and re expansion in all stages is 1.35. Neglecting pressure losses, find the B.P of the motor required to run the compressor if the mechanical efficiency is 80%.

7. (a) Define the volumetric efficiency of a reciprocating compressor and explain why it is less than unity.
(b) Determine the size of the cylinder of a double acting air compressor of 32 KW I.P. in which air is drawn in at 1 bar and compressed to 16 bar according to the law pv1.25 constant. R.P.M. 300, Piston speed = 180 m/min, Volumetric efficiency = 0.8.

8. A two-stage double acting air compressor, operating at 200 r.p.m, takes in air at 1.013 bar and 27° C. The size of the L.P. cylinder is 350 x 380 mm, the stroke of H.P. cylinder is the same as that of the L.P. cylinder and the clearance of both the cylinders is 4%. The L.P. cylinder discharges the air at a pressure of 4.052 bar. The air passes through the inter-cooler so that it enters the H.P. cylinder at 27° C and 3.850 bar, finally it is discharged from the compressor at

9.4 bar The value of n is both cylinders is 1.3. Cp = 1.0035 kJ/kg-K and R = 0.287 kJ/kg-K.
Calculate :
(i) The heat rejected in the inter-cooler.
(ii) The diameter of H.P. cylinder and
(iii) The power required to drive H.P. cylinder.

10. (a) What are the advantages of multistage compression? (4)
(b) A single stage single acting reciprocating air compressor takes in 17 m3/min at suction conditions of 100 kPa and 25°C. The delivery pressure is 700 kPa. The clearance volume is 6% of swept volume. The compression and expansion follows the law pV1.3 = Constant. The speed of the compressor is 600 rpm. Stroke to bore ratio is 1. Find the power required to drive the compressor and Cylinder dimensions.

UNIT V REFRIGERATION AND AIR CONDITIONING

Part-A

1. Explain unit of refrigeration.
2. Define: COP.
3. Differentiate between refrigeration & air conditioning.
4. What are the properties of good refrigerants?
5. What is net refrigerating effect of a refrigerant?
6. What are the advantages of vapour compression refrigeration system over air refrigeration system?
7. How does the actual vapour compression cycle differ from that of the ideal cycle?
8. What is the function of throttling valve?
9. What is meant by sub-cooling?
10. What are the effect of superheat and sub cooling in vapour compression cycle?
11. What is the objective of under cooling? Sketch the process in a TS diagram
12. What is the basic difference between vapour compression and vapour absorption refrigeration
system?
13. Name the refrigerant normally used in simple vapour absorption system.
14. Name the various components used in simple vapour absorption system.
15. What is the function of analyzer and rectifier in simple vapour absorption system?
16. How does humidity affect human comfort?
17. With help of h-s diagram explain the effect of subcooling.
18. Define sensible heat ratio and draw cooling and dehumidification in a typical psychrometric chart.
19. Which thermodynamic cycle is used in air conditioning of air planes using air as refrigerant?
20. What do you mean by the term “infiltration” in heat load calculations?

Part-B

1.(i) With a neat sketch, discuss briefly the ammonia absorption refrigeration cycle.
(ii) With a neat sketch, explain a vapour compression refrigeration system.

2. A refrigeration system of 10.5 tonnes capacity at an evaporator temperature of 12°C and a condenser temperature of 27°C is needed in a food storage locker. The refrigerant ammonia is sub cooled by 6°C before entering the expansion valve. The vapour is 0.95 dry as it leaves the evaporator coil. The compression in the compressor is of adiabatic type. Find
(i) Condition of vapour at the outlet of the compressor
(ii) Condition of vapour at the entrance of the evaporator
(iii) COP and
(v) The power required. Neglect valve throttling and clearance effect.

3. (i) A Freon-12 refrigerator producing a cooling effect of 20 kJ/s operates on a simple vapour compression cycle with pressure limits of 1.509 bar and 9.607 bar. The vapour leaves the evaporator dry saturated and there is no under cooling. Determine the power required by the machine. (10)

(ii) If the compressor operates at 300 r.p.m. and has a clearance volume of 3% of stroke volume, determine the piston displacement of the compressor. For compressor assume that the expansion following the law pv1.3 = constant. (6)

4. A simple saturation refrigeration cycle developing 15 tons of refrigeration using R12 operates with a condensing temperature of 35°C and an evaporator temperature of - 6°C. Calculate: (i) The refrigerating effect, (ii) Refrigerant flow rate,
(iii) The power required to drive the compressor, (iv) COP

5. Explain with a neat sketch the summer Air - Conditioning suitable for Chennai weather conditions. OR Explain the summer Air Conditioning system suitable for hot and humid weather.

6.(i) Exp1ain summer Air Conditioning with a neat layout. (10)
(ii) Sketch various processes of summer Air Conditioning in a Psychometric chart (6)

7. (a) A sling psychrometer reads 40OC DBT and 36OC WBT. Find the humidity ratio, relative humidity, DPT, specific volume of air, density of air, density of water vapour and enthalpy. [8]

(b) Saturated air at 21OC is passed through a drier so that the final relative humidity is 20%. The air is then passed through a cooler until its final temperature is 21OC without a change in specific humidity. Find (i) The temperature of air after drying process, (ii) the heat rejected in cooling process, (iii) the due point temperature at the end of drying process.

8. 40 m3 of air per minute at 31oC DBT and 18.5oC WBT is passed over the cooling coil whose surface temperature is 4.4oC. The coil cooling capacity is 3.56 tons of refrigeration under the given condition of air. DetermineDBT and WBT of the air leaving the cooling coil.

9. A sling psychrometer in a laboratory test recorded the following readings. Dry bulbtemperature = 35°C, Wet bulb temperature = 25°C Calculate the following
(i) specific humidity
(ii) relative humidity
(iii) vapour density in air
(iv) dew point temperature and
(v) enthalpy of mixture per kg of dry air
Take atmospheric pressure = 1.0132 bar.

10. An office is to be air-conditioned for 50 staff when the outdoor conditions are 30°C DBT and 75% RH if the quantity of air supplied is 0.4m3/min/person, find the following:
(i) Capacity of the cooling coil in tonnes of refrigeration
(ii) Capacity of the heating coil in kW
(iii) Amount of water vapour removed per hour
Assume that required air inlet conditions are 20°C DBT and 60% RH, Air is conditioned first by cooling and dehumidifying and then by heating.
(iv) If the heating coil surface temperature is 25°C, find the by-pass factor of the heating coil?