QUESTION BANK ON THERMAL ENGINEERING -I

(MECHANICAL ENGINEERING - 4TH SEM)

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Question Bank

UNIT I GAS POWER CYCLES

Otto, Diesel, Dual, Brayton cycles, Calculation of mean effective pressure, and air standard efficiency -Actual and theoretical PV diagram of four stroke and two stroke engines.

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. Write any four differences between Otto cycle and Diesel cycle.
18. When the efficiency of diesel cycle approaches the Otto cycle efficiency?
19. Sketch the Dual cycle on P-V and T-S planes and mention the various processes.
20. 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.
21. For the same compression ratio and heat supplied, state the order of decreasing air standard efficiency of Otto, Diesel and Dual cycles.
22. When will be the gas turbine cycle efficiency reaches maximum?
23. Sketch the Brayton cycle (Limited pressure cycle) on P-V and T-S planes and mention the various processes.
24. Explain the effect of pressure ratio on the net output and efficiency of Brayton cycle.
25. Sketch the schematic arrangement of open cycle gas turbine plant and name the components.
26. It is always useful to have a regenerator in gas turbine power cycle. Why?
27. What are the affects of reheat cycle?

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, 35^oC and 0.5 m^3 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.

4. An engine working on Otto cycle has a volume of $0.45m^3$, pressure 1 bar and temperature 30ºC at the beginning of compression stroke. At the end of compression stroke, the pressure is 11bar and 210KJ of heat is added at constant volume. Determine (i) Pressure, temperatures and volumes at salient points in the cycle. (ii) Efficiency.

5. The compression ratio in an air-standard Otto cycle is 8. At the beginning of the compression stroke the pressure is 0.1Mpa and the temperature is 15°C. The heat transfer to the air per cycle is 1800 kJ/kg of air. Take C_p and C_v for air as 1.005 and 0.7 18 kJ/kg K respectively. Determine the following

   (i) The pressure and temperature at the end of each process of the cycle.

   (ii) The thermal efficiency.

   (iii) The mean effective pressure.

6. An engine 20 cm bore and 30 cm stroke works on Otto cycle. The clearance volume is 1600 cu cm. The initial pressure and temperature are 1bar and 60°C. If the maximum pressure is limited to 24 bar, find the following:

   (i) The air standard efficiency (ii) The mean effective pressure of the cycle.

7. An engine working on Otto cycle has a volume of 0.45 m^3, pressure of 0.45 m^3, pressure 1 bar and temperature 30ºC at the beginning of compression stroke. At the end of compression stroke, the pressure is 11 bars. 2 10 kJ of heat added is at constant volume. Determine
   (i) Pressures, temperatures and volumes at salient point in the cycle,
   (ii) Percentage of clearance
   (iii) Efficiency
   (iv) Mean effective pressure
   (v) Ideal power developed by the engine if the number of working cycle per minute is 210.

8. In an air standard Otto cycle the compression ratio is 6.5, and at the beginning of isentropic compression, the temperature is 15ºC and the pressure is 1 bar. Heat is added during constant volume process so that the maximum temperature in the cycle is 1480CC. Calculate
   (i) The heat supplied per kg of air,
   (ii) The cycle efficiency and

(iii) The mean effective pressure

Diesel Cycle:

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

2. 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.

3. 1kg of air is taken through a diesel cycle. Initially the air is at 25^{o}C and 1 bar. The compression ratio is 14 and the heat added is 1850KJ. Calculate the ideal cycle efficiency and the mean effective pressure.

4. Draw the theoretical and actual P.V. diagrams for 4-stroke diesel engine and explain why in practice the actual condition differs from the ideal condition.

5. In an air standard Diesel cycle, the compression ratio is 18, and at the beginning of isentropic compression, the temperature is 27CC and the pressure is 0.1 MPa. 1800 kJ of heat is added at constant pressure. Calculate i) the cut-off ratio, ii) the heat supplied per kg of air iii) the cycle efficiency and iv) mean effective pressure

Dual Cycle:

1. With the help of p-v and T-s diagrams, show that for the same maximum pressure and temperature of the cycle and the same heat rejection

$$\eta_{Diesel} > \eta_{Dual} < \eta_{Otto}$$

2. 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.

3. In engine working on Dual cycle, the temperature and pressure at the beginning of cycle are 90^{o}C 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.

4. A dual combustion air standard cycle has a compression ratio of 10. The constant pressure part of combustion takes place at 40 bar. The highest and the lowest temperatures of the cycle are 1727° C and 27° C respectively. The pressure at the beginning of compression is 1 bar. Calculate (i) the pressures and temperatures at key points of the cycle,(ii)the heat supplied at constant volume, (iii) the heat supplied at constant pressure, (iv) the heat rejected, (v) the work output, (vi) the efficiency and (vii) MEP.

6. An air standard dual cycle has a compression ratio of 16 and compression begins at1.013 bar, 50°C. The maximum pressure is 70 bar. The heat transferred to air at constant pressure is equal to that at constant volume. Estimate the temperatures at the cardinal points of the cycle and the cycle efficiency.

7. An air-standard Dual cycle has a compression ratio of 10. The pressure and temperature at the beginning of compression are I bar and 27°C. The maximum pressure reached is 42 bar and the maximum temperature us 1500ºC Determine
   (i) The temperature at the end of constant volume heat addition
   (ii) Cut-off ratio
   (iii) Work done per kg of air and
   (iv) Net work output per kg
   (v) Cycle efficiency

Brayton Cycle:

1. 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.

2. 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.

3. A gas turbine works on an air standard Brayton cycle. The initial condition of the air is 25°C and 1 bar. The maximum pressure and temperature are limited to 3 bar and 650°C. Determine the following:
   (i) Cycle efficiency
   (ii) Heat supplied and heat rejected/kg of air
   (iii) Work output/kg of air
   (iv) Exhaust temperature

4. Air enters the compressor of a gas turbine at 100 kPa and 25° C. For a pressure ratio of 5 and a maximum temperature of 850°C determine the thermal efficiency using the Brayton cycle.

5. An air standard Limited pressure cycle has a compression ratio of 15 and compression begins at 0.1MPa, 40°C. The maximum pressure is limited to 6MPa and the heat added is 1.675 MJ/Kg. Compute

(i) The heat supplied at constant volume per kg of air, and the heat supplied at constant pressure per kg of air.

(ii) The work done per kg of air, the cycle efficiency, and the temperature at the end of the constant volume heating process.

iii) The cut-off ratio, and iv) The m.e.p. of the cycle.

UNIT II INTERNAL COMBUSTION ENGINES

Classification - Components and their function - Valve timing diagram and port timing diagram - Comparison of two stroke and four stroke engines – Carburettor system, Diesel pump and injector system. Performance calculation – Comparison of petrol and diesel engine - Lubrication system and Cooling system – Battery and Magneto Ignition System – Formation of exhaust emission in SI and CI 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. Define Cetane number of a fuel.
18. What is the function of a carburettor? What is carburetion?
19. Why a choke is used in carburettor and what is meant by automatic chocking?
20. What are the limitations of simple carburettor?
21. During peak power operation, why petrol engine requires rich mixture?
22. Mention the different types of fuel injection system in CI Engine.
23. What are the basic requirements of a fuel injection system of a diesel engine?
24. What do you understand by air injection and solid injection?
25. Define delay period with respect to a CI Engine.
26. Differentiate brake power and indicated power.
27. What are the various methods to determine the FHP of a engine?

28. Differentiate between SFC and TFC in engine performance.
29. What is the necessity of cooling in IC engines?
30. What is the purpose of thermostat in an engine cooling system?
31. What is the need of lubrication system for IC engines?
32. What is splash lubrication?
33. What do you mean by mist lubrication?
34. List the advantages and disadvantages of battery ignition system. Also draw the V-N curve.
35. List the advantages of electronic ignition system over the conventional systems.
36. List out the effects of detonation.

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. Describe with a suitable sketch the two-stroke cycle spark ignition (SI) engine.How its indicator diagram differs from that of four-stroke cycle engine?

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

4. 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.

5. (a) Explain why cooling is necessary in an I.C. engine.
   (b) With neat sketches describe the working of Water Cooling System used for multi cylinder engine.

6. 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?

7. 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.

8. (i) Explain with neat sketch Air Cooling of Engines.

(ii) Explain any one lubrication system adopted in multi cylinder SI engines.

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

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

(b) Explain the combustion phenomenon in SI Engines. (8)

11. (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

12. (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)

13. (a)Draw the port timing diagram with fuel injection of a two-stroke diesel engine and explain the salient points.

(b) Explain the effects of time loss factor and heat loss factor with suitable graphs on the performance of actual I.C. Engines

14. (i) Explain the phenomenon of knock in SI engine. What are the different factors which influences the knocking? Describe the methods used to suppress it. [9]

(ii) With a neat sketch explain magneto and coil ignition system. [7]

15.(a) Compare the petrol and diesel engines with reference to the following:

(1) Power to weight ratio

(2) Acceleration response

(3) Economy in road transport

(4) Maintenance and repair.

(b) Enumerate the desirable properties of a good fuel for a petrol engine. (4)

(c) Explain the significance of flame speed and its influence on combustion in S.I.engine.

16.(a) Explain the phenomenon of knock in CI engine. Describe the methods used to suppress it. Compare the knocking in Diesel engine with that of petrol engine.

(b) The petrol used in an engine is approximated to both methane and ethane. Calculate the theoretical A/F Ratio. If 30% of excess air is supplied, find the actual A/F ratio.

17. (a) A six cylinder, 4 stroke SI engine having a piston displacement of 700 cm^3 per cylinder developed 78 kW at 3200rpm and consumed 27 kg of petrol per hour. The calorific value of petrol is 44 MJ/kg. Estimate

i. The volumetric efficiency of the engine if the air fuel ratio is 12 and intake air is at 0.9 bar, 32ºC.
ii. The brake thermal efficiency, and
iii. The braking torque.

(b) Describe a simple carburetor with a neat sketch and also state its limitations.

18. Following data relates to 4 cylinders, 2 stroke petrol engine. Air/Fuel ratio by weight 16:1. Calorific value of the fuel = 45200 kJ/kg, mechanical efficiency = 82%. Air standard efficiency = 52%, relative efficiency =70% volumetric efficiency = 78%,

stroke/bone ratio = 1.25 suction conditions = 1 bar, 25°C. Speed = 2400 rpm power at brakes = 72 kW. Calculate

(i) Compression ratio.

(ii) Indicated thermal efficiency

(iii) Brake specific fuel consumption and

(iv) Bore and stroke.

19. The following observations were taken during trial on a single cylinder oil engine.

Duration of trial	=	1 hour
Fuel consumption	=	7.6 kg
Total revolutions	=	12000
Net brake load	=	1.5 kN
Brake drum diameter	=	1.83 m
Total cooling water circulated	=	550 kg
Inlet temperature of cooling water	=	15°C
Outlet temperature of cooling water	=	60°C
Temperature of exhausted gases	=	300°C
Atmospheric temperature	=	20°C
Air consumption	=	360 kg
Mean effective pressure	=	6 bar
Take the followings		
CV. of fuel	=	45000 kJ/kg
Cp (for exhaust gases)	=	1 kJ/kg-K
Bore	=	30 cm
Stroke	=	45 cm

Determine:

(i) Brake power

(ii) Mechanical efficiency

(iii) Indicated thermal efficiency

(iv) Draw up the heat balance.

20. The following data refer to a single cylinder four stroke petrol engine:

Compression ratio	=	5.6
Mechanical efficiency	=	80%
Brake specific fuel consumption	=	0.37 kg/kW h
Calorific value of fuel	=	44000 kJ/kg
Adiabatic index for air	=	1.4

Find (i) brake thermal efficiency

(ii) Indicated thermal efficiency

(iii) Air standard efficiency.

(iv) Relative efficiency with respect to indicated thermal efficiency and

(v) Relative efficiency with respect to brake thermal efficiency.

21. **(a)** A 4 - cylinder, 4-stroke petrol engine 6 cm bore and 9 cm stroke was tested at constant speed. The fuel supply was fixed to 0.13 kg/mm and plugs of 4 – cylinders were successively short circuited without change of speed: The power - measurements were as follows:

With all cylinder working = 16.25 kW.

With No.1 - cylinder cut-off = 11.55 kWh,

With No.2 - cylinder cut-off = 11.65 kW(B.P)

With No. 3 - cylinder cut-off = 11.70 kW (B.P),

With No.4 - cylinder cut-off = 11.50kW (B.P)

Find (1) the I.P of the engine, (2) the Mechanical efficiency (3) Indicated thermal efficiency if CV. of fuel used is 42 000 kJ/kg (4) Also find the relative efficiency on I.P basis assuming clearance volume 65 cu cm. (10)

(b) Explain the Diesel knock in CI Engines. (6)

22. An 4-stroke, single cylinder gas engine develops 15.6 kW B.P. at 240 r.p.m. Using the following data find the relative efficiency of the engine.

Gas consumption = 12.57 Cu. rn/hr measured at 1.05 bar and 15°C. C.V. of the gas = 25 kJ/litre at 1 bar and 0°C. Cylinder diameter = 25 cm.,Stroke of the engine = 50 cm.,Clearance volume = 4.5 litres.

23. An eight cylinder four stroke engine of 9 cm bore and 8 cm stroke has a compression ratio of 7 is tested at 4500 rpm on a dynamometer which has a 54 cm arm. During a ten minute test the dynamometer load reading was 42 kg and the engine consumed 4.4 kg of gasoline having a calorific value of 44 MJ/kg. Air at 27°C and 1 bar was supplied to the carburettor at the rate of 6 kg/mm. Find the following:

(i) Brake Mean Effective Pressure

(ii) Specific Fuel Consumption and specific Air Consumption

(iii)Relative efficiency

(iv)Volumetric efficiency.

24. Determine the size of the fuel orifice to give a 13.5 1 air-fuel ratio, if the venture throat has a 3 cm diameter and the pressure drop in the venturi is 6.5 cm Hg. The air temperature and pressure at carburetor entrance are 1 bar and 27°C respectively. The fuel orifice is at the same level as that of the float chamber. Take density of gasoline as 740 kg/m^3 and discharge coefficient as unity. Assume atmospheric pressure to be 76 cm of Hg.

25. A four stroke petrol engine has a piston displacement of 2210 cm^3. The compression ratio is 6.4. The fuel consumption is 0.13 kg/mm. The calorific value of fuel is 45000 KJ/kg. The brake power developed while running at 2500 rev/mm is 50.25 KW. Determine the brake mean effective pressure and the relative efficiency based on brake thermal efficiency.

26. During the trial of four stoke, single cylinder oil engine the following observations were recorded: bore = 300 mm; stroke 400 mm; speed 200 rpm; duration of trial = 60 minutes; fuel consumption 7.050 kg: calorific value 14000 kJ/kg; area of indicator diagram 322 mm2 length of indicator diagram 62 mm; spring index = 1.1 bar/mm; dead

load on the brake drum = 140 kg; spring balance reading = 5 kg; brake drum diameter = 1600 mm; total weight of cooling water = 495 kg: temperature rise of cooling water = 38°C; temperature of exhaust gases = 300°C: air consumption = 311 kg; specific heat of exhaust gases 1.004 kJ/kg K; specific heat of water = 4.186 kJ/kg K; room temperature 20°C. Determine

(i) Brake power
(ii) Indicated power
(iii) Mechanical efficiency
(iv) Thermal efficiency and draw up a heat balance sheet

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 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.
21. What is meant by compounding of turbines?
22. State the functions of fixed and moving blades.
23. Explain the need of compounding in steam turbines.
24. What is the function of governors in steam turbines?
25. What are the different methods of governing steam turbine?

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 250^0C. 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. Steam at a pressure of 10.5 bar and 0.95 dry is expanded through a convergent divergent nozzle. The pressure of steam leaving the nozzle is 0.85 bar.

(i) Find the velocity of steam at throat for maximum discharge take n=1.135.

(ii) Also find the area at the exit and the steam discharge if the throat area is 1.2 cm^2. Assume flow is isentropic and there are no friction losses.

4. (a) Briefly explain super saturated flow of steam through nozzle with h-s plot. What is meant by Wilson line?

(b) In a steam nozzle, the steam expands from 4 bar to 1 bar. The initial velocity is 60 m/s and the initial temperature is 200°C. Determine the exit velocity if the nozzle efficiency is 92%.

5. (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.

6. 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.

7. (a) Dry saturated steam at 2.8 bar is expanded through a convergent nozzle to 1.7 bar. The exit area is 3 cm^2. Estimate the exit velocity and the mass flow rate, assuming isentropic expansion and supersaturated flow exists.

7(b) The inlet condition to a steam nozzle are 10 bar and 250ºC. The exit pressure is 2 bar. Assuming isentropic expansion and negligible.determine the velocity at inlet for 1 kg/s of mass of steam,

(i) Throat area
(ii) Exit velocity
(iii) The exit area of the nozzle

8. (a)(i) State the factor on which nozzle efficiency depends.

(ii) Determine the throat and exit height of a Delaval nozzle to discharge 27 kg of a perfect gas per minute. The inlet and exit pressure are 480 kPa and 138 kPa respectively. Initial temperature of the gas is 535°C. Nozzle efficiency is 90°c and frictional losses occur only after the throat. The molecular weight of the gas is 29 and its adiabatic index is 1.4. Assume square cross of the nozzle.

8. (b) Steam enters the blade row of an impulse turbine with a velocity of 600m/s at an angle of 25^{o}C to the plane of rotation of blades. The mean blade speed is 200m/s. the blade angle at the exit is 30^o. The blade friction loss is 10%. Determine

(i) The blade angle at inlet

(ii) The work done per kg of steam

(iii)The diagram efficiency

(iv)The axial thrust per kg of steam per second.

9. In a stage of impulse reaction turbine, steam enters with a speed of 250 m/sec, at an angle of 30° in the direction of blade motion. The mean speed of the blade is 150 m/sec. when the rotor is running at 3000 r.p.m. The blade height is 10 cm. The specific volume of steam at nozzle outlet and blade outlet are 3.5 m3/kg and 4 m3/kg respectively. The turbine develops 250 kW. Assuming the Efficiency of nozzle and blades combinedly considered is 90% and carryover coefficient is 0.8 ; find

(i) The enthalpy drop in each stage

(ii) Degree of reaction

(iii) Stage efficiency.

10. 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

11. 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.

12. 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 m^3/Kg. Calculate for this stage.

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

(ii) The diagram work

13. (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 $[2\cos^2 \alpha_1/(1+\cos^2\alpha_1)]$,where α_1 is the angle at which the steam enters the blades.

14. (i) The data pertaining to impulse turbine is as follows:

Steam velocity = 500.mls; Blade speed = 200 m/s; Exit angle of moving blade = 25°; Nozzle angle = 25°. Neglecting the effect of friction when passing through the blade passages, calculate (1) inlet angle of moving blade, (2) exit velocity and direction, (3) work done/kg of steam, (4) axial thrust and power for a steam flow rate of 5 kg/s, and (5) diagram efficiency. (10)

(ii) What is reheat factor in turbine? (6)

15. In a Parson turbine running at 1500 r.p.m. the available enthalpy drop for an

expansion is 65 kJ/kg. If the mean diameter of the rotor is 100 cm, find the number of rows of moving blades required, assume stage efficiency as 80%, blade outlet angle as 20° C and speed ratio as 0.7. (12)

(ii) What are the different methods commonly used for governing steam turbines? (4)

16. In a Parson turbine running at 1500 r.p.m, the available enthalpy drop for an expansion is 65 kJ/kg. If the mean diameter of the rotor is 100 cm, find the number of rows of moving blades required, assume stage efficiency as 80%, blade outlet angle is 20° and speed ratio is 0.7.

17. (i) What are the advantages and limitations of velocity compounding?

(ii) In a two stage velocity compounded steam turbine, the mean blade speed is 150 m/s while the steam velocity as it issued from the nozzle is 675 rn/s. The nozzle angle is 20°. The exit angle of first row moving blade, fixed blade and the second row moving blades are 25°, 25° and 30° respectively. The blade friction coefficient is 0.9. Determine for a flow rate of 4.5 kg/s (1) the power output and (2) the diagram efficiency.

18. The steam enters an impulse wheel having a nozzle angle of 20º at a velocity of 450 m/sec. The exit angle of the moving blade is 20° and the relative velocity of the steam may be assumed to remain constant over the moving blades. If the blade speed is 180 m/sec, determine (i) Blade angle at inlet (ii) Work done per kg of steam (iii) Power of the wheel, when the turbine is supplied with 1.8 kg of steam per second.

19. The blade angles of both fixed and moving blades of reaction steam turbine are 35° at the receiving tips and 20° at the discharging tips. At a certain point in the turbine, the drum diameter is 1.37 m and blade height is 127 ‘mm. The pressure of steam supply to a ring of fixed blades at this point is 1.25 bar and the dryness fraction is 0.925. Find the work done in next row of moving blades for 1 kg of steam at 600 rpm, the steam passing through the blades without shock. Assuming an efficiency of 85% for the pair of rings of

fixed an moving blades, find the heat drop in the pair and state the properties of steam at the entrance to the next row of fixed blades,

20. (i) What are the different methods commonly used for governing steam turbines?

(ii) The following data refer to a single stage impulse turbine:

Isentropic nozzle enthalpy drop = 210 kJ/kg, Nozzle efficiency = 90%, Nozzle angle = 25°, Ratio of blade speed to whirl component of steam speed = 0.5, Blade velocity coefficient = 0.9, the velocity of steam entering the nozzle = 30 m/sec. Find (1) the blade angles at inlet and outlet if the steam enters the blades .without shock and leaves the blades in an axial direction (2) blade efficiency and (3) power developed and (4) axial thrust if the steam flow rate is 10 kg/sec.

21. 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.

22. (i) Explain pressure-velocity compounding with a neat sketch.

(ii)What is governing of turbines? Explain nozzle control and bypass governing.

23. (i) With a neat sketch explain the principle of operation of impulse and reaction turbine. (ii) Sketch inlet and outlet velocity triangles for a moving blade of an impulse turbine and indicate all velocities.

24. (i) What is the need for governing the steam turbines? What are the different methods of governing steam turbines? Describe any one method of governing with simple sketches.

(ii) Explain the difference between the operation of impulse and reaction steam turbines and give two examples for both types of turbines?

25. 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

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. 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 bar such that stage pressure ratio will not exceed 4. Determine the number of stages required.
21. Give two examples for positive displacement rotary compressor.
22. Give the expression for work done for a multi stage compressor with perfect inter cooling. also write the expression for volumetric efficiency

Part-B

1. (a) Derive an expression for volumetric efficiency of a reciprocating compressor.

(b) The free air delivery of a single cylinder single stage reciprocating air compressor is 2.5m^3/min. The ambient air is at STP conditions 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. If L=1.2D and compressor runs at 150rpm, determine the size of the cylinders.

2. (a) 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.

3. 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.

4. Prove that the heat rejected (Per kg of air) with perfect intercooling

$$=\left[c_p + c_v\left(\frac{\gamma - n}{n-1}\right)\right](T_2 - T_1).$$

5. Derive an expression for the minimum work required for a two stage reciprocating air compressor with perfect inter cooling and neglecting clearance.

6. A two-cylinder single-acting air compressor is to deliver 16 kg of air per minute at 7 bar from suction conditions 1 bar and 15°C. Clearance may be taken as 4% of stroke volume and the index for both compression and re expansion as 1.3. Compressor is directly coupled to a four-cylinder four-stroke petrol engine which runs at 2000 r.p.m. with a brake mean effective pressure of 5.5bar. Assuming a stroke-broke ratio of 1.2 for both engine and compressor and a mechanical efficiency of 82% for compressor, calculate the required cylinder dimensions.

7. A two stage air compressor compresses air from 1 bar and 20°C to 42 bar. If the law of compression is $pv^{1.3}$= 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.

8. (i) With a neat sketch describe any one type of rotary compressor.

   (ii) A single stage single acting reciprocating air compressor delivers 14 m^3 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 $pv^{1.35}$ = 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.

9. (i) Explain with suitable sketches the working of two stage air compressor with actual p-v diagram. (6)

(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 $PV^{1.3}$ = 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)

10. A three-stage air-compressor delivers 5.2 m^3 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%.

11. (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 $pv^{1.25}$ constant. R.P.M. 300, Piston speed = 180 m/min, Volumetric efficiency = 0.8.

12. 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 15.4 bar. The value of n is both cylinders is 1.3. C_p = 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.

13. (a) What are the advantages of multistage compression? (4)

(b) A single stage single acting reciprocating air compressor takes in 17 m^3/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 $pV^{1.3}$ = 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.

14. The FAD (free air delivered) of a single cylinder (16) single stage air compressor is 2.5 m^3min. The ambient is at 0°C and 1.013 bar and delivery pressure is 7 bar. The clearance volume is 500 of the stroke volume and law of compression and expansion is $PV^{1.25}$=C. If L = 1.2 D and compressor runs at 150 rpm. Determine power required, mean effective pressure and size of the cylinder.

15. Four cylinders, double acting air compressor is required to compress 25 m/min of air at I bar and 25°C to a pressure of 15 bar, Determine the size of motor required and the cylinder dimensions if the following additional data is given: clearance volume = 5%; L / D = 1.2; rpm = 300; mechanical efficiency 80°o: polytropic index n = 1.35. Assume no pressure changes in suction valves and that the air gets heated by 10°C during suction stroke.

16. A single-acting two stage compressor with complete inter-cooling delivers 10.5 kg/min of air at 16 bar. The suction occurs at 1 bar and 27°C. The compression and expansion processes are reversible, polytropic index n = 1.3. The speed of the compressor is 440 rpm. Calculate the following.

(i) The power required to drive the compressor. (ii) Isothermal efficiency

(iii) Free air delivered (iv) The heat transferred in the intercooler.

17. A single acting two stage air compressor with complete inter-cooling delivers 10 kg of air at16 bar pressure. The suction occurs at 1 bar and 15°C. The compression and expansion processes are reversible polytropic with the polytropic index n = 1.25. Calculate,

(i) Indicated power. (ii)Free air delivery,(iii) Isothermal efficiency and (iv) Heat transferred in the intercooler.

18. A single stage single acting air compressor running at 1000 rpm delivers air at 25 bar. For this purpose the induction and free air condition can be taken as 1.013 bar and 15ºC and the free air delivery as $25m^3$/min. The clearance volume is 3% of the swept volume and the stroke/bore ratio is 1.2:1. Calculate the bore, stroke and the volumetric efficiency of this machine. Take the index of compression and expansion a 1.3. Calculate also the indicated power and the isothermal efficiency.

19. (a) Explain the working principle of axial compressor with a neat sketch.

(b) A single stage single acting air compressor, the clearance volume is 5% of stroke volume. Air is drawn in constant pressure of 1 bar at a temperature of 37oC. Compression follows the law $pv^{1.2}$ = C and the receiver pressure is 7 bar. The compressor delivers 15kg of air / min. Find

(i) Volumetric efficiency, (ii) Power required to drive the compressor.

20.(a) Derive an expression for the minimum work required for a two-stage reciprocating air compressor with perfect intercooling and neglecting clearance.

(b) A two stage air compressor compresses air from 1 bar and 20°C to 42 bar. If the law of compression is pV1.35 = 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.

UNIT V REFRIGERATION AND AIR CONDITIONING

Vapour compression refrigeration cycle- super heat, sub cooling –

Performance calculations - working principle of vapour absorption system, Ammonia –Water, Lithium bromide –water systems (Description only) - Alternate refrigerants –Comparison between vapour compression and absorption systems.

Air conditioning system: Types, Working Principles - Psychrometry, Psychrometric chart - Cooling Load calculations - Concept of RSHF, GSHF, ESHF.

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?

21. Define Degree of saturation.
22. Define relative humidity and specific humidity.
23. Define DBT, WBT and DPT.
24. Define Wet bulb Depression.
25. What is adiabatic humidification of air?
26. What is meant by sensible heating and cooling?
27. Define ADP (Apparatus dew Point) of cooling coil.
28. Define By pass factor (BPF).
29. Define effective temperature (ET).
30. What is comfort chart?
31. Define RSHF and RTH.
32. Define GSHF and ESHF.

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

(iv) 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)

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(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 $pv^{1.3}$ = constant. (6)

4.a) Draw a neat sketch of a simple vapour compression refrigeration system and explain its principle of operation.

(ii) An ammonia refrigerator produces 30 tonnes of ice from and at 0°C in a day of 24 hours. The temperature range in the compressor is from 25°C to 15°C. The vapour is dry saturated at the end of compression and an expansion valve is used. Calculate the coefficient of performance. The properties of the refrigerant are given in the following table:

Temperature °C	Enthalpy KJ/kg		Entropy KJ/kg-K	
	Liquid	Vapour	Liquid	Vapo
25	100.04	1319.22	0.3473	4.485
-15	-54.56	1304.99	-2.1338	5.058

Temperature °C	P_s bar	υ_g m^3/kg	Enthalpy kJ/kg		Entropy kJ/kg K		Speci
-20	1.509	0.1088	17.8	178.61	0.73	0.7082	-
40	9.607	-	74.53	203.05	0.2716	0.682	0.747

5. (a) Freon-12 is compressed from 200 kPa to 1.0 MPa in an 80 percent efficient compressor. The condenser exiting temperature is 40^0 C. Calculate the COP and the refrigerant mass flux for 100 tons (352 kW) of refrigeration.

5(b) A food storage locker requires a refrigerating capacity of 50kW. It works between a condenser temperature of 35°C and an evaporator temperature of -10°C. The refrigerant is ammonia, It is sub-cooled by 5°C before entering the expansion valve and 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 and

(ii) The cylinder dimensions. Properties of ammonia are

Saturation Temperature °C	Pressure bar	Enthalpy kJ/kg		Entropy kJ/kg K		Specific volume m^3/kg		Specific heat kJ/kg K	
		Liquid	Vapour	Liquid	Vapour	Liquid	Vapour	Liquid	Vapour
-10	2.9157	154.056	1450.22	0.82965	5.7550	-	0.417477	-	2.492
35	13.522	366.072	1488.57	1.56605	5.2086	1.7023	0.095629	4.556	2.903

6. 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.

7. 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.

8.(i) Exp1ain summer Air Conditioning with a neat layout. (10)

(ii) Sketch various processes of summer Air Conditioning in a Psychometric chart (6)

9. (a) A sling psychrometer reads 40°C DBT and 36°C 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 21°C 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 21°C 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.

10. 40 m^3 of air per minute at 31°C DBT and 18.5°C WBT is passed over the cooling coil whose surface temperature is 4.4°C. The coil cooling capacity is 3.56 tons of

refriger ation under the given condition of air. Determine

11. A sling psychrometer in a laboratory test recorded the following readings.

Dry bulb tempera

ture = 35°C, Wet bulb temperature = 25°CCalculate the following

(i) specific humidity

(ii) relative humidity

(iii) vapour density in air

(iv) dew point temperature and

DBT and WBT of the airleaving the cooling coil.

(v) enthalpy of mixture per kg of dry air Take atmo spheric pressure = 1.0132 bar.

12. An office is to be air-conditioned for 50 staff when the outdoor conditions are 30°CDBT and 75% RH if the quantity of air supplied is $0.4m^3$/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 conditionedfirst 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 heatingcoil?

13) 100 m^3 of air per minute at 15° C DBT and 80% R.H. is heated until its temperaturebecomes 22° C. Find the following

(i) Heat added to the air per min.

(ii) R.H, of the heated air, Assume air pressure is at 1.033 bar.

14. (a) What are the various loads for Air Conditioning.

(b) An air-conditioning plant is to be designed for a small office for winner conditions.

Out - door conditions	:	10°C DBT and 8°C WBT
Required indoor - conditions	:	20°C DBT and 60 % R.H
Amount of air circulaion	:	0.3 m^3/min/person
Seating capacity of the office	:	50

The required condition is achieved first by heating and then by adiabatic humidifying. Findthe followings:

(i) Heating capacity of the coil in kW and the surface temperature required if the bypass factor of the coil is 0.32.

(ii) The capacity of the humidifier.

15. A cinema hall of seating capacity 1500 persons has been provided with an air conditioned plant with the following data:

Outdoor conditions = 40°C DBT and 20°C WBT

Required conditions = 20°C DBT and 60% RH

Amount of air supplied = 0.3 m^3/min/person.

If the required condition is achieved first by adiabatic humidifying and then cooling, find the capacity of the cooling coil and capacity of the humidifier.

16. (a) Explain the winter air conditioning system with the help of a neat sketch. (10)

(b) Explain the following terms:

(1) Degree of saturation

(2) Dew point temperature

(3) Humidity ratio.

17. (i) What is comfort zone? Show it on a psychrometric chart. With the help of a line diagram explain the working of a winter air-conditioning system [8]

(ii) Air at 16ºCand 25% relative humidity passes through a heater and then through a humidifier passes through a humidifier to reach final dry bulb temperature of 30ºC and 50%relative humidity. Calculate the heat and moisture added to the air. What is the Sensible heat factor? [8]

18. It is required to design an air-conditioning system for an industrial process for the following hot and wet summer conditions: (16)

Outdoor conditions	:	32°C DBT and 65% TH
Required air inlet conditions	:	25°C DRT and 60% RH
Amount of free air circulated	:	250 m^3/min
Coil dew point temperature	:	13°C

The required condition is achieved by first cooling and dehumidifying and then by heating. Calculate the following:

(i) The cooling capacity of the cooling coil and its by-pass factor.
(ii) Heating capacity of the heating coil in kW and surface temperature of the heating coil if the by-pass factor is 0.3.
(iii) The mass of water vapour removed per hour. Solve this problem using psychrometric chart.