Code No: R2031031 **R20** SET - 1

III B. Tech I Semester Regular Examinations, Dec/Jan -2022-23
THERMAL ENGINEERING - II
(Mechanical Engineering)

Time: 3 hours Max. Marks: 70

Answer any **FIVE** Questions **ONE** Question from **Each unit**
All Questions Carry Equal Marks
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UNIT-I

1. a) Explain the working and analysis of regenerative Rankine cycle with one feed water heater. [7M]
   b) In a Rankine cycle the steam at inlet to turbine is saturated at a pressure of 35 bar and exhaust pressure is 0.2 bar. Determine (i) The pump work (ii) The turbine work (iii) The Rankine efficiency (iv) The condenser heat flow (v) The dryness fraction at the end of expansion. Take a flow rate of 12kg/sec. [7M]

(OR)

2. a) What are the essentials of a good steam boiler? Estimate the factors which should be considered while selecting a boiler. [7M]
   b) Calculate the height of a chimney required to produce a draught equivalent to 1.6 cm of water if the flue gas temperature is 250^0 C and ambient temperature is 27^0 C and minimum amount of air per kg of fuel is 20 kg. [7M]

UNIT-II

3. a) Explain the classification and working principle of a nozzle. [7M]
   b) The velocity of steam leaving nozzles of an impulse turbine is 900m/s and the nozzle angle is 20^0. Blade velocity is 300m/s and blade velocity coefficient is 0.7. Calculate for a mass flow rate of 1kg/Sec and symmetrical blading, (i) The blade inlet angle (ii) Driving force on wheel (iii) The axial thrust (iv) Diagram power (v) Diagram efficiency. [7M]

(OR)

4. a) What do you mean by compounding of steam turbine? Discuss various methods of compounding steam turbines? [7M]
   b) A single row impulse steam turbine with a blade speed of 200m/s and mass flow rate of 4 kg/s develops 300 kW of power. Steam leaves the nozzles at 500 m/s, and the blade velocity coefficient is 0.92. If the steam leaves the turbine blade at such an angle that the absolute velocity at exit is kept minimum. Determine nozzle angle, blade angles and diagram efficiency. [7M]

UNIT-III

5. a) Distinguish between impulse and reaction turbine. [7M]

   b) The blade angles of both fixed and moving blades of a 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 in the 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 I kg of steam at 600 r.p.m., the steam passing through the blades without shock. Assuming an efficiency of 85% for the pair of rings of fixed and moving blades, find the heat drop in the pair and the state of steam at entrance to the next row of fixed blades. [7M]

(OR)

6. a) What are the characteristics of the Parson's reaction turbine? And also explain the conditions for its maximum efficiency. [7M]

   b) 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 blades in 19^0 and the absolute discharge velocity of steam is 100 m/s in the direction 70^0 to the motion of the blades. If the rate of flow through the turbine is 15000 kg/hr., calculate the power developed by the turbine. [7M]

UNIT-IV

7. a) Explain the working principle of rotary compressor and the methods to improve its efficiency. [7M]

   b) A single-stage air compressor delivers air at 6 bar. The pressure and temperature at the end of suction are 1 bar and 27°C. It delivers 1.5 m^3 of free air per minute when the compressor is running at 350 rpm. The clearance volume is 5% of when the compressor is running at 350 rpm. The clearance volume is 5% of stroke volume. The free air conditions are 1.013 bar and 15°C. The index of compression and expansion is 1.3. Find
   (i) The volumetric efficiency,(ii) Bore and stroke if both are equal,(iii) The power required if the mechanical efficiency is 80%. [7M]

(OR)

8. a) Explain the working principle of the reciprocating compressor and also write the expression for its isothermal efficiency. [7M]

   b) A single stage double acting air compressor running at 120 rpm and power input of 75 kW, piston speed 200 m/min, suction pressure 1 bar and the delivery pressure is 10 bar. Take volumetric efficiency as 85%. The law is $PV^{1.25} = C$. Find the cylinder bore and clearance volume as a percent of stroke volume. [7M]

UNIT-V

9. a) What are the advantages or effects of multi stage compression with intercooling over single stage compression for the same pressure ratio? [7M]

   b) A centrifugal compressor delivers 50 kg of air per minute at a pressure of 2 bar and 97^0 C. The intake pressure and temperature of the air is I bar and 15^0 C. If no heat is lost to the surrounding, find: (i) index of compression and (ii) power required, if the compression is isothermal. Take R = 287 J/kg K. [7M]

(OR)

10. a) What are surging, stalling and choking in an axial as well as in centrifugal compressors? [7M]

    b) An axial flow compressor is to be designed to generate a total pressure ratio of 4.0 with an overall isentropic efficiency of 0.85. The inlet and outlet blade angles of the rotor blades are 45^o& 10^o, respectively and the compressor stage has a degree of reaction of 50 percent. If the blade speed is 220 m/s and the work done factor is 0.86, find the number of stages required. The ambient air static temperature is 290 K and the air enters the compressor through guide vanes. [7M]

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UNIT-I

1. a) Briefly discuss about regeneration and reheating. [7M]
   b) In a steam power cycle the steam supply is at 15 bar and dry saturated. The condenser pressure is 0.4 bar. Calculate the carnot and Rankine efficiencies of the cycle. Neglect pump work [7M]

(OR)

2. a) Explain the working principle of Low pressure and High-pressure boilers. [7M]
   b) In an experiment on a small oil-fired boiler the steam produced is at 6 bar gauge. The quality of steam produced is found out to be 0.96 dry. 75 liters of water is converted into steam in 9.5 minutes. The fuel is a light diesel oil with specific gravity of 0.85 and calorific value of 43125 kJ/kg. 10 liters of oil is consumed in 11 minutes and 25 seconds. The feed water temperature is 35^{o}C. Determine the boiler efficiency. Take atmospheric pressure as 1 bar. [7M]

UNIT-II

3. a) Explain the classification and working principle of a nozzle. [7M]
   b) Steam having pressure of 10.5 bar and 0.95 dryness is expanded through a convergent divergent nozzle and the pressure of steam leaving the nozzle is 0.85 bar. Find the velocity at the throat for maximum discharge conditions. Index of expansion may be assumed as 1.135. Calculate mass rate of flow of steam through the nozzle. [7M]

(OR)

4. a) Explain with a neat sketch of velocity compounding, pressure compounding, pressure-velocity compounding. [7M]
   b) 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. Calculate nozzle angle, blade angles at entry and exit, assuming no shock. [7M]

UNIT-III

5. a) What do you understand by the term 'height of blades' as applied to a reaction turbine? [7M]
   b) At a particular ring of a reaction turbine, the blade speed is 66 m/s and the flow of steam is kg/s dry saturated at 1.4 bar. Both fixed and moving blades have inlet and exit angles of 35° and 20° respectively. Calculate: (i) the required blade height which is to be one-tenth of the mean blade ring diameter. (ii)the power developed by. the pair of rings, and (iii) the heat drop required by the pair if the steam expand with an efficiency of 80 percent. [7M]

(OR)

6. a) The work done in Parson's reaction turbine is twice the work done during expansion in the moving blades, why? [7M]
   b) Derive the expression for the maximum blade efficiency of the Parson's reaction turbine. [7M]

UNIT-IV

7. a) Give the classification of fan, blower and compressor. [7M]
   b) A single stage, double acting air compressor is required to deliver 14 m^3 of air per minute measured at 1.013 bar and 15^0C. The delivery pressure is 7 bar and the speed 300 rev/minute. Take the clearance volume as 5% of the swept volume with a compression and re-expansion index of n = 1.3. Calculate the swept volume of the cylinder, the delivery temperature, and the indicated power. [7M]

(OR)

8. a) Explain the working principle of rotary compressor and its efficiency. [7M]
   b) A single stage single acting reciprocating air compressor has a bore of 200 mm and stroke of 300 mm. It receives the air at atmospheric conditions and delivers at 5.5 bar. The compression follows the law $PV^{1.3} = C$, and clearance volume is 6% percent of the stroke volume and compressor runs at 500 rpm. Show the process in a P-V diagram and calculate the power required to drive the compressor. [7M]

UNIT-V

9. a) Differentiate between centrifugal and axial flow compressors. [7M]
   b) Acentrifugal air compressor having internal and external diameters of 250 mm and 500 min respectively compresses 30 kg of air per minute while running at 4000 rpm The vane angles at inlet and outlet are 30^0 and4^0 respectively. Find the necessary thickness of the blade if the impeller contains 40 blades. Take specific volume of air as 0.8 m^3/kg. [7M]

(OR)

10. a) Briefly explain the blade shape losses, slip factor, power input factor, pressure coefficient and adiabatic coefficient for centrifugal compressor. [7M]

    b) An axial flow compressor having eight stages and with 50 % reaction design compresses air in the pressure ratio of 4:1. The air enters the compressor at 20^0 C and flows through it with a constant speed of 90 m/s. The rotating blades of compressor rotate with a mean speed of 180 m/s. Isentropic efficiency of compressor may be taken as 82%. Calculate: (i) work done by the machine, (ii) blades angles, if γ =1.4,Cp =1.005 kj/kg K. [7M]

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UNIT-I

1. a) Explain the concept of "mean temperature of heat addition". [7M]
   b) A simple Rankin cycle works between pressures 28 bar and 0.06 bar. The initial condition of the steam being dry saturated. Calculate the cycle efficiency, work ratio and specific steam consumption. [7M]

(OR)

2. a) List out the merits and demerits of water tube and fire tube boilers. [7M]
   b) A boiler is to provide 7000 kg/hr of steam with superheated by 40ºC at a pressure of 20bar. The temperature of water is 60ºC. If the thermal efficiency of the boiler is 75%, how much fuel oil will be consumed in one hour? The calorific value of oil used is 45000 kJ/kg. Take specific heat of superheated steam as 2.093 kJ/kg K and also calculate the equivalent evaporation from and at 100ºC [7M]

UNIT-II

3. a) What is the effect of friction on the flow through a steam nozzle? Explain with help of h-s diagram. [7M]
   b) Derive an expression for maximum discharge through convergent divergent nozzle for steam. [7M]

(OR)

4. a) Explain with a neat sketch of combined velocity diagram for a velocity compounded impulse turbine. [7M]
   b) In a single stage impulse turbine, the blade angles are equal and the nozzle angle is 20°. The velocity coefficient for the blade is 0.83. Find the maximum blade efficiency possible. If the actual blade efficiency is 90% of maximum blade efficiency, find the possible ratio of blade speed to steam speed. [7M]

UNIT-III

5. a) Draw the combined velocity triangle for a single stage reaction turbine and derive an expression for work done per stage. [7M]
   b) The outlet angle of a blade of Parson's turbine is 20° and the axial velocity of flow of steam is 0.5 times the mean blade velocity. Draw the velocity diagram for a stage consisting of one fixed and one moving row of blades. It is given that mean diameter= 710 mm and speed of rotation = 3000 r.p.m. Find the inlet angle of blades if the steam is to enter the blade channels without shock. If the blade height is 64 mm, the mean steam pressure 5.6 bar, the steam dry saturation (υ_g= 0.3434 m3/kg); find the power developed in the stage. [7M]

(OR)

6. a) Explain the working principle of steam condensers and its importance. Also, briefly explain the types of steam condensers. [7M]
   b) A Parson's reaction turbine comprising one ring of fixed blades and one ring of moving blades. Mean diameter of the blade ring is 90 cm and its speed is 3000 rpm. The inlet absolute velocity of the steam to the blades is 300 m/s. The blade outlet angle is 20^o. The rate of steam flow is 10 kg/s. Determine the following: (i) blade inlet angle, (ii) tangential force and (iii) power developed in the stage. [7M]

UNIT-IV

7. a) A single stage single acting reciprocating air compressor has a bore of 200 mm and stroke of 300 mm. It receives the air at atmospheric conditions and delivers at 5.5 bar. The compression follows the law $PV^{1.3} = C$, and clearance volume is 6% percent of the stroke volume and compressor runs at 500 rpm. Show the process in a P-V diagram and calculate the power required to drive the compressor. [7M]
   b) What do you understand by positive displacement and non-positive displacement? Explain the positive displacement and non-positive displacement type reciprocating and rotary compressors. [7M]

(OR)

8. a) What is the working principle of reciprocating air compressor? Discuss the factors affecting the efficiency of the reciprocating compressor. [7M]
   b) A single stage double acting air compressor running at 120 rpm and power input of 75 kW, piston speed 200 m/min, suction pressure 1 bar and the delivery pressure is 10 bar. Take volumetric efficiency as 85%. The law is $PV^{1.25} = C$. Find the cylinder bore and clearance volume as a percent of stroke volume. [7M]

UNIT-V

9. a) A centrifugal compressor running at 2000 r.p.m. receives air at 17^0 C. If the outer diameter of the blade sip is 750 mm find the temperature of the air leaving the compressor. Take c_p= 1 kJ/kg K. [7M]
   b) Explain the working principle of air flow compressor and also mention its isentropic efficiency. [7M]

(OR)

10. a) Explain, with a neat sketch, the working of a centrifugal compressor. [7M]
    b) An axial flow compressor with an overall isentropic efficiency of 85% draws air at 20^oC and compresses it in the pressure ratio of 4:1. The mean blade speed and flow velocity are constant throughout the compressor. Assuming 50% of reaction blading and taking blade velocity as 180 m/s and work factor as 0.82. Calculate: (i) Flow velocity, (ii) number of stages. [7M]
    Take α_1 =120, β_1 =420

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UNIT-I

1. a) Briefly discuss about adiabatic flame temperature. [7M]
   b) In a regenerative cycle the inlet conditions are 40 bar and 400^0C. Steam is bled at 10 bar in regenerative heating. The exit pressure is 0.8 bar. Neglecting pump work, determine the efficiency of the cycle. [7M]

(OR)

2. a) With the help of a neat diagram explain the working principle and construction of any water tube boiler. [7M]
   b) Calculate the height of chimney required to produce a draught equivalent to 1.7cm of water if the flue gas temperature is 270°C and ambient temperature is 22°C and minimum amount of air per kg of fuel is 17kg. [7M]

UNIT-II

3. a) Explain the phenomenon of meta stable flow of steam through a nozzle. What is the significance of Wilson's line in it? [7M]
   b) Steam enters an impulse wheel having a nozzle angle 20^0 at a velocity of 450 m/sec. The exit angle of moving blade is 20^0 and the relative velocity of steam may be assumed to remain constant over the moving blades. If the blade speed is 180m/sec; Calculate i) Blade angle at inlet, ii) Work done per kg of steam, iii) Power developed if rate of steam flow is 1.6 kg/sec. [7M]

(OR)

4. a) Briefly discuss about De-laval turbine with neat sketch. [7M]
   b) The blade speed of a single ring impulse blading is 250 m/s and nozzle angle is 20°. The heat drop is 550 kJ/kg and nozzle efficiency is 0.85. The blade discharge angle is 30° and the machine develops 30 kW, when consuming 360 kg of steam per hour. Draw the velocity diagram and calculate: 1. Axial thrust on the blading and 2.the heat equivalent per kg of steam friction of the blading. [7M]

UNIT-III

5. a) Explain the working of single stage reaction turbine. Sketch the pressure and velocity variations along the axis of the turbine. [7M]
   b) A reaction turbine running at 360 r.p.m. consumes 5 kg of steam per second. The leakage is 10%. The discharge blade tip angle for both moving and fixed blades is 20°. The axial velocity of flow is 0.75 times blade velocity. The power developed by acertain pair is 4.8 kW where the pressure is 2 bar and dryness fraction is 0.95. Find the drum diameter and blades height. [7M]

(OR)

6. a) What are the requirements of steam condensing plant? Also, discuss vacuum efficiency and condenser efficiency. [7M]
   b) A parson's reaction turbine running at 400 r.p.m with 50% reaction develops 75 kW per kg of the steam. The exit angle of the blade is 20° and the steam velocity is 1.4 times the blade velocity. Determine, (i) Blade velocity (ii) Blade inlet angle. [7M]

UNIT-IV

7. a) Give classifications of fan, blower and compressors. [7M]
   b) A reciprocating air compressor takes in 2 m^3/min at 0.11 MPa, 20°C which it delivers at 1.5 MPa, 111°C to an after cooler where the air is cooled at constant pressure to 25°C. The power absorbed by the compressor is 4.15 kW. Determine the heat transfer in, (i) The compressor (ii) The cooler [7M]

(OR)

8. a) Explain, with a neat sketch, the working of a centrifugal compressor and obtain an expression for the work done. [7M]
   b) A single-acting two-stage air compressor deals with 4 m^3/min of air under atmospheric conditions of 1.016 bar and 15°C with a speed of 250 r.p.m. The delivery pressure is 78.65 bar. Assuming complete inter cooling find the minimum 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 $PV^{1.25}$ = C and neglect the clearance. [7M]

UNIT-V

9. a) Explain, with a neat sketch, the working of a axial flow compressor and obtain an expression for the work done. [7M]
   b) A centrifugal air compressor having a pressure compression ratio of S compresses air at the rate of 10 kg/s. If the initial pressure and temperature of the air, is 1 bar and 20^0 C. find: (i) the final temperature of the gas, and
   (ii) Power required to drive the compressor. Take γ=I.4 and c_p=1 kJ/kg K. [7M]

(OR)

10. a) Differentiate between centrifugal compressor and axial flow compressor. [7M]
    b) An axial flow compressed has a constant axial velocity of 150 m/s and 50% reaction. The mean diameter of the blade ring is 35 cm and speed is 15000 rpm. The exit angle of the blade is 27^0 . Calculate blade angle at inlet and work done per kg of air. [7M]