BACHELOR OF PRODUCTION ENGINEERING EXAMINATION, 2025
[3rd Year 1st Semester (5th Semester)]

ENERGY PRODUCTION SYSTEMS

Time: Three hours **Full Marks: 100**

Answer **any FIVE** questions.

All parts of a question ***(a, b, c* etc**) should be answered at one place.
Marks allotted for each question are given **at the right side below** the questions.
Assume any missing data with proper justification.

1.(a) Compare gas turbine and steam turbine power plant.

(b) A gas turbine power plant working on Brayton cycle has an overall pressure ratio **5:1** and the maximum cycle temperature **750° C**. The turbine drives the compressor and an alternator. The ambient pressure and temperature are **1 bar** and **27° C** respectively. Using following data:
Isentropic efficiency of compressor = **82%**
Isentropic efficiency of turbine = **85%**
Mechanical efficiency of drive = **97%**
Index of compression and expansion = **1.4**
Flow rate of air **10 kg/s**; c_p for air= **1.005 kJ/kg-K**
determine (i) power output from the plant,
(ii) thermal efficiency of the plant and
(iii) maximum attainable specific work-output.
Assume there are no pressure and kinetic energy loss in the combustion chamber. Neglect the mass of fuel.

5+15 =20

2.(a) Derive an expression for work required per unit mass of air compressed with clearance volume in a single- stage and single-acting reciprocating air compressor.

(b) A double-acting, double-stage reciprocating air compressor with perfect inter-cooling takes in air at **1 bar** and **25° C**. The law of compression in both the stages is $\mathbf{pv^{1.33}=C}$. The compressed air is delivered at **9 bar** from HP cylinder to an air receiver. Estimate for per kg of air (i) minimum work-done and (ii) heat rejected to the inter-cooler. Neglect the area of connecting rod. Also, estimate the minimum work-done for per kg of air, if the compressor works in three stages under same conditions.

8+12=20

3.(a) Differentiate between nozzle and diffuser.

(b) What is nozzle efficiency? What are the various types of nozzle?

(c) What do you mean by the phenomena chocking in a nozzle? - Explain.

(d) Steam is expended from **14 bar** and **300° C** to **6 bar** while it is passed through in a convergent-divergent type nozzle. If the flow rate is **1 kg/s** find the throat area and exit area of the nozzle.

4+(2+3)+4+7=20

4.(a) Explain about the working principle of Rankine cycle with the help of flow diagram and ***T-s*** diagram.

(b) Steam is supplied at dry saturated at **40 bar** and the condenser pressure is **0.03 bar** in a thermal power plant. If the plant is operated on Rankine cycle calculate for per kilogram of steam (i) work output and (ii) Rankine thermal efficiency.

10+10=20

5.(a) Differentiate between the velocity compounded and the pressure compounded impulse turbines with neat sketch.

(b) Distinguish between the impulse turbine and reaction turbine.

(c) Derive an expression of maximum blade efficiency for a single-stage Parson's reaction turbine in term of nozzle angle α.

(d) Show that for a single-stage impulse turbine the optimum blade speed ratio is given by $\rho = \frac{\cos\alpha}{2}$; where, α= nozzle angle.

7+3+5+5=20

6.(a) In a simple impulse turbine nozzles are inclined at **20°** to the direction of motion of moving blades and steam leaves the nozzles at **375 m/s**. The speed of blades is **165 m/s**. Find the suitable entry and exit angles of the blades in order that the axial thrust is **zero**. The relative velocity of steam is reduced by **15%** by friction as it flows over the blades. Draw the velocity diagram.

(b) In a stage of impulse-reaction turbine having a degree of reaction of **0.5** the fixed and moving blades are of identical section and the blades' exit angle is **18°**. The absolute velocity of discharge from the moving blades is **40 m/s** in a direction of **110°** to the motion of the blades and the change of velocity produced by the moving blades is parallel to that direction. Find (i) power developed for steam flow rate of **4 kg/s** and (ii) stage efficiency if the frictional loss is **25%** of the kinetic energy corresponding to the relative velocity at the entry of each ring of blades and the expansion loss is **10%** of the heat drop in the blades.

8+12=20

7.(a) Distinguish between the following.

(i) Fire tube and Water tube boilers
(ii) Accessories and Mountings of boiler.

(b) Write a short note on cooling tower.

(c) Discuss about the working of evaporative type condensers with neat sketch.

10+4+6=20

8. Answer any **FOUR** from the following:

(a) Illustrate the working principle of a flat plate solar collector for generation of electricity.

(b) Explain the basic principle of an Ocean Thermal Energy Conversion (OTEC) with a neat sketch.

(c) Describe with a neat sketch the working principle of Wind power generation.

(d) State the working principle of Magneto Hydrodynamic (MHD) systems.

(e) Discuss about the Nuclear power plant cycle with a neat sketch.

5x4=20

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