MODEL QUESTION PAPER

13.406 TURBO MACHINERY (s)

MARKS: 100 TIME: 3Hrs

PART A

ANSWER ALL QUESTIONS

1. Define a Specific speed.
2. Write down the general energy equation for a system with heat and work transfers and changes in the internal energy , kinetic energy and datum head.
3. List out the various laws dealing with the problems of design and operation of turbo machines.
4. What is secondary flow in the axial turbine and compressor cascades? Does it lead to a loss of energy?
5. Write down the equation for lift, drag forces acting on a turbine blade?
6. Draw a sketch of the two- stage axial flow compressor with inlet guide Vanes.
7. What is slip factor?
8. How is the degree of reaction of an axial turbine stage defined?
9. Draw an enthalpy-entropy diagram for flow through an IFR turbine stage.
10. Define Mach Number.

(10X2=20 marks)

PART B
ANSWER ALL QUESTIONS, EACH QUESTION CARRIES 20 MARKS

MODULE I

11. a) Explain briefly with the help of neat sketch different types of impellers.
    b) With the help of an h-s diagram discuss specific work.

OR

12. a) Define and classify turbo machine.
    b) Explain the different variables involved in determine the performance of an axial turbo machines.

MODULE II

13. Draw the following for axial flow compressor and turbine cascades:
    i) typical static pressure and velocity distribution curves around the blades, and
    ii) velocity and direction profiles at the cascade exit

OR

14. a) Illustrate nomenclature of an axial compressor cascade.
    b) Derive the optimum space chord ratio of turbine blades.

MODULE III

15. a) A centrifugal compressor runs at a speed of 15000 rpm and delivers 30 kg of air per second. Exit radius is 0.35m, relative velocity at exit is 100 m/s at an exit angle of 75^0 . Assume axial inlet and T_{01}=300 K and p_{01}= 1 bar. Calculate (a) the torque (b) the power required to drive the compressor (c) the ideal head developed (d) the work done and (e) the exit total pressure
    b) Derive an expression for Degree of Reaction for an axial flow compressor.

OR

16. A centrifugal air compressor stage has the following data:

Type of impeller	radial-tipped
Speed	17000 rpm
Impeller tip diameter	48cm
Eye tip diameter	24cm
Eye hub diameter	12cm
Mass flow rate	8kg/s
Slip factor	0.92
Stage efficiency	0.77
Entry conditions	p_{01} =1.05bar, T_{01} = 306k

Determine:

a) The air angles at the hub, mean and tip sections of the inducer, maximum Mach number at the inducer entry, total pressure ratio developed and power required to drive the compressor without IGVs.
b) The air angles at the hub, mean and tip sections of the IGVs at exit for axial entry to the inducer, total pressure ratio developed and the power required.

MODULE IV

17. a) How are the loss coefficients for stationary and moving rows of blades in a turbine stage defined?

    b) How would you predict the cascade losses in a stage from its velocity triangles?

OR

18. A ninety degree IFR stage has the following data:

Total-to-static pressure ratio	$P_{01}/P_3=3.5$
Exit pressure	1 bar
Stagnation temperature at entry	650^0c
Blade-to-isentropic speed ratio	$\sigma=0.66$
Rotor diameter ratio	$d_3/d_2=0.45$
Rotor speed	N=16000rpm
Nozzle exit air angle	$\alpha_2=20^0$
Nozzle efficiency	$\eta_N=0.95$
Rotor width at entry	b_2=5cm

Determine a) the rotor diameter, b) the rotor blade exit air angle, c) the mass-flow rate, d) hub and tip diameters at the rotor exit, e) the power developed and f) the total-to-static efficiency of the stage.