The Assam Royal Global University, Guwahati

Royal School of Engineering & Technology
B.Tech., Mechanical Engineering, 6th Semester
Semester End Examination, July 2022
Course Title: **Gas Dynamics and Jet Propulsion**
Course Code: **MEE022D6031**

Time: 3 Hours **Maximum Marks: 70**

Note: Attempt all questions as per instructions given.
The figures in the right-hand margin indicate marks.
(The use of non-programmable scientific calculator is allowed)

Section – A

1. Attempt **all questions**. **2 x 8**

a. Define Mach number.

b. Draw schematic of Brayton cycle and represent it on *p-v* & *T-s* diagram

c. Draw the combine velocity diagram of centrifugal compressor.

d. Differentiate between diffuser and nozzle.

e. Define degree of reaction of a turbine.

f. In a reaction turbine the heat drop in the fixed blade is 8 kJ/kg and total heat drop per stage is 20 kJ/kg. Find degree of reaction?

g. Why is jet engine called an air-breathing engine?

h. Differentiate between jet propulsion and rocket propulsion.

Section – B

2. Attempt **any two** of the following: **6 x 2**

a. A gas-turbine power plant operates on the simple Brayton cycle between the pressure limits of *100 kPa* and *1200 kPa*. Air enters the compressor at *300 K* at a rate of *150* m^3/min and the turbine at *1300 K*. Assuming a compressor isentropic efficiency of *82%* and a turbine isentropic efficiency of *88%* determine (i) the net power output, (ii) the back work ratio, and (iii) the thermal efficiency?

b. A gas turbine power plant operating on an open cycle has a pressure ration of *8*. The gas temperature is *300 K* at compressor inlet and *1300 K* at the turbine inlet, determine the thermal efficiency. If regenerator is installed, what will be the change in thermal efficiency?

c. Explain with a neat sketch the working of Brayton cycle with regeneration.

3. Attempt **any two** of the following: **7 x 2**

a. Explain the phenomenon of "Surging" and "Chocking" in centrifugal compressors. Identify the range of operation on the characteristics curve of a centrifugal compressor

b. A centrifugal compressor having a pressure ratio of *4:1* and an isentropic efficiency of *80%* is running at *15000 rpm* and inducing air at *293K*. Curved vanes at the inlet give the air a pre-whirl of *25°* to the axial direction at all radii. The tip diameter of the eye of the impeller is *250 mm*. The absolute velocity at inlet is *150 m/s* and the impeller diameter is *600 mm*. Calculate the slip factor.

c. A 10-stage axial flow compressor provides an overall pressure ratio *5:1* with an overall isentropic efficiency of *87%*. When the temperature of air at inlet is *15°C*, the work is equally divided between the stages. A *50%* reaction is used with a blade speed of *210 m/s* and a constant axial velocity of *170m/s*. Estimate blade angles. Assume a work done factor is equal to *1*.

4. Attempt **any two** of the following: **7 x 2**

a. Derive an expression for the degree of reaction of an axial flow gas turbine.

b. For an axial flow gas turbine shaft work is *46.5 kJ/kg*, Blade velocity is *183 m/s*, Axial velocity of air is *91.5 m/s*, Degree of reaction is *30%*. Find inlet and outlet blade angles.

c. Gas at *7 bar* and *300°C* expands *3 bar* in an impulse turbine stage. The nozzle angle is 70° with reference to the exit direction. The rotor blades have equal inlet and outlet angles, and the stage operates with optimum blade speed ratio. Assuming isentropic efficiency of nozzle *0.9* and that the velocity at the entry to the stage is negligible, deduce the blade angle used and the mass flow required for this stage to produce *75 kW*. Take $Cp = 1.15\ kJ/kg$.

5. Attempt **any two** of the following: **7 x 2**

a. With the aid of a neat sketch, explain the working principle of a Turbo-Prop Jet Engine.

b. With the aid of a neat sketch, explain the working principle of a Hybrid Propellent Rockets.

c. With the aid of a neat sketch, explain the working principle of Flying Bomb.