KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering

B.Sc. Engineering 4th year Special Backlog Examination, 2020

ME 4105

(Applied Thermodynamics)

Time: 3 Hours | Total Marks: 210

N.B.: i) Answer any THREE questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.
iii) Assume reasonable data if any missing.

SECTION – A

1(a) Discuss the means of improving the efficiency and the specific output of a gas turbine working on Brayton cycle. 09

1(b) Prove that the optimum pressure ratio of an actual gas turbine cycle depends on the temperature ratio and the isentropic efficiencies of the gas turbine and compressor. 09

1(c) In a gas turbine unit, air is compressed from 1 bar and 28°C through a pressure ratio of 4.5:1. It is then heated to 1050°C in a combustion chamber and expanded back to atmospheric pressure of 1 bar in the turbine. Heating value of the fuel is 41 MJ/kg. The isentropic efficiencies of turbine and compressor are 85% and 80% respectively. For an air flow rate of 1.35 kg/sec, determine- (i) air-fuel ratio of the turbine plant, (ii) overall efficiency of the plant, and (iii) back work ratio. Assume $C_p = 1.005$ KJ/kgK and $\gamma = 1.4$ for both air and gases. 17

2(a) With neat sketch, describe the working principle of Ramjet engine. Also mention its advantages. 10

2(b) How does rocket propulsion differ from jet propulsion? Show that, efficiency of rocket propulsion can be expressed as $\eta_{rocket} = \frac{2\sigma}{(1+\sigma^2)}$, where symbols have their usual meanings. 11

2(c) A turbojet engine flying at a speed of 720 km/hr, consumes air at the rate 42 kg/sec. Given the enthalpy change for the nozzle is 175 kJ/kg, velocity coefficient is 0.95, air-fuel ratio is 71, heating value of the fuel is 42 MJ/kg, and combustion efficiency is 95%; Calculate: (i) thrust specific fuel consumption; (ii) thermal efficiency of the plant; (iii) propulsive power; and (iv) overall efficiency. 14

3(a) Describe the principle of action of steam turbine. Differentiate between impulse turbine and reaction turbine. 08

3(b) Show that for frictionless and symmetrical blading the maximum diagram efficiency of an impulse turbine can be expressed as $\eta_{d_{max}} = cos^2\alpha$, where α is the nozzle angle. 10

3(c) The mean diameter of the blades of an impulse turbine with a single row wheel is 110 cm and the speed 3100 rpm. The nozzle angle is 17°, the ratio of blade speed to steam speed is 0.48 and the ratio of the relative velocity of outlet from the blades to that at inlet is 0.85. The outlet angle of the blades is to be made 3° less than the inlet angle. The steam flow is 8 kg/sec. Draw the velocity diagram for the blade and determine- (i) resultant thrust on blades; (ii) tangential thrust on blades; (iii) axial thrust on blades; (iv) power developed in blades and (v) blading efficiency. 17

4(a) What are the different types of plate blade sections? Discuss with neat sketches. 08

4(b) What are the different losses encountered in steam turbine? How blade windage is accounted? 07

4(c) Show that the overall efficiency of steam turbine can be expressed as $\eta_0 = \frac{\Sigma \Delta h}{\Delta H}$, where symbols have their usual meanings. Why reheat factor has a value greater than unity? 08

4(d) For frictionless and symmetrical blading, show that the maximum rate of doing work corresponding to maximum diagram efficiency can be expressed as, $W_{max} = \frac{2C_b^2}{g_c}$, where C_b is the speed at the mean height of the blade. 12

SECTION – B

5(a) What are the standard ways for the performance test of an IC engine? What parameters are recorded and what are to be found out during engine testing and study of an IC engine. Explain in brief. 09

5(b) Differentiate between *ihp* and *fhp*. Draw the performance curves for *ihp*, b_{sfc}, b_{theff} versus speed for a SI engine test. 08

5(c) Following data were recorded from a test on a single cylinder 4-stroke IC engine: cylinder bore = 150 mm, engine stroke = 250 mm, area of the indicator diagram = 450 mm^2, length of indicator diagram = 50 mm, indicating spring rating = 1.2 mm, engine speed = 4200 rpm, brake torque = 217 N.m, fuel consumption = 2.95 kg/hr, calorific value of fuel = 44000 KJ/kg, cooling water flow rate = 0.068 kg/sec, cooling water temperature rise = 45 K, specific heat of cooling water = 4.1868 KJ/kgK. Calculate- (i) mechanical efficiency; (ii) brake thermal efficiency; (iii) specific fuel consumption; (iv) draw hp and energy balance in kW. 18

6(a) What are the basic requirements of a good SI engine combustion chamber for high power output? 04

6(b) How ignition delay in SI engine differs from that in CI engine? Discuss the variables that affect the ignition delay in CI engine. 10

6(c) Discuss the different stages of combustion in CI engine with the help of heat release rate–crank angle diagram. 10

6(d) What is meant by 'surface ignition' and 'knock'? "Factors that tend to increase knock in SI engine reduce knock in CI engine"- Discuss the validity of the above statement. 11

7(a) What are the methods for generating air swirl in CI engines? Compare induction swirl with compression swirl. 08

7(b) Describe crevice-flow and blow-by with appropriate diagrams. 08

7(c) What are the purposes of supercharging? Discuss the factors that limit the supercharging in both SI and CI engines. 09

7(d) What are the limitations of turbo-charging? Discuss the operating principle of Buchi turbocharger. 10

8(a) Classify fuel injection systems for CI engines. Draw and briefly explain a typical heat release diagram for a CI engine. 09

8(b) What is meant by supercharging in CI engines? Describe in brief how a turbo-charger works in CI engines. 09

8(c) What is meant by MBT? What are the factors that influence the MBT timing? 05

8(d) Develop an expression for mass flow rate of air through the venturi of a carburetor used in SI engines. 12

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering

B. Sc. Engineering 4th Year Backlog Examination, 2020

ME 4113/ ME 4213 (Old)

(Fluid Machinery/ Fluid Mechanics III)

Time: 3 Hours | Total Marks: 210

N.B.: i) Answer any THREE questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.
iii) Assume reasonable data if any missing.

SECTION-A

1(a) How air vessel minimizes the fluctuation of flow in suction side of a reciprocating pump? 05

1(b) Show that the work saved against friction by fitting an air vessel in a single acting reciprocating pump is 84.8%. 14

1(c) A double acting reciprocating pump having piston area 0.1 m^2 has a stroke 0.3 m long. The pump is discharging 2.5 m^3 of water per minute at 45 rpm through a height of 10 m. Find the slip of the pump and power required to drive the pump. 16

2(a) Why priming is necessary before starting a centrifugal pump? Explain. 06

2(b) Deduce the expression of least diameter of a centrifugal pump. 12

2(c) Water to be pumped out of a deep well under a total head of 95 m. A number of identical pumps of design speed 1000 rpm and specific speed 900 rpm with a rated capacity of 150 lit/sec are available. How many pumps will be needed and how should they be connected? 17

3(a) What is the specific speed of a turbine? Describe the function of surge tank. 10

3(b) Distinguish between the impulse and reaction turbine. 08

3(c) A Kaplan turbine produces 10^4 kW under a head of 30 m with an overall efficiency of 90%. The hub diameter is 4 times the outer diameter of the runner. Determine – (i) Diameters, (ii) The speed of the turbine assuming the speed ratio $K_u = 1.5$ and flow ratio = 0.65. 17

4(a) Describe with neat sketch the working principle of governing system for a reaction turbine. 17

4(b) A ¼ scale turbine model is tested under a head of 12 m. The prototype turbine is required to run under a head of 30 m at a speed of 425 rpm. At what speed the model turbine be run and it develops 100 kW and uses 1.14 m^3/sec of water at this speed? What power will be obtained from the prototype turbine, assuming that its efficiency is 3% better than that of model? Also indicate the type of runner used in this turbine. 18

SECTION-B

5(a) What is circulation? Show that circulation around a contour is equal to the product of the vortices within the area of the contour. 12

5(b) Write a short note on: (i) Stream function, and (ii) Velocity potential. 10

5(c) Determine the flow rate between the points (3.1, 2.2) and (6.1, 4.4) for the flow field expressed by $\psi = 2x^3y + 3x^2y^2$. Also determine the velocity potential for the flow field. 13

6(a) Show graphically the effect of superimposition of uniform flow and a doublet. Find out the stream function and velocity potential of the resulted flow field. 18

6(b) Derive the expressions of lift and drag for flow about a rotating cylinder. 17

7(a) Show that for a given specific energy, the discharge in a given channel section is maximum when the flow is in critical state. 18

7(b) A trapezoidal channel having bottom width 5 m and 1:1 side slope carries a discharge of 12.2 m^3/sec. Compute the critical depth and the critical velocity. If Manning's n = 0.2, determine the bottom slope required to maintain the critical depth. 17

8(a) What is hydraulic jump? Show that the head loss in a hydraulic jump in a rectangular channel may be expressed as 17

$$\Delta E = \frac{(y_2 - y_1)^3}{4y_1 y_2}$$

where, the symbols have their usual meanings.

8(b) Water on a horizontal channel of 25 m wide spillway has depth of 0.18 m and velocity of 5.5 m/sec before a hydraulic jump. Determine – 18

(i) The Froude numbers before and after the jump,
(ii) The depth after the jump,
(iii) The power dissipated within the jump.

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering

B. Sc. Engineering 4th Year Special Backlog Examination, 2020

ME 4017

(Refrigeration and Air Conditioning)

Time: 3 Hours Total Marks: 210

N.B.: i) Answer any THREE questions from each section in separate script.
ii) Figures in the right margin indicate full marks.
iii) Assume reasonable data if any missing.

SECTION-A

1(a) What is refrigeration? Describe vapor compression refrigeration system with schematic diagram. 10

1(b) Why refrigerant is superheated before compression? Draw the standard and actual refrigeration cycle in *p-h* diagram. 10

1(c) A CO_2 refrigerating plant fitted with an expansion valve, works between the pressure limits of 54.81 bar and 20.93 bar. The vapor is compressed isentropically and leaves the compressor cylinder at 32°C. The condensation takes place at 18°C in the condenser and there is no undercooling of the liquid. Determine the theoretical coefficient of performance and the power required to drive the compressor. 15

2(a) What types of multi-evaporators systems are used? What are its benefits? 10

2(b) Describe the working principle of thermostatic expansion valve with neat a sketch. 12

2(c) What is hermetically sealed compressor? Why is it used for refrigeration? 05

2(d) What are the types of condensers? Describe the water-cooled condenser. What are its applications? 08

3(a) Explain the working principle of two stage cascade refrigeration system and also derive the expression of COP for this system. 10

3(b) Describe the reduced ambient air cooling system. In what kind of aircraft uses this system for cooling? 08

3(c) A 80 kW compressor compresses 1000 kg of CO_2 per hour from a pressure 2 bar to 12 bar to produce dry ice following a saturated cycle. If only 25% CO_2 is converted to dry ice in the system and CO_2 is superheated by 5°C before entering the compressor, what would be the temperature of make-up CO_2? 17

4(a) How halocarbon refrigerants are designated? Explain with example. 10

4(b) Describe the environmental and safety properties of a good refrigerant. 09

4(c) Describe the classification of compressors. 08

4(d) Explain the working principle of evaporative condensers. 08

SECTION-B

5(a) Define the followings- 06
(i) Specific humidity, (ii) Relative humidity and (iii) Dew point temperature

5(b) What are the basic thermodynamic processes in air conditioning? 05

5(c) Describe the working principle of air washer mentioning the possible thermodynamic processes in air washer. 13

5(d) Moist air enters a chamber at 10°C DBT and 8°C WBT at a rate of 100 cmm. While passing through the chamber, the air absorbs sensible heat at the rate of 35 kW and picks up 40 kg/hr of saturated steam at 110°C. Determine the dry and wet bulb temperatures of the leaving air. Assume the barometric pressure is 1.01325 bar. 11

6(a) What is bypass factor? What is the role of it in calculating cooling load? 07

6(b) What are the methods of winter air conditioning system? Show the schematic arrangement of a winter air conditioning system. 08

6(c) In an auditorium which is to be maintained at a temperature of 24°C and RH 60%, a sensible heat load of 132 kW and 78 kg/hr of moisture has to be removed. Air is supplied to the auditorium at 18°C. Find: 20

(i) The amount of air in kg/hr must be supplied,
(ii) The dew point temperature and relative humidity of supply air,
(iii) The amount of latent heat is picked up in the auditorium.

7(a) What is meant by infiltration? Describe its effects on the design of an air conditioning system. 07

7(b) A room of a single storey building is to be air-conditioned having the data: 28

Size of the room: 20 x18 x 4 m high;
East side glass area: 10 m^2
West side glass area: 15 m^2
South side glass area: 15 m^2
North side glass area: 10 m^2

Solar gain through glass: West 510 W/m^2; South 70 W/m^2; East 50 W/m^2 and North 20 W/m^2 at 4 pm.
Overall heat transfer coefficient of roof = 3.5, wall = 4.5, and glass = 6.5 W/m^2K.
Door in east wall: 3.5 x 3.0 m with U = 6.0 W/m^2K;
Door in north wall: Two of each 4.0 x 3.0 m with U = 6.0 W/m^2K
Equivalent temperature differentials at 4 pm are: E-wall = 14°C; W-wall = 15°C; S-wall = 10°C; N-wall = 7°C and Roof = 20°C.
Infiltration through window crack: 2.5 m^3/hr per m of crack.
Infiltration through door opening: 1.98 cmm
Windows: 7 windows of 4 x 3 m; occupancy: 80
Sensible and latent heat gain per person are75 W and 55 W respectively
Lighting: 2 kW florescent and 1 kW incandescent;
Appliances: 1.5 kW (sensible heat)
Ventilation: 0.27 cmm/person;
Outside conditions: 42 °C DB and 27 °C WB
Inside conditions: 24 °C DB and 55% RH;
Assume maximum solar radiation comes at 4 pm, fan heat 5%, supply duct heat gain 1%, leakage 0.5% of room sensible heat and bypass factor of 0.15. Calculate -

(i) Effective room sensible heat
(ii) Effective room latent heat, and
(iii) Grand total heat on the air conditioning plant.

8(a) What are the losses occurred in the duct of air conditioning system? Derive the expression of frictional pressure drop. 09

8(b) What factors are essential to be considered in designing ducts of an air conditioning system? 08

8(c) For an air duct system as shown in figure: (i) Determine the dimensions of AB, BC and CD using equal friction method assuming the friction rate of 0.07 mm H_2O/m length of the duct. (ii) Calculate the total and static pressures at point A. Assume free exit at each outlet. Losses are given by: 18

For elbow: 0.25 P_{v2}
For branch: 0.2 P_{v2} + Elbow loss
For straight through section: 0.25 x Difference of velocity pressure.