KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY
Department of Mechanical Engineering
B. Sc. Engineering 4th Year Backlog Examination, 2021

ME 4017
(Refrigeration and Air conditioning)

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) What is refrigeration system? Write down its field of uses. 07

1(b) Which thermodynamic cycle does it follow? Draw its schematic diagram. 06

1(c) Draw the p-v, T-s and p – h diagrams of vapour compression refrigeration cycle. 06

1(d) A 15 ton refrigeration plant works on R_{12} refrigerant from low side pressure of 4 bar to high side pressure of 12 bar. The refrigerant superheated by 10°C after evaporation and subcooled by 10°C after condensation. Determine (i) the mass flow rate of refrigerant, (ii) COP_R, (iii) COP_H and (iv) the power required to run the system. 16

2(a) Mention the advantages and disadvantages of Electrolux refrigeration system. 07

2(b) Show that for a vapour absorption refrigeration system the theoretical maximum possible $COP = COP_{Carnot} \times \eta_{Carnot}$. 10

2(c) A refrigeration system using R_{12} as refrigerant consists of three evaporators of capacities 20 TR, 30 TR and 15 TR with individual expansion valves and individual compressors. The temperature in the three evaporators is to be maintained at –10°C, 5°C and 10°C respectively. The vapours leaving the evaporators are dry and saturated. The condensing temperature is 40°C and liquid refrigerant leaving the condenser is subcooled to 30°C. Assuming isentropic compression in each compressor, calculate – 18
(i) The mass flow rate of refrigeration in each evaporator,
(ii) The power required to drive the system, and
(iii) COP of the system.

3(a) How air is liquified? Describe the Claude system of air liquefaction with net sketch. 11

3(b) Describe the magnetic cooling system. What is the range of cooling of this system? 07

3(c) A boot-strap air refrigeration system is used for an aeroplane to take a load of 10 TR. The ambient pressure and temperature are 0.9 bar and 15°C respectively. The air is rammed isentropically to a pressure of 1.1 bar. The pressure of the air bled off the main compressor is 3.5 bar and this is further compressed in secondary compressor to a pressure of 4.5 bar. The isentropic efficiency of both the compressors and cooling turbine is 90%. The effectiveness of both heat exchangers is 0.6. If the cabin is to be maintained at 25°C and the pressure in the cabin is 1 bar, calculate – 17
(i) Mass of air passing through the cabin,
(ii) Power required, and
(iii) COP of the system.
Assume C_P = 1kJ/kg K and γ = 1.4.

4(a) Explain: frosting, non-frosting and defrosting evaporators. 06

4(b) Explain the working principle of evaporative condenser. 09

4(c) Write down the chemical formulae of the following refrigerants: R_{11}, R_{113}, R_{143}, R_{717}, and R_{22}. 05

4(d) What type of compressor is used for domestic refrigerator? Describe the working principle of reciprocating compressor with schematic diagram. 15

SECTION-B

5(a) What is air conditioning? Write down its applications. 09

5(b) Classify air conditioning system. 06

5(c) What are the basic thermodynamic processes for air conditioning? 04

5(d) One stream of moist air at 18°C DBT and 75% RH mixes with another stream of moist air at 38°C DBT and 9°C dewpoint in the ratio of 1:2 by mass. Determine the temperature and specific humidity of the air after mixing. 16

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

6(b) How many ways a room is cooled? Describe the summer air conditioning with schematic arrangement. 10

6(c) An air conditioned space is maintained at 25°C DBT and 50% RH. The ambient temperatures of air are 39°C DBT and 26°C WBT. The space has a sensible heat gain of 15 kW. Conditioned air supplied to the space at 8°C saturated state. Calculate 18

i) Mass of moist air supplied to space in kg/hr,
ii) Latent heat gain of space in kW,
iii) Cooling load of the system in kW if 25% of the air supplied to the space is fresh and the remainder being recirculated.

7(a) What is meant by cooling load? Describe the various components of cooling load. 15

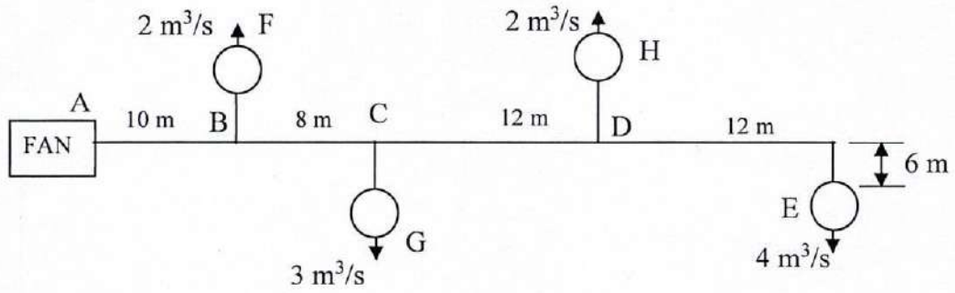
7(b) The ME seminar room has following calculated cooling load: 20
RSH gain = 310 kW, RLH gain = 100 kW.
The seminar room is maintained at the following conditions:
Room DBT = 25°C, Room RH = 50%.
Out door air is at 30°C and 60% RH and 10% by mass of air supplied to the building is outdoor air. If the air supplied to the space is not to be at a temperature lower than 18°C, calculate:

i) Minimum amount of air supplied to room in m^3/s,
ii) State and volume flow rate of air entering the cooling coil,
iii) Capacity, ADP, BPF and SHF at the cooling coil.

8(a) What are the losses occurred in the duct of air conditioning system? Derive the expression of frictional pressure drop. 10

8(b) What factors are essential to be considered in designing a duct system of air conditioning system? 10

8(c) An air duct system as shown in figure below, 15
(i) determine the dimensions of AB, BC, CD and DE using the equal friction method assuming rate of friction as 0.08 mm H_2O/m of length of duct, and (ii) Calculate the total and static pressure of point A.



KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY
Department of Mechanical Engineering
B. Sc. Engineering 4th Year Backlog Examination, 2021

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) Explain the functions of regenerators and intercoolers in a gas turbine. 08

1(b) Distinguish between open cycle and closed cycle gas turbine. For a gas turbine, show that the optimal pressure ratio is equal to the square root of the maximum pressure ratio, i.e. $(r_p)_{opt} = \sqrt{(r_p)_{max}}$. 12

1(c) A gas turbine plants operates on Brayton cycle with lower and upper temperature limits being 300° K and 980° K. The efficiencies of turbine and compressor are 87% and 83% respectively for actual cycle. What would be the optimum value of pressure ratio if the turbine is to be operated for maximum power output? Also determine the plant efficiency for that calculated pressure ratio. 15

2(a) What is meant by restricted and unrestricted burning of propellant in rocket engine? 08

2(b) Show that the efficiency of rocket propulsion can be expressed as $\eta_{rocket} = \frac{2\sigma}{(1+\sigma^2)}$, where the symbols have their usual meanings. 12

2(c) A turbo-jet engine flying at a speed of 800 km/hr consumes air at the rate of 42 kg/sec. Given the enthalpy change for the nozzle is 200 kJ/kg, velocity coefficient is 0.95, air-fuel ration is 70, heating value of the fuel is 43 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. 15

3(a) Why staging is done in case of steam turbine? Describe the principal features of pressure staging. 08

3(b) 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

3(c) Steam with absolute velocity of 325 m/s enters the stage of an impulsive turbine provided with a single row wheel. The nozzles are inclined at 21° to the plane of wheel. The blade rotor with diameter 90 cm rotates with a speed of 2900 rpm. Find: (i) suitable inlet and outlet angles for the moving blade so that there is axial thrust on the blade. It may be assumed that the friction in blade passage is 20% of the kinetic energy corresponding to the relative velocity at inlet to blades, (ii) power developed in blading for a steam flow of 1 kg/s; and (iii) kinetic energy of steam finally leaving the stage. 15

4(a) What are different internal losses encountered in steam turbine? Also mention the differences between impulse turbine and reaction turbine. 12

4(b) Show that the maximum blading efficiency of a reaction turbine can be expressed as $\frac{2cos^2\alpha}{(1+cos^2\alpha)}$, where α is the inlet angle of steam to the blade. 12

4(c) What is meant by degree of reaction? Show the condition curve in h–s diagram for a multistage turbine. Why is it important in turbine design? 11

SECTION-B

5(a) Draw and explain the standard performance curves for IC engine. 07

5(b) Draw a typical valve timing diagram for a petrol engine and discuss the reasons for early opening and late closing of both inlet valves and exhaust valves. Hence, justify the vale overlapping. 09

5(c) "Pumping loss in SI engine could be minimized by direct injection of fuel" – discuss with necessary diagrams. 05

5(d) The air flow to a 4-stroke 4-cylinder oil engine is measured by means of a 8 cm diameter orifice with $C_d = 0.65$. During a test on the engine the following data were recorded: 14
Bore × stroke = 11.5 cm × 13 cm, engine speed = 1300 rpm, brake torque = 150 N.m, fuel consumption = 5.2 kg/hr, heating value of fuel = 43 MJ/kg, head across orifice = 6 cm of water, ambient temperature and pressure is 25 C and 1 bar respectively. Calculate – (i) thermal efficiency on b.p. basis, (ii) brake mean effective pressure, (iii) volumetric efficiency based on free air condition.

6(a) What are the causes of surface ignition? Explain the following terms – (i) Pre–ignition, (ii) Post–ignition, (iii) End gas autoignition. 13

6(b) "A good SI engine fuel is a bad CI engine fuel" – justify the statement. 08

6(c) How ignition delay in SI engine differs from ignition delay in CI engine? Discuss the different stages of combustion in CI engine with the help of heat release rate–crank angle diagram. 14

7(a) How spark timing influences MBT? Discuss the factors that affect tendency to knock in SI engine. 13

7(b) Classify fuel injection system and injection nozzle. Compare Pintaux nozzle with Pintle nozzle. 08

7(c) "2-stroke CI engine is more common than 2-stroke SI engine" – why? Explain. 06

7(d) How supercharging influences, the performance of SI and CI engines? What kind of modifications in engine are required if supercharging is to be employed? 08

8(a) Derive the expression for air-fuel ratio of simple carburetor taking compressibility into account and also without it. 15

8(b) What is meant by scavenging? Why more attention is required for scavenging in 2-stroke engine than that in 4-stroke engine? 09

8(c) Why electronic fuel injection (EFI) is superior over conventional carburetion. Describe the different types of fuel injection system for CI engines. 11

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KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering

B. Sc. Engineering 4th Year 1st Term Backlog Examination, 2021

ME 4051

(Operations Research)

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) What is meant by mathematical modeling? Write down the characteristics of LP models. 10

1(b) A farmer owns 200 cows that consume 90 kgs of special feed daily. The feed is prepared as a mixture of corn and soybean meal with the following compositions: 25

	Kg per kg of feed stuff			
	Calcium	Protein	Fiber	Cost ($/kg)
Corn	0.001	0.09	0.02	0.20
Soybean meal	0.002	0.06	0.06	060

The dietary requirement of the cows are:
(i) At most 1% Calcium
(ii) At least 30% Protein and
(iii) At most 5% fiber.
Develop a mathematical model to determine the daily minimum cost of feed mix?

2(a) Write short notes on: 12
(i) Slack variable, (ii) Surplus'variable, (iii) Unrestricted variable, (iv) Redundant constraint.

2(b) What is meant by solution space? Solve the following problem by graphical method. 23

$$\text{Max } z = 2x_1 + 5x_2$$

Subject to

$$x_1 + x_2 \le 4$$
$$4x_1 + 3x_2 \le 12$$
$$-x_1 + x_2 \ge 1$$
$$x_1 + x_2 \le 6$$
$$x_1, x_2 \ge 10$$

3(a) Solve the following problem by Simplex method. 25

$$\text{Max } z = 3x_1 + 2x_2$$

Subject to

$$4x_1 + 3x_2 \le 12 \quad \text{resource 1}$$
$$4x_1 + x_2 \le 8 \quad \text{resource 2}$$
$$4x_1 - x_2 \le 8 \quad \text{resource 3}$$
$$x_1, x_2 \ge 0$$

Also determine-
(i) The states of each resource.
(ii) The unit worth of each resource.
(iii) Based on the worth, which resource should be given priority for an increase in level.
(iv) The maximum range of change in the availability of the first resource that will keep the current solution feasible.

3(b) Write down the dual of the following primal problems 10

Minimize $z = x_1 + 2x_2 - 3x_3$

Subject to

$$-x_1 + x_2 + x_3 = 5$$
$$12x_1 - 9x_2 + 9x_3 \ge 8$$
$$x_1, x_2, x_3 \ge 0$$

4(a) What is meant by balanced and unbalanced transportation model? How can you convert an unbalanced transportation problem into a balanced one? Explain with example. 05

4(b) Prove that assignment problem is a special case of transportation problem. 05

4(c) Find out the initial basic feasible solution of the following transportation problem by any one method. Also, find the optimum solution of the problem. 25

Source	Destinations			Supply
	A	B	C	
I	2	7	4	5
II	3	3	1	8
III	5	4	7	7
IV	1	6	2	14
Demand	7	9	18	

SECTION-B

5(a) What is meant by queue? Write down the elements of queueing system. 10

5(b) What is meant by memoryless property of exponential distribution? Mathematically prove the memoryless property of exponential distribution. 05

5(c) Patients arrive at a clinic according to Poisson distribution at a rate of 30 patients per hour. The waiting room does not accommodate more than 14 patients. 20
Examination time per patient is exponential with mean rate 20 per hour.
(i) Find the effective arrival rate at the clinic.
(ii) What is the probability that an arriving patient will not wait?
(iii) What is the average number of customers in the clinic?

6(a) Differentiate between decision under uncertainty and decision under risk. 05

6(b) A person has two independent investments A and B available to him, but he can undertake only one at a time due to certain constraints. He can choose "A" first and then stop or if "A" is successful then take "B" or vice versa. The probability of success of "A" is 0.6, while for "B" it is 0.4. Both investments require an initial capital only TK. 10,000 and both return nothing if the venture is unsuccessful. Successful completion of "A" will return TK. 20,000 (over cost) and successful completion of "B" will return TK. 24,000 (over cost). 30
(i) Draw and properly label the decision tree
(ii) Evaluate the decision tree and
(iii)Determine the optimal policy.

7(a) What is meant by game? Discuss its characteristics. 10

7(b) Solve the following game graphically. 25

		Player B			
		1	2	3	4
Player A	1	2	2	3	-1
	2	4	3	2	6

8(a) What is dynamic programming and what sort of problems can be solved by it? Explain. 05

8(b) The number of crimes in each of city's police station's jurisdiction depends on the number of patrol cars assigned to each police station as shown in the table. Five patrol cars are available. Use dynamic programming to determine how many patrol cars should be assigned to each police station. 30

	No. of patrol cars assigned to police stations					
	0	1	2	3	4	5
Police station 1	14	10	7	4	1	0
Police station 2	25	19	16	14	12	11
Police station 3	20	14	11	8	6	5