KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering

B. Sc. Engineering 4th Year Special Backlog Examination, 2019

ME 4019

(Aerodynamics)

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 airfoil nomenclature with neat sketch. Also describe the geometry of a NACA 2412 and NACA 23012 airfoils 15

1(b) Derive the expression of stream function and velocity potential for a doublet flow. 20

2(a) What are the sources of aerodynamics forces? Draw lift, drag and moment coefficient with the angle of attack both for cambered and symmetric airfoil. 20

2(b) Consider an NACA2414 airfoil with a chord of 0.6 m in an air-stream at standard sea level conditions. The free stream velocity is 80 m/sec. Lift per unit rpm is 1300 N/m. Calculate coefficient of lift and coefficient of drag per unit rpm. 15

3(a) Explain how lift force is generated in an air plane. 10

3(b) Why the aerodynamic characteristics of a finite wing are different from that of its airfoil section? 07

3(c) Deduce the expression of the location of aerodynamic centre $\left(\overline{X}_{ac}\right)$ as a function of the cord length. 18

4(a) State and drive Kutta-Joukowski theorem. 17

4(b) Show that the fundamental equation of the airfoil can be expressed by– 18

$$\frac{1}{25}\int_0^c \frac{\gamma(\xi)d\xi}{x-\xi} = \mathrm{V}_\alpha\left(\alpha - \frac{dz}{dx}\right)$$ where, the symbols have their usual meanings.

SECTION-B

5(a) Explain compressibility effect. Derive Prandtl-Glauert rule of compressibility correction from the linearized pressure coefficient equation. 17

5(b) Derive an expression for velocity potential equation for subsonic compressible air flows over the airfoil. 18

6(a) Show that quarter cord point of an airfoil is both the centre of pressure and aerodynamic centre if $\gamma(\theta) = 2\,\alpha\,\mathrm{V}_\alpha\left(\frac{1+\cos\theta}{\sin\theta}\right)$, where the symbols have their usual meanings. 17

6(b) A finite wing with an aspect ratio of 7 and a taper ratio of 0.85. The airfoil section is thin and symmetric. Calculate the lift and induced drag coefficient for the wing when it has an angle of attack of 4.8°. Assume that $\delta = \tau$. 18

7(a)	Explain why and how shock wave and expansion waves are generated in supersonic flow over a body.	10
7(b)	With the neat sketches, explain the fundamental differences in flow physics between the subsonic and supersonic flow.	10
7(c)	Show that the lift coefficient for a supersonic airfoil of arbitrary shape depends only on the angle of attack.	15
8(a)	Define drag divergence Mach number and explain Area rule with neat sketch.	15
8(b)	Obtain an expression for Newton sine squared law.	20

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ME 4113

(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) Show the effect of acceleration in suction pipe on the indicator diagram and hence also show the maximum speed of reciprocating pump. 18

1(b) Determine the maximum speed at which a single acting reciprocating pump can be operated with a very large air vessel fitted on the suction side close to the pump. The pump details are: the suction lift 4.2 m, length of suction pipe 6 m, diameter of suction pipe 100 mm and diameter of piston 140 mm and length of stroke is 0.50 m. Assume piston motion is SHM, atmospheric pressure head as 10.3 m of water and separation occurs at 2.6 m of water absolute. Use Darcy's $f = 0.024$. 17

2(a) Discuss how water is lifted by a centrifugal pump? 08

2(b) Explain the condition of least diameter and then derive the expression of least diameter. 12

2(c) Determine the horse power required to drive a centrifugal pump which delivers 40 litres of water per second to a height of 20 m through a 100 mm diameter and 102 m long pipeline. The overall efficiency of the pump is 56% and Darcy's $f = 0.03$ for the pipe line. Assume inlet losses in suction pipe is equal to 0.4 m. 15

3(a) Deduce the expression of efficiency of a Kaplan turbine. 18

3(b) An outward flow reaction turbine has a speed of 300 rpm and a constant breadth of 30 cm. The diameter of the wheel at inlet and outlet are 1.25 m and 2.5 m respectively. The wheel works under a head of 45 m and discharges 6 m^3/sec. If the hydraulic efficiency is 89%, calculate the angles of the blades and guide vanes. 17

4(a) Write short notes on: 16

(i) Governing of turbine and (ii) Surge tank.

4(b) What is specific speed of turbine? What are the performance characteristic curves? 06

4(c) A modern Kaplan turbine one-fourth of full size, develops 3.5 kW at 350 rpm under a head of 2.0 m. Find the speed and power of full size turbine operating under a head of 8.0 m if (i) the efficiency of the model and the full size turbine are same and (ii) the efficiency of the model turbine is 70% and the scale effect is considered. 13

SECTION-B

5(a) Show that for irrotation flow vorticity is zero. 12

5(b) Deduce the expression of Cauchy-Reiman equation in cylindrical polar coordinates. 13

5(c) What are the physical significance of flow net? 10

6(a) Deduce the expressions of stream function and velocity potential for a doublet flow also show with diagram. 18

6(b) Derive the expressions of Lift and Drag on cylinder for flow past a cylinder without circulation. 17

7(a)	What is meant by best economic cross section of an open channel?	08
7(b)	Derive the expression of depth of flow and hydraulic diameter for a trapezoidal channel.	12
7(c)	Water flows at a uniform depth of 2.5 m in a trapezoidal channel having bottom width 5.5 m, and side slope 2:1. If it has to carry a discharge of 0.83 m^3/sec, find the bottom slope of the channel. Assume Manning's $n = 0.026$.	15
8(a)	What is hydraulic jump in an open channel? What are the assumptions needed for the analysis of this jump?	06
8(b)	What are the types and applications of hydraulic jump?	10
8(c)	A rectangular channel carries a discharge of 2.5 m^3/sec per meter width. If the loss of energy in the hydraulic jump is occurred 2.8 m, determine the conjugate depths before and after the jump.	19

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B. Sc. Engineering 4th Year Special Backlog Examination, 2019

ME 3205

(Heat Transfer II)

Time: 3 Hours | Total Marks: 210

N.B.: i) Answer any THREE questions from each section in separate scripts.
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iii) Assume reasonable data if missing.

SECTION-A

1(a) Derive the expression of thermal boundary layer thickness when the fluid is flowing over a heated flat plate. 18

1(b) An ingot ($\rho = 8053$ kg/m^3 and $C_P = 480$ J/kg.K) of size 25 cm × 20 cm and 15 cm high placed in flowing air with a velocity 4.20 m/sec at a temperature of 320°C from a furnace at 1 atm. pressure. The surface temperature of the ingot drops to 240°C. Determine the average loss of heat from the ingot. 17

2(a) Deduce the relation between fluid friction and heat transfer for laminar flow on a flat plate. 18

2(b) Consider a rectangular plate of 65 cm × 55 cm with one surface insulated and other surface maintained at uniform temperature of 90°C, which is placed in a quiescent air at atmospheric pressure and at 25°C. Calculate the average heat transfer coefficient, if the plate is inclined at 72° and the hot surface faces upward. 17

3(a) Derive an expression of temperature distribution for a fluid flows inside a smooth tube at constant wall heat flux boundary condition. Assume the temperature gradient at the centre of the tube is zero and the flow is laminar. 18

3(b) A horizontal pipe of 45 cm diameter is maintained at a uniform temperature of 150°C. The pipe passes through a room where the quiescent air was at a temperature of 25°C. Calculate the heat transfer for a pipe length 30 cm. 17

4(a) Show that the local heat transfer coefficient can be evaluated from the correlation, $Nu_x = 0.53\, Pe_x^{\frac{1}{2}}$, when the liquid metal flows over a horizontal plate at laminar flow condition. 18

4(b) Engine oil flows with a mean velocity of 0.8 m/sec inside a 2.0 cm diameter tube, which is heated at the wall at a uniform rate of 2500 W/m^2. The heat transfer is taking place in the thermally developed region. Calculate the temperature difference between the tube wall surface and the free stream temperature. 17

SECTION-B

5(a) Distinguish between film-wise and drop-wise condensation. 05

5(b) Derive an expression for the film thickness of condensate for laminar film condensation of vapor on an inclined plate. 15

5(c) One hundred tubes of 12 mm in diameter are arranged in a square array and exposed to atmospheric steam. Calculate the mass of steam condensed per unit length of the tubes for a tube wall temperature of 90°C. 15

6(a) Define and explain the terms: 09

(i) Pool boiling, (ii) Sub-cooled boiling, and (iii) Film boiling,

6(b) What is meant by bubble dynamics? Describe the growth of bubble when water is converted to steam. 11

6(c) Describe the different regions of boiling curve and show the critical heat flux and Leiden frost point on the boiling curve. 15

7(a) What is meant by LMTD and NTU? Derive an expression for the effectiveness of a counter flow water-to-water heat exchanger. 18

7(b) A shell and tube condenser with OD = 2.8 cm single pass horizontal tubes at $T_{C,in} = 20°C$, flow rate of $m_C = 0.9$ kg/sec per tube and leaves at $T_{C,out} = 38°C$. The overall heat transfer coefficient based on the outer surface of the tube is U = 3800 w/m°C. Calculate the tube length and the heat transfer rate. 17

8(a) Derive the expression Stefan's equation. 18

8(b) Determine the diffusion rate of water from the bottom of a flask of 6 cm in diameter and 20 cm long into dry atmospheric air at 35°C. Assume diffusion coefficient for water is D = 0.255 cm^2/sec. 17

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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.
iv) Necessary charts may be supplied on request.

SECTION-A

1(a) What is refrigeration? Explain the vapour compression refrigeration system with schematic diagram. What are the effects of condensing temperature on the COP of the system? 18

1(b) An ammonia ice plant operates on simple saturation cycle at the following temperatures. 17
Condensing temperatures 40°C
Evaporating temperatures –20°C
It produces 10 tons of ice per day at –5°C from water at 30°C. Determine:
(i) Capacity of the refrigeration plant,
(ii) Mass flow rate of refrigeration,
(iii) Isentropic discharge temperature, and
(iv) Theoretical and actual COP.

2(a) What is multi-pressure vapour compression refrigeration system? What are the functions of inter-cooler and flash tank? 08

2(b) What are the advantages and disadvantages of vapour absorption system over vapour compression system? 07

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: 20
(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) Describe the Boot strap air cycle refrigeration system for aircraft cooling. 13

3(b) Describe Linde system for liquefaction of air with appropriate diagram. 12

3(c) Explain the working principle of steam jet refrigeration system. 10

4(a) What type of condenser is required for a big fish processing industry? Describe its working principle. 10

4(b) Describe the working principle of thermostatic expansion valve. 08

4(c) Describe the environmental and safety properties of refrigerant selection criteria. 09

4(d) Write down the chemical formulae of the following refrigerants using ASHRAE designation principle. 08
(i) R114, (ii) R216, (iii) R50, and (iv) R744.

SECTION-B

5(a) What is psychrometry? Define the following psychrometric properties: 10

(i) Humidity ratio, (ii) Dew Point temperature, (iii) Degree of saturation, and (iv) Relative humidity.

5(b) What is sensible heat factor (SHF)? How SHF line is drawn on the psychrometric chart? 06

5(c) What is by-pass factor? Why is it important in designing air-conditioning system? 06

5(d) The makeup air at rate of 100 m^3/min from the environment having 40°C DBT and 26°C WBT is mixed with 700 m^3/min of return air from the conditioned space having 23°C DBT and 50% RH. Compute the DBT, WBT and specific humidity of the mixture. 13

6(a) What devices are generally used as dehumidifier in an air conditioning system? Describe any one of them. 08

6(b) Describe in brief a method of heating and humidification system. 07

6(c) What is infiltration? What factors are responsible for infiltration? 07

6(d) 40 cmm of a mixture of return air and outdoor air enters a cooling coil of an air conditioning system at 32°C DBT and 19°C WBT. The effective surface temperature of the coil is 5°C. The surface area of the cooling coil provides 14 kW of refrigerating effect. Determine the dry bulb and wet bulb temperatures of the air leaving the cooling coil and the bypass factor. 13

7(a) What is meant by cooling load? Describe the various components of cooling load. 13

7(b) A building has following calculated cooling load: 22

RSH gain = 310 kW

RLH gain = 100 kW

The space is maintained at the following conditions:

Room DBT = 25°C

Room RH = 50%

Outdoor air is at 28°C and 50% 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 space in m^3/s,

(ii) State and volume flow rate of air entering the cooling coil, and

(iii) Capacity, ADP, BPF, and SHF at the cooling coil.

8(a) What are the methods of duct design? Describe the equal friction method of duct design. 10

8(b) What factors are to be taken into consideration in locating the supply air outlets and return air inlets? 10

8(c) For the air duct system as shown in figure, determine the dimensions of the rectangular ducts AB, BC, CD and DE with aspect ratio 3:1 assuming friction rate of 0.1 mm H_2O/m length of duct. 15