KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering

B. Sc. Engineering 2nd Year 1st Term Examination, 2021

ME 2105

(Thermodynamics)

Time: 3 Hours Full 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 is missing.

SECTION-A

1(a) Explain the two view points of thermodynamic study. 06

1(b) State and explain Zeroth law of thermodynamics. Why this law is considered as basis for temperature measurement? 06

1(c) Define internal energy. Show that any quantity of heat supplied to a system is utilized to increase the internal energy of the system plus the work done by the system. 10

1(d) A perfectly insulated system contains 0.06 m^3 of hydrogen, at 24°C and 550 kPa, which receives an input of paddle work at constant pressure until the temperature is 66 °C. Determine (i) the heat Q, (ii) the change of internal energy, ΔU, (iii) the work input, and (iv) the change of entropy, Δs. 13

2(a) Distinguish between reversible process and irreversible process. What factors render a process irreversible? Explain briefly. 10

2(b) Derive the steady flow energy equation and apply it to a nozzle to obtain the expression for exit velocity when the inlet velocity is not negligible. 10

2(c) The velocity and enthalpy of fluid at the inlet of a certain nozzle are 50 m/s and 2850 kJ/kg, respectively. The enthalpy at the exit of the nozzle is 2570 kJ/kg. The nozzle is horizontal and insulated. Find (i) the velocity of the fluid at the exit of the nozzle; (ii) the mass flow rate, if the area at inlet of nozzle is 0.09 m^2 and the specific volume is 0.185 m^3/kg; (iii) the exit area of the nozzle, if the specific volume at the exit of the nozzle is 0.495 m^3/kg. 15

3(a) Distinguish between source and sink. Why a ship cannot be run by taking energy from the sea-water? 06

3(b) State and prove Clausius inequality principle. 12

3(c) Define entropy. Prove that the enthalpy of this universe is increasing towards a maximum. 08

3(d) From Tds equation, show that c_p is greater than c_v. 09

4(a) Draw the following cycles on p-v and T-s plane indicating heat and work transfer: (i) Otto cycle, (ii) Stirling cycle, (iii) Atkinson cycle, (iv) Brayton cycle. 06

4(b) What is air standard cycle efficiency? Derive the efficiency expression of a Dual cycle operating on an air standard cycle in terms of various ratios. 12

4(c) An ideal Diesel engine operates on 0.5 kg of air with a suction state of 0.1 MPa and 35°C. The pressure at the end of compression is 35 bar and the cut off is at 6.3% of the stroke from the head end dead centre position. Using air properties, determine – (i) the compression ratio, (ii) the percentage clearance, (iii) the heat supplied, (iv) the thermal efficiency, and (v) the mep. 17

SECTION-B

5(a) How does the vapour power cycle differ from gas power cycle? Why Carnot cycle is not used in actual practice? 07

5(b) "When the condenser temperature, superheater temperature and stream quality at the exit from the turbine is fixed, the boiler pressure is also fixed" Justify the statement with the help of T-s diagram. 09

5(c) What is meant by ssc in vapour power cycle? 03

5(d) A steam power plant operates on Reheat cycle. The steam pressure and temperature are 100 bar and 500°C, respectively, and the condenser pressure is 0.04 bar. The reheat pressure and temperature are 8 bar and 500°C, respectively. Calculate (i) the quality of steam at turbine exhaust, (ii) the cycle efficiency considering pump work, (iii) ssc and work ratio, and (iv) compare the efficiency, if the cycle operates on Rankine cycle. 16

6(a) What is back work ratio? Explain its physical significance. 04

6(b) What is mean temperature of heat addition? Show that the efficiency of a vapour power cycle is a function of mean temperature of heat addition. 10

6(c) Why an economizer is not suitable in regenerative vapour power cycle? 06

6(d) In a single heater regenerative cycle the steam enters the turbine at 30 bar, 450°C and the exhaust pressure is 0.10 bar. The feed water heater is a direct-contact type which operates at 5 bar. Calculate (i) the efficiency and the stream rate of the cycle, and (ii) the increase in mean temperature of the heat addition, efficiency and steam rate, as compared to the Rankine cycle without regeneration. Neglect the pump work. 15

7(a) What is adiabatic saturation process? Show that the enthalpy of the mixture remains constant during an adiabatic saturation process. 08

7(b) Why do we feel sweat in summer and dry in winter? Explain. 05

7(c) Prove that specific humidity, ω is given by, $\omega = 0.622\frac{p_s}{p-p_s}$, where p is the atmospheric pressure and p_s is the saturation pressure of water vapour. From there also show the relation, $\varphi = \frac{\mu}{1-(1-\mu)(p_s/p)}$, where φ and μ are relative humidity and degree of saturation, respectively. 10

7(d) Atmospheric air at 1.0325 bar has a dbt of 33°C and a wbt of 26°C. Compute (i) the partial pressure of water vapour, (ii) the specific humidity, (iii) the dew point temperature, (iv) the relative humidity, and (v) degree of saturation. 12

8(a) Define and classify fuel. Distinguish between LCV and HCV of fuel. 07

8(b) Why solid fuels are need to be modified? Describe any method of converting low bulk density materials to high bulk density materials. 10

8(c) State and prove Dalton's law of partial pressure. Also prove that density of a gas mixture is equal to the sum of the partial density of all the constituents. 06

8(d) A mixture of ideal gases consists of 3.6 kg N_2, 5.6 kg CO_2 at pressure of 300 kPa, temperature 220°C. Find (i) mass fraction and mole fraction, (ii) equivalent molecular weight of the mixture, (iii) volume and density of the mixture, (iv) c_p and c_v of the mixture. Assume γ for CO_2 and N_2 are 1.29 and 1.4, respectively. 12

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering

B. Sc. Engineering 2nd Year 1st Term Examination, 2021

ME 2113

(Fluid Mechanics I)

Time: 3 Hours | Full Marks: 210

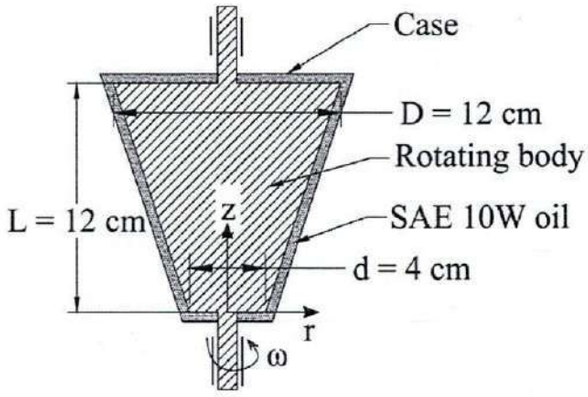
N.B.: i) Answer any THREE questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.
iii) Assume reasonable data if any is missing.

SECTION-A

1(a) Show graphically the characteristics of various fluids and explain the behavior of Thixotropic fluid. 09

1(b) What is surface tension? What is its cause? Why is the surface tension also called surface energy? 09

1(c) A frustum-shaped body is rotating at a constant angular speed of 200 rad/s in a container filled with SAE 10W oil at 20°C ($\mu = 0.1$ Pa.s), as shown in the figure. If the thickness of the oil film on all sides is 1.2 mm, determine the power required to maintain this motion. Also, determine the reduction in the required power input when the oil temperature rises to 80°C ($\mu = 0.0078$ Pa.s). 17

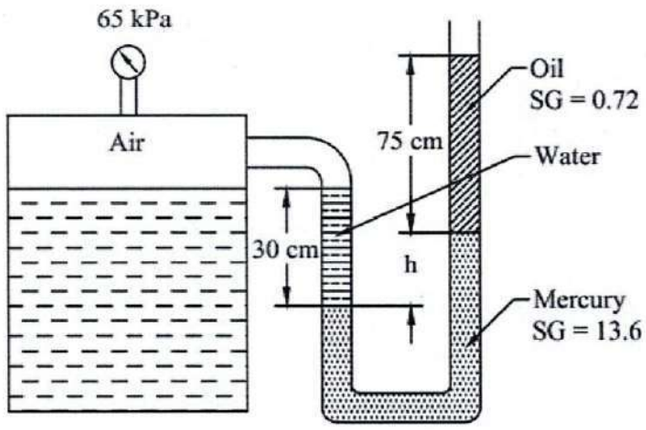


2(a) What is absolute, gage and vacuum pressure? Show their relations in a diagram. 08

2(b) Show that the pressure at a point in a fluid has the same magnitude in all directions. 07

2(c) A manometer containing oil ($\rho = 850$ kg/m^3) is attached to a tank filled with air. If the oil-level difference between the two columns is 150 cm and atmospheric pressure is 98 kPa, determine the absolute pressure of the air in the tank. 07

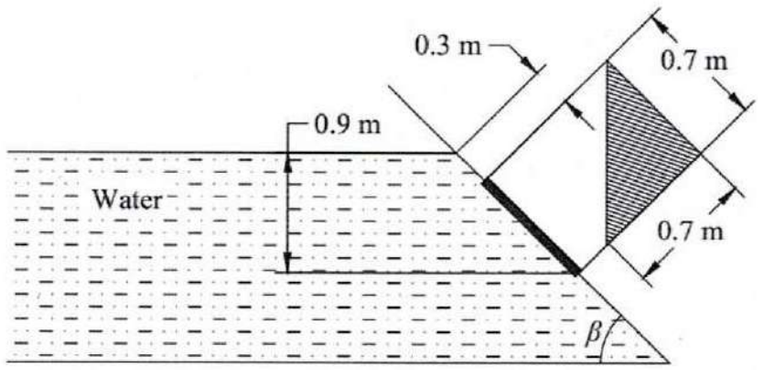
2(d) The gage pressure of the air in the tank is measured to be 65 kPa. Determine the differential height h of the Mercury column. 13



3(a) Show that the location of the metacenter for any ship tilting through a small angle depends on the geometry and the weight. 10

3(b) A 180 kg granite rock ($\rho = 2700$ kg/m^3) is dropped into a lake. A man dives in and tries to lift the rock. Determine how much force the man needs to apply to lift it from the bottom of the lake. Do you think that he can do it? 08

3(c) Determine the resultant force acting on the 0.7 m high and 0.7 m wide triangular gate as shown in the figure and its line of action. 17



4(a) For a vertical cylindrical container partially filled with a liquid and rotating about its axis at a constant angular velocity, show that the free surface or rotating liquids becomes paraboloid shape. Also, develop an expression for the pressure distribution at any point in the fluid. 20

4(b) An 80 cm high fish tank of cross-section 2 m × 0.6 m is partially filled water and is to be transported on the back of a truck. The truck accelerates from 0 to 98 km/h in 10 sec. If it is desired that no water spills during acceleration, determine the allowable initial water height in the tank. Would you recommend the tank to be aligned with the long or short side parallel to the direction of motion? 15

SECTION-B

5(a) Derive the relation between system approach and control volume approach. 20

5(b) Derive the Bernoulli's equation with proper assumptions 15

6(a) Explain the similarity laws with sketches. Also, write the similarity models with their applications. 15

6(b) Define dimensional analysis. What are the advantages of dimensional model analysis? 08

6(c) The variables controlling the motion of a floating vessel through water are the drag force F, the speed V, the length L, the density ρ, the dynamic viscosity μ of water and the gravitational acceleration g. Derive an expression for the drag force by dimensional analysis of Buckingham's π-theorem. 12

7(a) What is the hydraulic grade line? How does it differ from the energy grade line? Under what conditions do both lines coincide with the free surface of a liquid? 10

7(b) Deduce the relation, $c_d = c_c \times c_v$. The symbols have their usual meanings. 10

7(c) Deduce the expression of flow rate for liquid flowing over a triangular notch. 10

7(d) How may Pitot tube be used to measure the velocity of water in the river? 05

8(a) Deduce the expression of flow rate for liquid flowing through a vertical venturimeter. 18

8(b) A vertical rectangular tank of size 1.2 m by 0.8 m has a hole at the bottom of 0.15 m diameter. If the initial depth of water is 3.0 m and $c_d = 0.61$, determine the time required to fall the water level to 0.4 m. 17

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Department of Mechanical Engineering

B. Sc. Engineering 2nd Year 1st Term Examination, 2021

Hum 2105

(Industrial Environment and Sociology)

Time: 3 Hours | Full Marks: 210

N.B.: i) Answer any THREE questions from each section in separate scripts.
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SECTION-A

1(a) What is population growth? How does an increase in the population growth rate affect economic growth? 12

1(b) Critically describe Malthus's theory on population growth. 10

1(c) Define industrialization. Explain the relation between industrialization and energy use. 13

2(a) What is environment? Describe different types of environments. 15

2(b) How does industrial revolution bring social and environmental changes? 20

3(a) Explain environmental pollution. What are the causes and consequences of environmental pollution? 18

3(b) What are the characteristics of hazardous waste? Describe the process of collection, transportation and treatment of industrial hazardous waste. 17

4(a) What is the meaning of industrial law? Why is industrial law important? 10

4(b) What are the safety measures required in an industry? How do you increase safety in an industry? 10

4(c) What are the main features of the Bangladesh Environment Conservation Act of 1995? Explain the strength and weaknesses of this Act. 15

SECTION-B

5(a) What is meant by sociology? Why sociology is important for Mechanical Engineers? 15

5(b) What is community? Distinguish between society and community? 10

5(c) Explain the elements of the social structure of Bangladesh. 10

6(a) Who were the proponent of formalistic school of thought of sociology? Briefly discuss their views. 12

6(b) Discuss the five major social problems in Bangladesh. Indicate the causes and remedies to these problems. 15

6(c) What is cultural lag? Give example. 08

7(a) What are Mega city and Meta city? How does primate city centralize people and their lifestyle? 10

7(b) "Urbanism - as a way of life" – Critically evaluate from Louis Winth's perspective on urbanism. 15

7(c) Explain the causes and remedies of juvenile delinquency. 10

8(a) Distinguish between cyclical poverty and collective poverty with example. 10

8(b) How does parenting style regulate children's delinquent behavior? 10

8(c) What are the grounds of white collar crime? How can we cure it? 15

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering

B. Sc. Engineering 2nd Year 1st Term Examination, 2021

Math 2105

(Mathematics III)

Time: 3 Hours | Full Marks: 210

N.B.: i) Answer any THREE questions from each section in separate scripts.
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SECTION-A

1(a) Find the matrix $A = \begin{pmatrix} x & y \\ z & w \end{pmatrix}$ such that the matrix A^2 is diagonal but not A. 05

1(b) If $A = \begin{bmatrix} 3 & 2 & 2 \\ 1 & 3 & 3 \\ 5 & 3 & 4 \end{bmatrix}$, compute A^{-1} by elementary row operations and hence find B using A^{-1} so that $AB = \begin{bmatrix} 3 & 4 & 2 \\ 1 & 0 & 1 \\ 5 & 6 & 4 \end{bmatrix}$. 13

1(c) Identify which of the following system has non-zero solution and hence solve those system, if any: 17

(i) $\begin{matrix} x + 3y - 2z = 0 \\ x - 8y + 8z = 0 \\ 3x - 2y + 4z = 0 \end{matrix}$, (ii) $\begin{matrix} x + 2y - 3z = 0 \\ 2x + 5y + 2z = 0 \\ 3x - y - 4z = 0 \end{matrix}$, (iii) $\begin{matrix} x + 2y - z = 0 \\ 2x + 5y + 2z = 0 \\ x + 4y + 7z = 0 \\ x + 3y + 3z = 0 \end{matrix}$

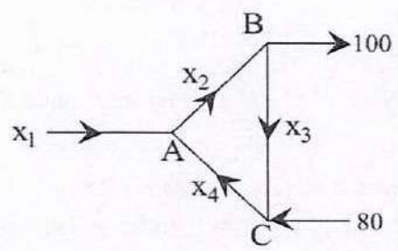
2(a) Determine the rank of the matrix $A = \begin{bmatrix} 0 & 1 & 3 & -2 \\ 0 & 4 & -1 & 3 \\ 0 & 0 & 2 & 1 \\ 0 & 5 & -3 & 4 \end{bmatrix}$ by reducing it to row canonical form. 13

2(b) Find the conditions on a, b, c so that the vector $v = (a, b, c) \in R^3$ is a linear combination of $u_1 = (1,2,0), u_2 = (-1,1,2)$ and $u_3 = (3,0,-4)$. 12

2(c) Find u and v such that $ze^z = u(x, y) + i\, v(x, y)$ and show that u and v satisfy Cauchy-Riemann equations wherever they are defined. 10

3(a) What is the physical meaning of rank of a matrix? How can rank of a matrix be used to determine whether a system has no solution, unique solution, or many solutions? 10

3(b) Form a system of equations and find the general flow pattern for the network flow shown in the figure below. Assuming that the flows are all nonnegative, what is the smallest possible value of x_4. 13



3(c) Test the linear dependency of the following 2×2 matrices over R: 12

$$A = \begin{bmatrix} 1 & -5 \\ -4 & 2 \end{bmatrix}, \quad B = \begin{bmatrix} 1 & 1 \\ -1 & 5 \end{bmatrix}, \quad C = \begin{bmatrix} 2 & -4 \\ -5 & 7 \end{bmatrix}, \text{ and } \quad D = \begin{bmatrix} 1 & -7 \\ -5 & 1 \end{bmatrix}$$

and find a linear combination of them, if possible.

4(a) Consider the matrix $A = \begin{bmatrix} 3 & -5 \\ 2 & -3 \end{bmatrix}$, find the eigenvalues and the corresponding eigenvectors and also verify the Cayley-Hamilton theorem. 15

4(b) Solve $Z^3 + \sqrt{3} - i = 0$ and locate the roots in the argand diagram. 08

4(c) If $f(z) = u(x,y) + i\,v(x,y)$, find the analytic function $f(z)$ such that $Re[f'(z)] = 3x^2 - 4y - 3y^2$ subject to the condition $f(1+i) = 0$. 12

SECTION-B

5(a) Explain scalar triple product geometrically and hence find the volume of parellelopiped if four of its eight vertices are $A = (0,0,0), B = (1,2,0), C = (0,-3,2)$ and $D = (3,-4,5)$. 10

5(b) The temperature at a point (x,y,z) in space is given by, $T(x,y,z) = 200e^{-x^2-3y^2-9z^2}$ where T is measured in °C and x, y, z in meters. 12

i) Find the rate of change of temperature at the point $P(2,-1,2)$ in the direction toward the point $(3,-3,3)$.

ii) Find maximum rate of increase at P.

5(c) A heat-seeking particle is located at the point (2,3) on a flat metal plate whose temperature at a point (x,y) is $T(x,y) = 10 - 8x^2 - 2y^2$. Find an equation for the trajectory of the particle if it moves continuously in the direction of maximum temperature increase. 13

6(a) Is the vector field $\bar{V} = e^{xy}(y\,\hat{i} + x\,\hat{j}) + 2e^z\,\hat{k}$ irrotational? If yes, find the scalar function $\phi(x,y,z)$ such that $\bar{V} = -\nabla\phi$. 12

6(b) Using line integration show that the vector field $\bar{F} = 3x^2y\,\hat{i} + (x^3 + 2yz)\,\hat{j} + y^2\,\hat{k}$ is conservative force field. Find the amount of workdone in moving an object in the field from (1,-2,1) to (3,1,4). 12

6(c) Find the center of mass of a thin wire lying along the curve $\bar{r}(t) = t\,\hat{i} + 2t\,\hat{j} + \frac{2}{3}t^{3/2}\,\hat{k}$, $0 \le t \le 2$; if the density is $\delta = 3\sqrt{5+t}$. 11

7(a) By using Green's theorem in plane evaluate $\int_c (y - \sin x)dx + \cos x\,dy$ where c is the triangle OAB having vortices $O(0,0), A\left(\frac{\pi}{2}, 0\right)$ and $B\left(\frac{\pi}{2}, 1\right)$ respectively, in anticlockwise direction. 10

7(b) Sketch the vector field, $\bar{V}(x,y) = x\,\hat{i} + y\,\hat{j}$. What is the circulation density of this field? 10

7(c) Verify Stoke's theorem for $\bar{F} = xz\,\hat{i} - y\,\hat{j} + x^2y\,\hat{k}$, where s is the surface of the region bounded by $x = 0, y = 0, z = 0, 2x + y + 2z = 8$ which is not included in the xz-plane. 15

8(a) Evaluate $\iint_s (a^2x^2 + b^2y^2 + c^2z^2)^{1/2} ds$ over the surface of the ellipsoid $ax^2 + by^2 + cz^2 = 1$. 13

8(b) Evaluate $\iiint_V \bar{F}.d\bar{V}$, where $\bar{F} = (2x^2 - 3z)\,\hat{i} - 2xy\,\hat{j} - 4x\,\hat{k}$ and V is the closed region bounded by the planes $x = 0, y = 0, z = 0$ and $x + 2y + z = 4$ using divergence theorem. 12

8(c) Express Curl A in orthogonal coordinates. 10