KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering

B. Sc. Engineering 2nd Year 1st Term Examination, 2019

Math 2105

(Mathematics 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 missing any.

SECTION-A

1(a) Define scalar point function and vector point function with example. 06

1(b) Sketch the space curve whose position vector is $4\cos t\,\hat{i} + 4\sin t\,\hat{j} + 3t\,\hat{k}$. Hence find unit tangent vector $\overline{T}$ and normal vector $\overline{N}$. Also, find the radius of curvature. 15

1(c) State divergence theorem in words. 03

1(d) If $\overline{A}$ is a constant vector, prove that (i) $div\left(\overline{A}.\overline{r}\right) = \overline{A}$ and (ii) $curl\left(\overline{A}\times\overline{r}\right) = 2\overline{A}$, where $\overline{r} = (x,\ y,\ z)$. 11

2(a) Test the nature of the vector point function $\frac{G\overline{r}}{r^2}$ (by using vector operator ∇), where G is constant and $\overline{r}$ is the position vector. Hence find the scalar potential function such that at (1, 0, 1) its value is 1. Also find the scalar potential at origin. 15

2(b) Find the value of the constant a and b such that the surface $ax^2 - byz = (a+2)x$ will be orthogonal to the surface $4x^2y + z^3 = 4$ at the point (1, −1, 2). 08

2(c) Evaluate ∇r^n. Hence find the value of ∇r^4, where $\overline{r}$ is the position vector. Also, find the value of ∇r^4 at the point (1, −1, 2). 12

3(a) Find the work done in moving a particle in the force field $\overline{F} = 3x^2\,\hat{i} + (2xz - y)\hat{j} + 2z\,\hat{k}$ along the curve defined by $x^2 = 4y$, $3x^2 = 8z$, from $x = 0$, to $x = 2$. 11

3(b) Evaluate $\int_s \overline{F}.\,\overline{n}\,ds$, where s is the surface of the plane $2x + y + 2z = 6$ located in the first octant and $\overline{F} = \left(x + y^2\right)\hat{i} - 2x\,\hat{j} + 2yz\,\hat{k}$. 13

3(c) Using divergence theorem, evaluate $\iint_s \overline{A}.\overline{n}\,ds$ for $\overline{A} = 2x^2y\,\hat{i} - y^2\,\hat{j} + 4xz^2\,\hat{k}$ taken over the region in the first octant bounded by $y^2 + z^2 = 9$ and $x = 2$. 11

4(a) Define scale factor in curvilinear coordinate system. Find the differential arc length "d_s" and volume element "d_v" in orthogonal curvilinear system (with figure). Hence express them in spherical polar coordinates. 15

4(b) Derive Grad f, where f is a scalar function in orthogonal curvilinear system. Hence, derive it in cylindrical coordinates. 14

4(c) Establish relation between Jacobian and scale factors in curvilinear coordinate system. 06

SECTION-B

5(a) Find the values of a and b such that the matrices 08

$$A = \begin{bmatrix} 5 & 1 \\ 3 & -2 \end{bmatrix} \text{ and } B = \begin{bmatrix} 6 & a \\ b & 1 \end{bmatrix} \text{ are commute.}$$

5(b) Define orthogonal matrix. Find the values of a, b, c such that the matrix 10

$$A=\begin{bmatrix} 0 & 2b & c \\ a & b & -c \\ a & -b & c \end{bmatrix}$$ is orthogonal.

5(c) What is the necessary condition of a matrix to be in invertable? If possible find A^{-1} and 17
B^{-1}, where $A=\begin{bmatrix} 7 & -3 & -3 \\ -1 & 1 & 0 \\ -1 & 0 & 1 \end{bmatrix}$, $B=\begin{bmatrix} 1 & 2 \\ 2 & 4 \end{bmatrix}$.

If AX = H, where H = [1, 1, 1]′, then find the solution of the system of linear equations AX = H.

6(a) Define Symmetric and Skew-symmetric matrices. If A and B are symmetric matrices, then prove that AB–BA is Skew-symmetric. 08

6(b) Reduce the following matrix to its canonical form and normal form. Also find its rank. 17

$$[A:H]=\begin{bmatrix} 0 & 1 & 2 & : & 3 \\ 2 & 3 & -1 & : & 2 \\ 4 & 5 & 0 & : & 1 \end{bmatrix}.$$

If AX = H, where [AH] be the augmented matrix of the linear system, then find the solution of X.

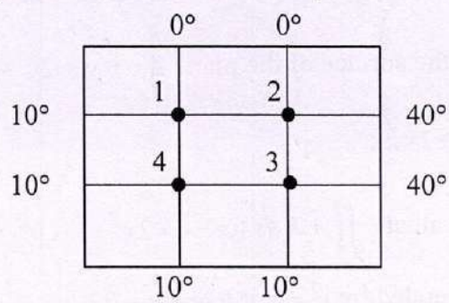
6(c) Determine the value of k for which the system of equations has non-trivial solution: 10

$$x-2y+z=0$$
$$2x+3y-kz=0$$
$$3x+y-z=0$$

With this value of k, find the solution of the system.

7(a) Find the eigenvalues and the corresponding eigenvectors of the matrix 16
$A=\begin{bmatrix} 1 & 0 & 0 \\ 0 & 2 & 1 \\ 2 & 0 & 3 \end{bmatrix}$. Also find the non-singular matrix P such that $P^{-1}AP$ is diagonal.

7(b) The steady state temperature distribution of a square thin uniform metal plate is shown in the figure: 14



Find the approximate temperatures at the four interior nodes 1, 2, 3 and 4 respectively of the mesh, by forming a linear system and solving the system.

7(c) Show that $ln\left(1+\sqrt{3}i\right)=ln\,2+i\frac{\pi}{3}$ 05

8(a) Find all the values of z satisfying $z-\frac{1}{z}=2i$. 08

8(b) Use ε –δ definition to show that s $\lim_{z\to i} z^2=-1$. 08

8(c) If $u(x,y)=ax^2+bxy+cy^2$, where a, b, c are real constant, then show that u is harmonic if $a=-c$. Hence, find the analytic function $f(z)=u+iv$. 13

8(d) Prove that an analytic function is necessarily continuous. 06

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering

B. Sc. Engineering 2nd Year 1st Term Examination, 2019

ME 2105

(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) Steam table, Mollier diagram etc. may be supplied on request.
iv) Assume reasonable data if missing any.

SECTION-A

1(a) Define and explain the following– 06
(i) System and surroundings, (ii) State and process, (iii) Cycle and equilibrium.

1(b) Define internal energy in the light of 1st law of thermodynamics and hence 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(c) What are the two viewpoints of thermodynamics? Explain. 06

1(d) A closed system executes a reversible process wherein the pressure and volume vary in accordance with pv^n = c, Q = 16.247 kJ, ΔU = 47.475 kJ. If p_1 = 138 kPa, v_1 = 141.6 litre, and p_2 = 827.4 kPa, find n and v_2. 13

2(a) What are the limitations of 1st law of thermodynamics? Write the two statements for 2nd law of thermodynamics. 07

2(b) What is meant by PMM2? Why a ship cannot be run by taking energy from the sea-water? 06

2(c) 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. 12

2(d) Steam is flowing through a horizontal nozzle. At the inlet to the nozzle, the enthalpy of the fluid passing is 3500 kJ/kg and the velocity is 50 m/sec. At exit, the enthalpy is 2775 kJ/kg. If the loss from the nozzle is 4.5 kJ/kg, then find the velocity of the fluid at exit from the nozzle. If the inlet area is 0.15 m^2 and the specific volume of steam at inlet is 0.18 m^3/kg, find the mass flow rate. 10

3(a) What is refrigerator and heat pump from thermodynamic point of view? Explain with schematic diagram. 06

3(b) Show that the work done by a system between two states at the same temperature during which the system exchanges heat only with environment is equal to or less than a decrease in the Helmholtz's function of the system. 12

3(c) Define entropy. Prove that the entropy of this universe is increasing towards a maximum. 09

3(d) Draw the following cycles on p-v and T-s plane indicating heat and work transfer. 08
(i) Stirling cycle, (ii) Carnot cycle, (iii) Atkinson cycle, and (iv) Brayton cycle.

4(a) What is meant by air-standard cycle efficiency? 05

4(b) Derive an expression for the efficiency of Duel cycle engine operation on an air standard cycle. 12

4(c) In a gas turbine plant, the pressure ratio is 7.5. The air enters the compressor at 0.1 MPa, 28°C. The maximum cycle temperature is 875°C. If the turbine and compressor isentropic efficiencies are 0.80 and 0.85 respectively, find the heat added, work done, and efficiency of the plant. Compare the efficiency with ideal cycle efficiency. 18

SECTION-B

5(a) What are the characteristics of vapour power cycle? Draw the schematic view of such a cycle and explain. 07

5(b) With the help of T-s diagram, explain the effect of increasing boiler pressure in vapour power cycle. 06

5(c) Why steam is reheated? What happens to mean temperature of heat addition by reheating? 07

5(d) A cyclic steam power plant is to be designed for a steam temperature at turbine inlet of 360°C and an exhaust pressure of 0.08 bar. After isentropic expansion of steam in the turbine, the moisture content at the turbine exhaust is not to exceed 15%. Determine the greatest allowable steam pressure at the turbine inlet, and calculate the Rankine cycle efficiency for these steam conditions. 15

6(a) Define extracted steam and bleeded steam. What is the physical significance of ssc? 09

6(b) Explain the term cogeneration. Why an economizer is not used in regenerative vapour power cycle? 08

6(c) In a regenerative cycle, steam enters a single stage turbine at 30 bar, 400°C and is condensed at 0.1 bar. Some steam is bled at a pressure of 5 bar and is passed to single feed heater. Calculate the amount of bled steam, the ssc and efficiency for the cycle. 18

7(a) Explain the terms: specific humidity, relative humidity, dew point temperature and degree of saturation. 08

7(b) Write a short note on Hygroscopic Substance. 05

7(c) Prove that relative humidity, ϕ is given by – 10

$$\phi = \frac{\mu}{1-(1-\mu)\left(p_s/p\right)}$$, where the symbols represent usual meaning.

7(d) Air at 25°C, 40% relative humidity is mixed adiabatically with air at 35°C, 45% relative humidity in the ratio of 3 kg of the former with 4.5 kg of the later (on dry basis). Find the final condition of air. 12

8(a) Why fuels are needed to be modified? Describe in brief the process of densifying loose biomass to solid fuel. 12

8(b) How coals are formed? Describe in brief the classification of coal according to ASTM. 07

8(c) What is calorific value of a fuel? How LCV could be obtained from HCV? 05

8(d) A gaseous mixture of CH_4, N_2, CO and O_2, occupies a vessel at the respective partial pressures of 130, 50, 70 and 20 kPa. Calculate the gravimetric and volumetric analysis. Also calculate the M_m and R_m. 11