L-2/T-2/MME Date : 01/10/2022

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2020-2021

Sub : **MME 213** (Phase Diagrams and Transformations)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) It is more common to observe the diffusion of components towards lower concentration (i.e., down-hill diffusion) – explain the driving force for up-hill diffusion. **(10)**

   (b) For a particular crystal system, there are only 4 (four) possible random jump directions for interstitial atoms, derive the net flux for interstitial diffusion. **(15)**

   (c) Consider a γ-Fe with a lattice constant b = 0.37 nm. At 1000°C carbon diffusion coefficient is $D = 2.5 \times 10^{-11}$ m^2/s. Estimate the successful jump frequency and one in how many attempts succeeds with a jump? **(10)**

2. (a) Apply Fick's 2nd Law in carburization of steel to determine the diffusion length. **(10)**

   (b) Vacancy diffusion is, in certain way, similar to interstitial diffusion. However, the diffusivity of vacancy is many orders of magnitude greater than the diffusivity of substitutional atoms – Explain. **(10)**

   (c) Deduce a condition where self-diffusion coefficient, partial diffusion coefficient and chemical diffusion coefficient will be the same. **(15)**

3. (a) Explain the relation between the two surface energy term E_{sv} and γ. Derive the surface energy for FCC (111) plane. **(10)**

   (b) Predict the shape of a partially coherent precipitate in metal system (e.g., θ′ precipitate in Al-Cu alloy system). **(10)**

   (c) "Spiral growth of pure elements from liquids is slower than continuous growth". Justify the statement. **(15)**

4. (a) Discuss the controlling factors of massive transformation in Cu-Zn system with the help of TTT diagram. **(10)**

   (b) Describe the mechanism behind the order-disorder transformation in Cu-Au system. **(10)**

   (c) Depict the Martensite transformation with crystallographic orientation phenomenon. **(15)**

Contd P/2

MME 213

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

Graph paper required.

5. (a) How do you distinguish alloying elements and impurities. **(5)**

(b) Write down the equation for Gibb's phase rule and define each of the terms. Is it possible to obtain 4 distinct phases in a specimen of a binary alloy? Explain your answer. **(10)**

(c) The size factor often plays a dominant role in precluding solid solution formation. **(20)**

Solely on the basis of the information provided below, indicate which of the following pairs of metals would not be likely to form a continuous series of solid solutions:

Ta-W, Pt-Pb, Co-Ni, Co-Zn, and Ti-Ta

Metal	Elemental Atomic Radius (nm)	Crystal Structure
Ti	0.1461	hcp (T < 883°C); bcc (T > 883°C)
Co	0.1251	hcp (T < 427°C); fcc (T > 427°C)
Ni	0.1246	fcc
Zn	0.1332	hcp
Ta	0.1430	bcc
W	0.1370	bcc
Pt	0.1387	fcc
Pb	0.1750	fcc

6. (a) Lead melts at 620°F and tin melts at 450°F. They form a eutectic containing 62 percent tin at 360°F. The maximum solid solubility of thin in lead at this temperature is 19 percent; of lead in tin, 3 percent. Assume the solubility of each at room temperature is 1 percent. **(20)**

(i) Draw the equilibrium diagram to scale on a piece of graph paper labeling all points, lines and areas.

(ii) Describe the solidification of a 40 percent tin alloy. Sketch its microstructure at room temperature, giving the chemical composition and relative amounts of the phases present.

(b) What is meant by a peritectic reaction? Sketch an equilibrium diagram of a system containing such a reaction and describe the equilibrium cooling of two typical alloys, at least one of which undergoes a peritectic reaction. **(15)**

Contd P/3

MME 213

7. (a) With reference to a hypothetical equilibrium diagram, describe how coring occurs during solidification, under normal industrial conditions, of a solid solution alloy. How coring is prevented or removed by cooling under equilibrium conditions. **(18)**

(b) Describe qualitatively the changes that occur upon cooling plain carbon steels with 0.20, 0.80 and 1.20 percent carbon through the critical range. Sketch and label the microstructures found in these alloys at room temperature after reasonably slow cooling. **(17)**

8. (a) Determine the composition of the ternary system in Figure 1, at points X_1, X_2, X_3, X_4, X_5 and X_6. **(12)**

(b) Describe the equilibrium freezing of a ternary isomorphous alloy showing the path of composition change of liquid and solid phase during freezing. **(13)**

(c) Discuss the advantages and limitations of isothermal and vertical sections. **(10)**

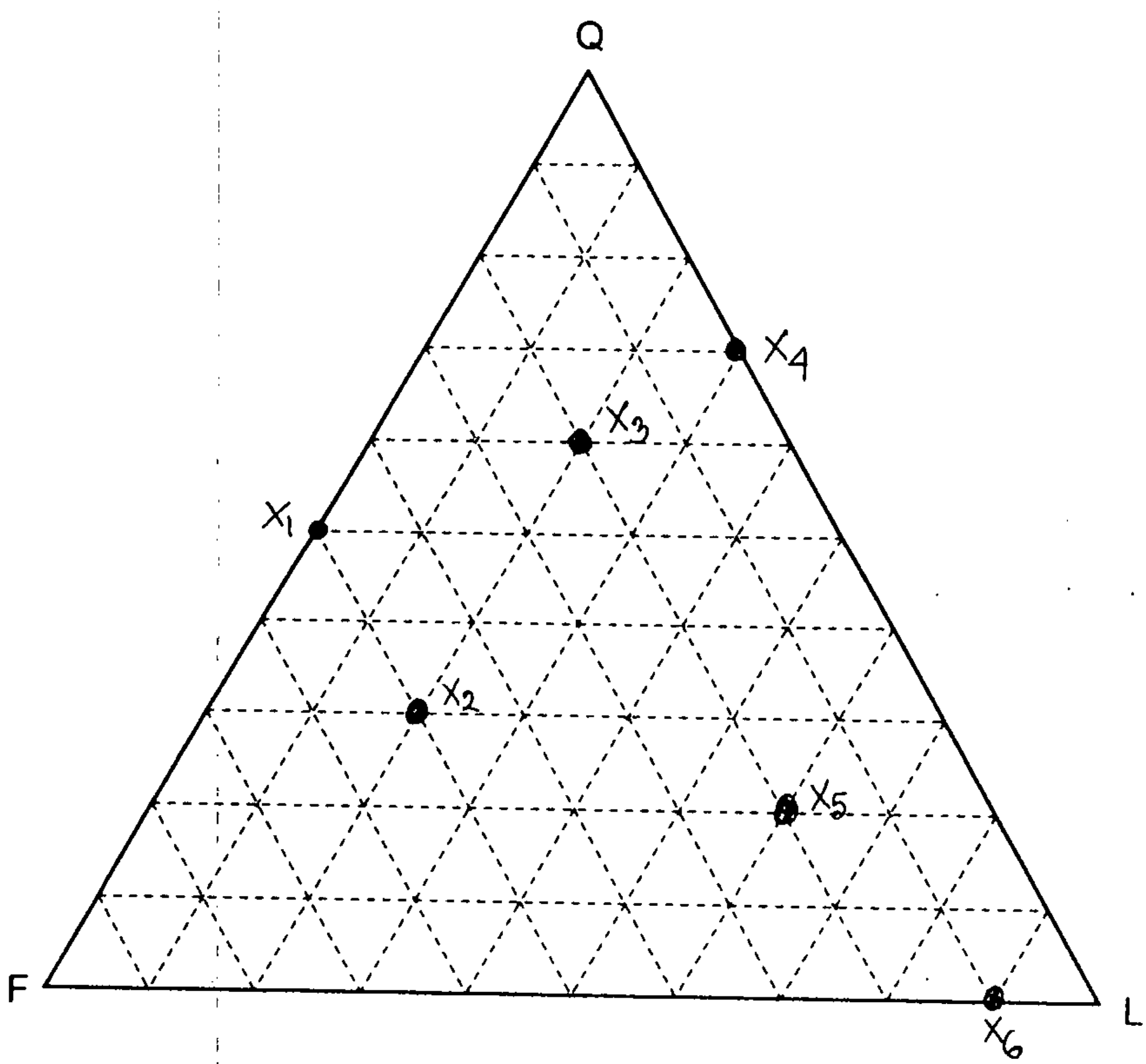


Figure 1 for question 8(a)

L-2/T-2/MME **Date: 16/10/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2020-2021

Sub: **MME 217** (Kinetics and Transport phenomena in Materials)

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE** questions.

Table Fourier Blackbody Radiation function and Figure Fourier View factor is provided

Assume reasonable values Fourier any missing data.

1. (a) Distinguish between thermal boundary layer and concentration boundary layer. Under what conditions do they develop? **(12)**

(b) Consider air flow over a flat plate of length L = 1m under conditions for which transition occurs at x_c = 0.5 m based on the critical Reynolds number, $Re_{x,c} = 5 \times 10^5$. **(17)**

For air at T = 350 K; k = 0.030 W/m.K, $\rho = 974$ kg/m^3, $\mu = 365 \times 10^{-6}$N. s/m^2.

(i) Determine the air velocity at 350 K.

(ii) In the laminar and turbulent regions, the local convection coefficients are, respectively, $h_{lam}(x) = C_{lam}\, x^{-0.5}$ and $h_{turb} = C_{turb} x^{-0.2}$ where, at T = 350 K, C_{lam} = 8.845 W/m$^{3/2}$.K,

C_{tur} = 49.75 W/m$^{1.8}$.K and x has units of m. Develop an expression for the average convection coefficient, as a function of distance from the leading edge, x, Fourier the laminar region, $0 \le x \le x_c$.

(iii) Develop an expression for the average convention coefficient, as a function of distance from the leading edge, x, for the turbulent region, $x_c \le x \le L$.

(c) Species A is evaporating from a flat surface into species B. Assume that the concentration profile for species A in the concentration boundary layer is of the formation $C_A(y) = Dy^2 + Ey + F$, where D, E, and F are constants at any x-location and y is measured along a normal from the surface. Develop an expression for the mass transfer convection coefficient h_m in terms of these constants, the concentration of A in the free stream $C_{A,\infty}$ and the mass diffusivity D_{AB}. **(6)**

2. (a) Two stainless steel plates of 10 mm thickness are subjected to a contact pressure of 1 bar under vacuum conditions for which there is an overall temperature drop of 100° across the plates. What is the heat flux through the plates? What is the temperature drop across the contact plane? [Use these values: k = 16.6 W/m. K, $R_{t,c}'' \approx 15 \times 10^{-4}$ m^2-K/W] **(12)**

MME 217
Contd... Q. No. 2

(b) An uninsulated, thin-walled pipe of 100-mm diagram is used to transport water to equipment that operates outdoors and uses the water as a coolant. During particularly harsh winter conditions, the pipe wall achieves a temperature of -15 °C and a cylindrical layer of ice forms on the inner surface of the wall. If the mean water temperature is 3 °C and a convection coefficient of 2000 $W/m^2 - K$ is maintained at the inner surface of the ice, which is at 0°C, what is the thickness of the ice layer? **(12)**

(c) 10-mm-thick horizontal layer of water has a top surface temperature of T_c = -4 °C and a bottom surface temperature of T_h =2 °C. Determine the location of the solid-liquid interface at steady state. Thermal conductivity of ice and water can be taken as 1.88 W/m. K and 0.569 W/m. K, respectively. **(11)**

3. (a) Determine the view factor F_{14} for the configuration shown in Figure 3(a). **(20)**

   (b) A spherical shell of inner and outer radii r_i and r_0 respectively, contains heat-dissipating components, and at a particular instant the temperature distribution in the shell in known to be of the form: $T(r) = \frac{C_1}{r} + C_2$ **(15)**

   Are the conditions steady-state or transient? How do the heat flux and heat rate vary with radius?

4. (a) Consider a small surface of are $A_1 = 10^{-4} m^2$, which emits diffusely with a total, hemispherical emissive power of $E_1 = 5 \times 10^4\ W/m^2$. At what rate is this emission intercepted by a small surface of area $A_2 = 5 \times 10^{-4} m^2$, which is oriented as shown in Figure 4(a)? What is the irradiation G_2 on A_2? **(15)**

   (b) The spectral absorptivity α_λ and spectral reflectivity ρ_λ for a spectrally selective, diffuse material are as shown in Figure 4(b). (i) Sketch the spectral transmissivity τ_λ. (ii) If solar irradiation with $G_s = 750\ W/m^2$ and the spectral distribution of a blackbody at 5800 K is incident on this material, determine the fractions of the irradiation that are transmitted, reflected, and absorbed by the material. (iii) If the temperature of this material is 350 K, determine the emissivity ε. **(3+12+5=20)**

MME 217

SECTION – B

There are **FOUR** questions in this section. Answer Q. No. 5 and any **TWO from the rest.**

5. (a) Analyze the characters of laminar flow and turbulent flow. **(5)**

(b) Derive relation for momentum balance for a fluid falling through a circular tube. Using the relation, obtain an equation for velocity distribution of the flow if the fluid is Newtonian. Clearly mention all assumption and boundary conditions you use while deriving these relations. **(20)**

(c) How does materials kinetics differ from chemical kinetics? Discuss the principle characteristic features of a rate process. **(10)**

(d) Steel often contains trace amounts of H_2, which can lead to embrittlement. To avoid embrittlement, steel is often degassed prior to use to remove these trace H_2 impurities. Degassing steel involves placing the steel in a vacuum, where the H_2 concentration in the vacuum can be always zero. Consider a steel plate that initially contains a uniform H_2 concentration H_2 of 10^{15} molecules/cm^3. If the diffusivity of H_2 in steel under degassing conditions is 10^{-6}cm^2/s how long must the steel be degassed to ensure the H_2 concentration at the center of the plate falls below 10^5 molecules/cm^3? Assume the steel plate is 1 mm thick. **(10)**

6. Apply Navier-Stoke relation to determine an equation of motion of fluid creeping around a spherical solid object. Deduce buoyant and drag components of the normal force acting on the solid surface. **(30)**

7. (a) Using Bernoulli's equation, determine the time required to completely empty a ladle of liquid metal. **(10)**

(b) A ladle with an inside diameter of 0.9 m and a capacity height of 1.25 m has a nozzle that tapers $\pi/4$ 4adians (45°) to a 75 mm exit diameter. (i) Calculate the time to empty the ladle if it is filled with A1-7% Si alloy at 973 K. (ii) Calculate the discharge rate (kg/s) initially and when the ladle is 75% empty. Data: Viscosity, $\eta = 2.75 \times 10^{-3}$ Ns/m; Density, $\rho = 2400$ kg/m^3. **(20)**

8. (a) Using the kinetic theory of gases, deduce a relation for viscosity of gas. **(20)**

(b) Examine the influence of temperature, diffusion mechanism and microstructure on the diffusion process. **(10)**

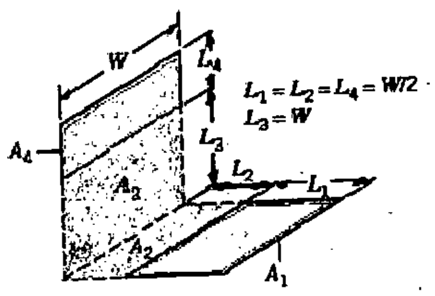


Figure 3(a)

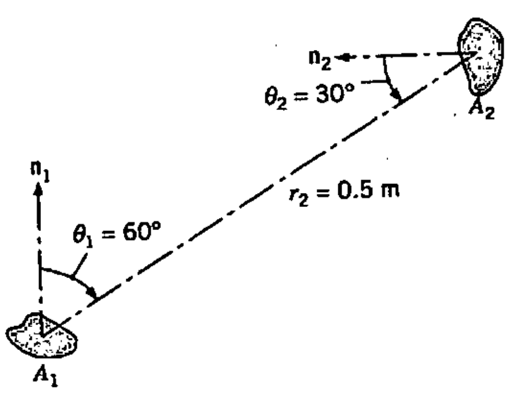


Figure 4(a)

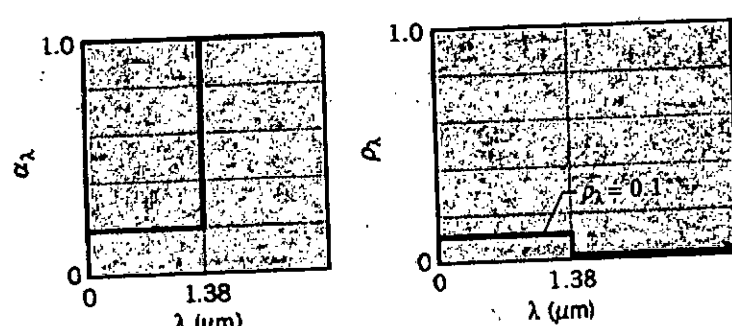


Figure 4(b)

Table: Blackbody Radiation Function

λT ($\mu m \cdot K$)	$F_{(0 \to \lambda)}$	$I_{\lambda,b}(\lambda, T)/\sigma T^5$ $(\mu m \cdot K \cdot sr)^{-1}$	$\frac{I_{\lambda,b}(\lambda, T)}{I_{\lambda,b}(\lambda_{max}, T)}$
200	0.000000	0.375034×10^{-27}	0.000000
400	0.000000	0.490335×10^{-13}	0.000000
600	0.000000	0.104046×10^{-8}	0.000014
800	0.000016	0.991126×10^{-7}	0.001372
1,000	0.000321	0.118505×10^{-5}	0.016406
1,200	0.002134	0.523927×10^{-5}	0.072534
1,400	0.007790	0.134411×10^{-4}	0.186082
1,600	0.019718	0.249130	0.344904
1,800	0.039341	0.375568	0.519949
2,000	0.066728	0.493432	0.683123
2,200	0.100888	0.589649×10^{-4}	0.816329
2,400	0.140256	0.658866	0.912155
2,600	0.183120	0.701292	0.970891
2,800	0.227897	0.720239	0.997123
2,898	0.250108	0.722318 × 10[illegible]	1.000000

Table: Blackbody Radiation Function (Continued)

λT ($\mu m \cdot K$)	$F_{(0\rightarrow\lambda)}$	$I_{\lambda,b}(\lambda,T)/\sigma T^5$ $(\mu m \cdot K \cdot sr)^{-1}$	$\frac{I_{\lambda,b}(\lambda,T)}{I_{\lambda,b}(\lambda_{max},T)}$
3,000	0.273232	0.720254×10^{-4}	0.997143
3,200	0.318102	0.705974	0.977373
3,400	0.361735	0.681544	0.943551
3,600	0.403607	0.650396	0.900429
3,800	0.443382	0.615225×10^{-4}	0.851737
4,000	0.480877	0.578064	0.800291
4,200	0.516014	0.540394	0.748139
4,400	0.548796	0.503253	0.696720
4,600	0.579280	0.467343	0.647004
4,800	0.607559	0.433109	0.599610
5,000	0.633747	0.400813	0.554898
5,200	0.658970	0.370580×10^{-4}	0.513043
5,400	0.680360	0.342445	0.474092
5,600	0.701046	0.316376	0.438002
5,800	0.720158	0.292301	0.404671
6,000	0.737818	0.270121	0.373965
6,200	0.754140	0.249723×10^{-4}	0.345724
6,400	0.769234	0.230985	0.319783
6,600	0.783199	0.213786	0.295973
6,800	0.796129	0.198008	0.274128
7,000	0.808109	0.183534	0.254090
7,200	0.819217	0.170256×10^{-4}	0.235708
7,400	0.829527	0.158073	0.218842
7,600	0.839102	0.146891	0.203360
7,800	0.848005	0.136621	0.189143
8,000	0.856288	0.127185	0.176079
8,500	0.874608	0.106772×10^{-4}	0.147819
9,000	0.890029	0.901463×10^{-5}	0.124801
9,500	0.903085	0.765338	0.105956
10,000	0.914199	0.653279×10^{-5}	0.090442
10,500	0.923710	0.560522	0.077600
11,000	0.931890	0.483321	0.066913
11,500	0.939959	0.418725	0.057970
12,000	0.945098	0.364394×10^{-5}	0.050448
13,000	0.955139	0.279457	0.038689
14,000	0.962898	0.217641	0.030131
15,000	0.969981	0.171866×10^{-5}	0.023794
16,000	0.973814	0.137429	0.019026
18,000	0.980860	0.908240×10^{-6}	0.012574
20,000	0.985602	0.623310	0.008629
25,000	0.992215	0.276474	0.003828
30,000	0.995340	0.140469×10^{-6}	0.001945
40,000	0.997967	0.473891×10^{-7}	0.000656
50,000	0.998953	0.201605	0.000279
75,000	0.999713	0.418597×10^{-8}	0.000058
100,000	0.999905	0.135752	0.000019

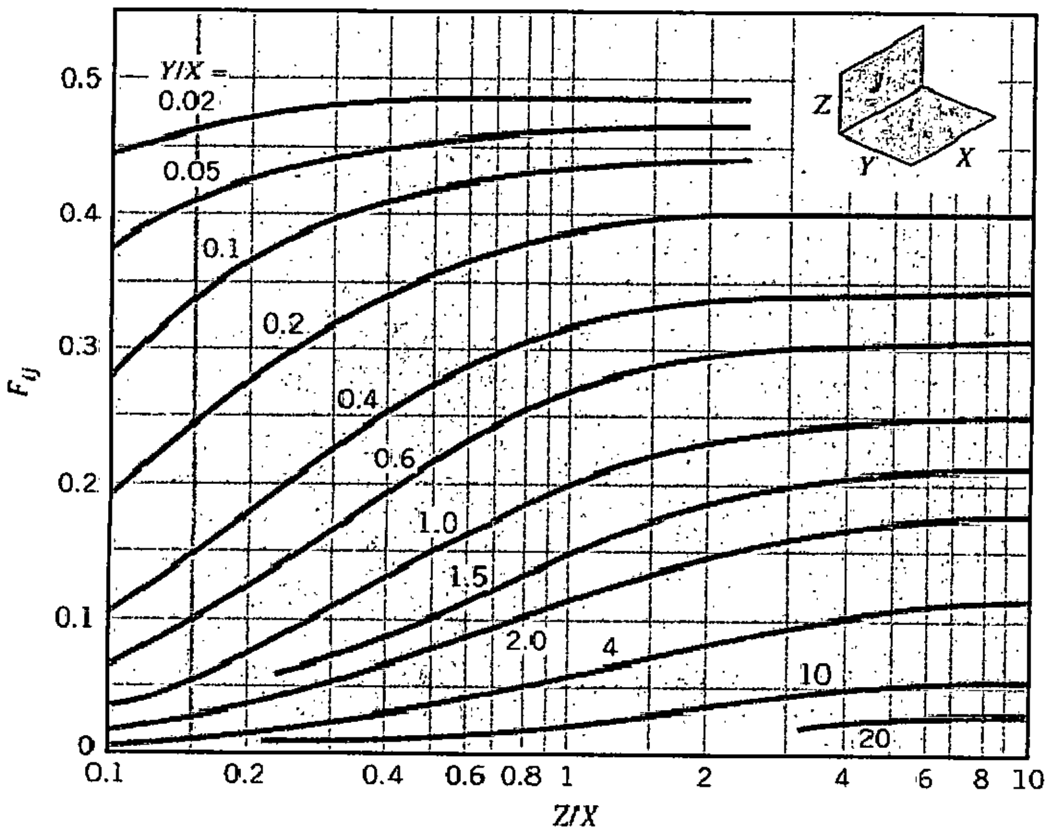


Figure: View factor for perpendicular rectangles with a common edge.

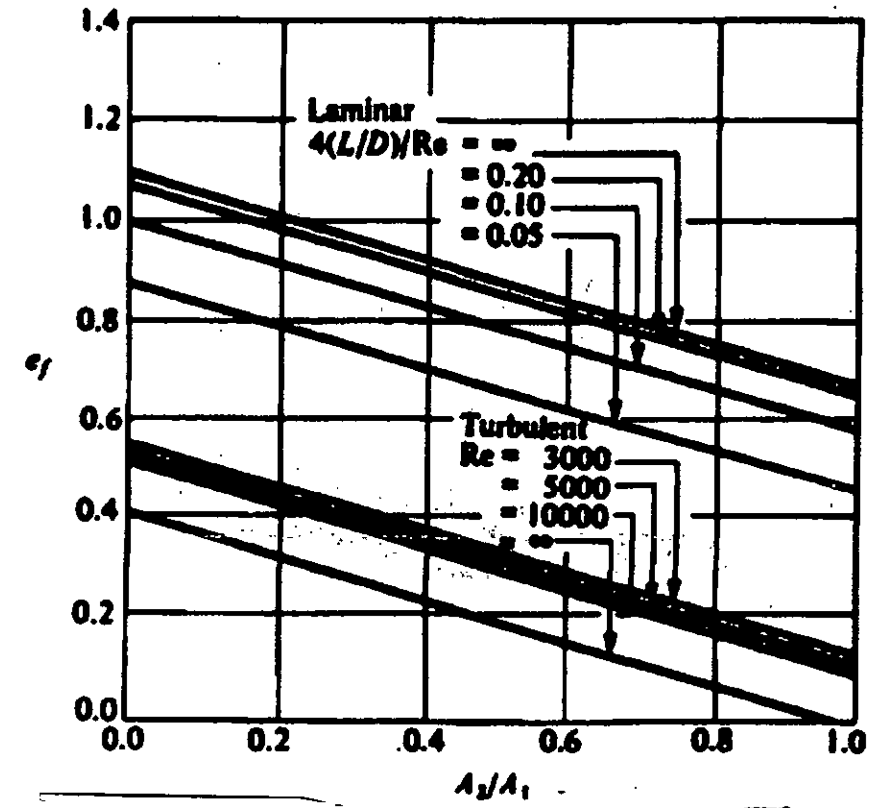


Figure 7(b): Friction loss for sudden contraction.

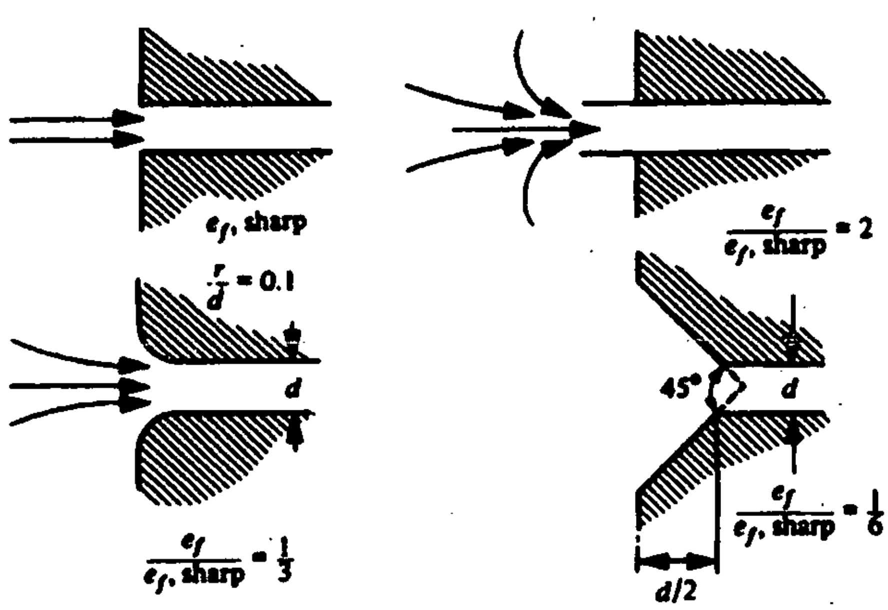


Figure 7(b): Entrance-loss coefficients.

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2020-2021

Sub: **MME 219** (Corrosion and Degradation of Metals and Alloys)

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE** questions.

All notation used in Sec A carry their usual meanings.

1. (a) Differentiate between parabolic equation and logarithmic equation relating film thickness 'y' with time 't'. Why does Al possess superior oxidation resistance at atmospheric condition? **(10)**

(b) 'Li has virtually no resistance to oxidation but Li improves oxidation resistance of Ni when added in small amounts. On the contrary, Cr invariably presents in oxidation resistance alloys but small additions of Cr in Ni deteriorates its oxidation resistance'. – Justify the assertion with necessary figures. **(20)**

(c) What will happen when (i) steel is immersed in HNO_3:H_2O = 1:1 solution with no stirring and (ii) the same at stated in (i) but with stirring? Contrast the situations very briefly. **(5)**

2. (a) Figure 1 shows three possible cases as indicated by 1, 2 and 3 when an active-passive metals is exposed into a corrosive environment. Find, with sound explanations, which case is the most desirable and which one is the least desirable. Give examples in all three cases. **(15)**

(b) Figure 2 shows comparison of Zn-Pt with Zn-Au galvanic couples having equal area for each metal. Write the conventional notations at seven points indicated by 1-7 arrowheads that best describe the galvanic comparison. Explain the comparison and hence make the concluding remark following mixed potential theory. **(15)**

(c) What precautions should be taken during use of inhibitors in corrosive environment? **(5)**

3. (a) 'When Ti is coupled to Pt of equal area, spontaneous passivation of Ti reduces its corrosion which is completely contrary to classic corrosion theory.' – Prove the statement with necessary figure. Which other metal/(s) does show this unusual behavior? Explain why some metals show this unusual behavior and why others do not. **(25)**

Contd P/2

MME 219
Contd... Q. No. 3

(b) Explain how and under which conditions hydrogen evolution poisons and scavengers control corrosion. **(10)**

4. (a) Outline the principles of cathodic protection. Draw neat sketch and write way that is used to cathodically protect a structure by applying impressed current. **(15)**

(b) What is stray current effect in cathodic protection system? How structure can be saved from this effect? **(15)**

(c) Mention the most important design rule for corrosion prevention of materials. **(5)**

SECTION – B

There are **EIGHT** questions in this section. Answer any **SIX**.
The questions are of equal value.

5. A large value of ΔG may or may not be an indicator of corrosion rate of any metal with its environment. With necessary examples and associated chemical reactions along with other possible relationship(s) explain the statement.

6. Depending on situation, use of dissimilar materials in contact might be economical in many real life applications. Give at least two examples and explain the underlying reasons.

7. At room temperature, Zn and steel wires are immersed in 0.05M NaCl solution in separate and coupled conditions. Explain what will happen? What is the possibility of corrosion in the coupled condition in the domestic boiling water?

8. Under what conditions intergranular corrosion takes in aluminum and its alloys? With neat sketches explain the underlying mechanisms of this type of intergranular corrosion.

9. Between are and gas welding, which one will cause higher level of sensitization? With the help of the Time-Temperature diagram given in Figure for Question No. 9 which zone will face the highest level of weld decay. Also explain the reasons behind this.

Contd P/3

MME 219
Contd... Q. No. 9

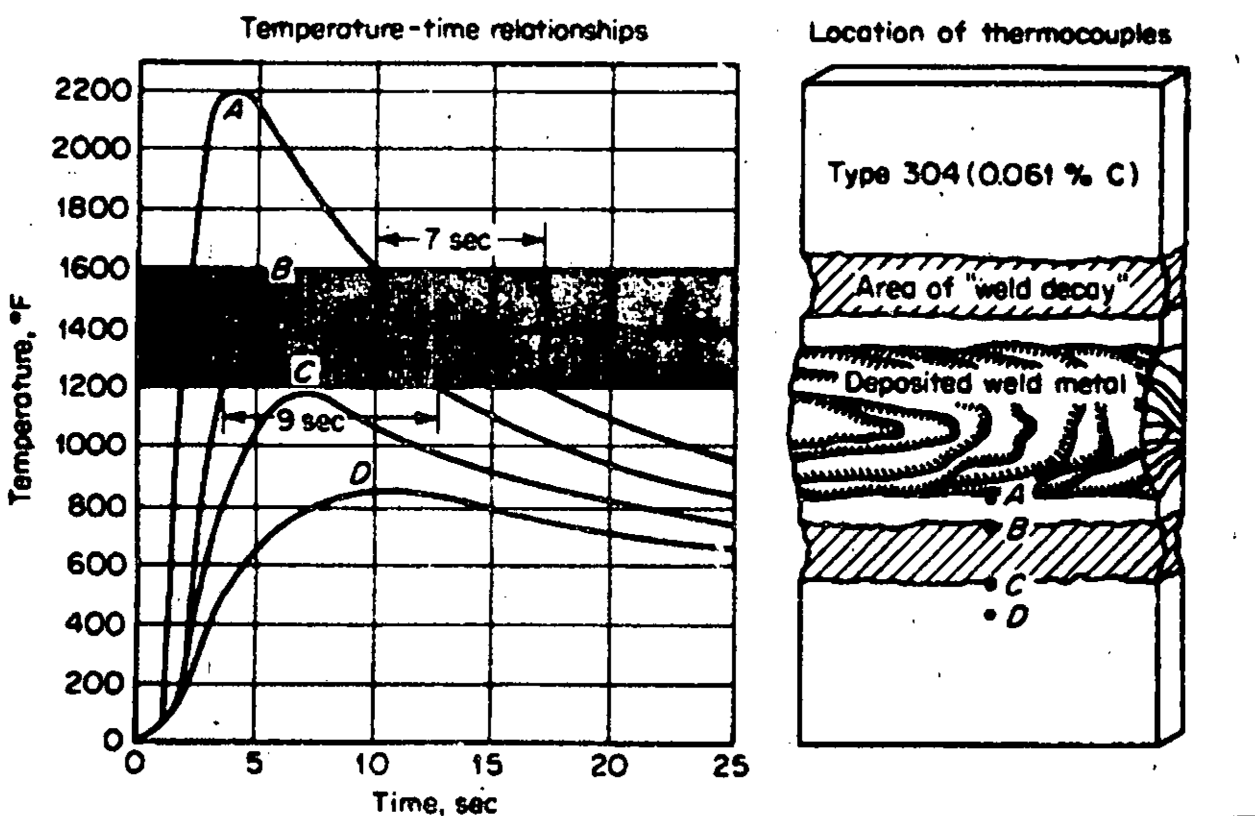


Figure for Question No. 9

10. Fretting corrosion is very common phenomena at bolted tie plates on railroad rails. Why? Explain how this type of corrosion ultimately causes fatigue failure in many loaded components.

11. Do you think that integranular corrosion and knife attack in stainless steel are identical to each other? Why? Discuss the corrosion attack steps in stabilized and unstabilized stainless steel.

12. Selective leaching might have beneficial and deleterious effects on the service performance of any alloy system. Give appropriate examples and explain how the actions ultimately take place.

MME 219/Sec. A

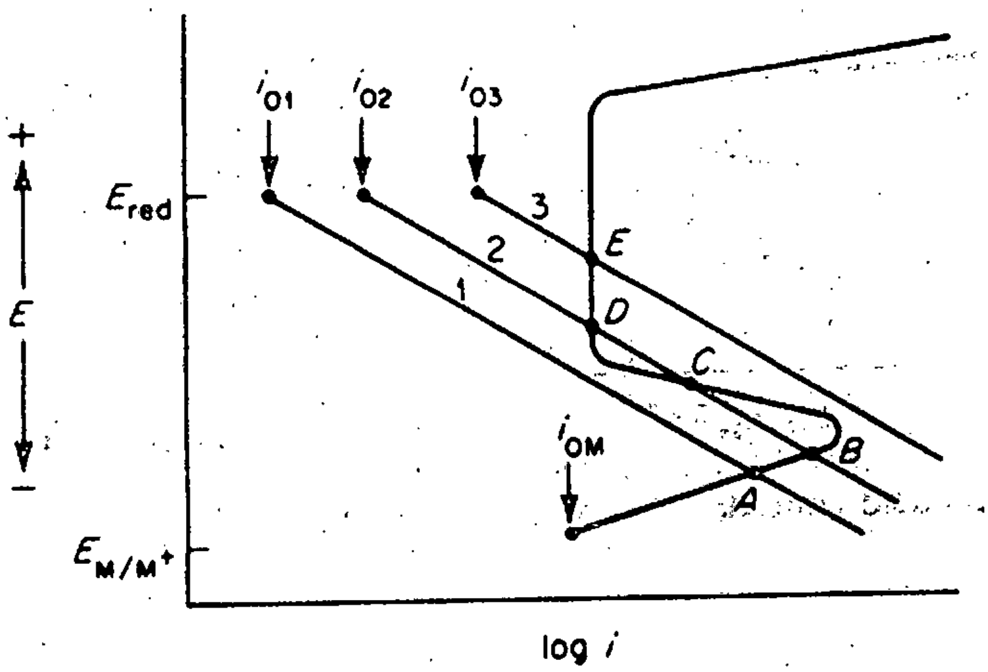


Figure 1 for question No. 2(a)

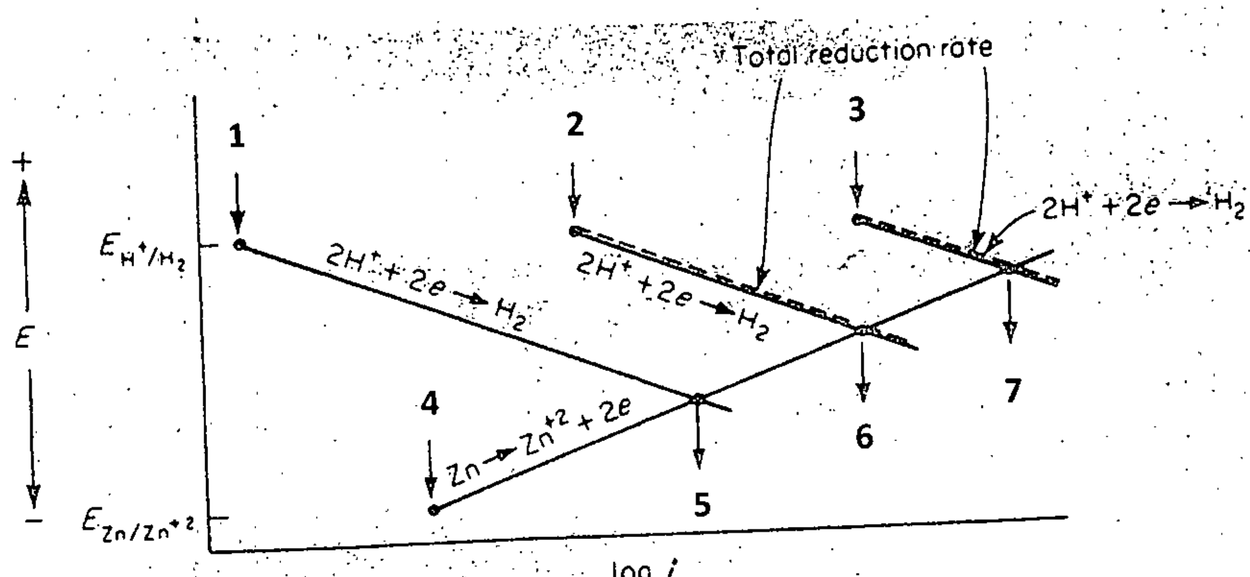


Figure 2 for question No. 2(b)

L-2/T-2/MME Date : 25/09/2022

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2020-2021

Sub : **ME 261** (Numerical Analysis)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

Symbols have their usual meanings and interpretations.

Assume a reasonable value for any missing data.

USE SEPARATE SCRIPTS FOR EACH SECTION

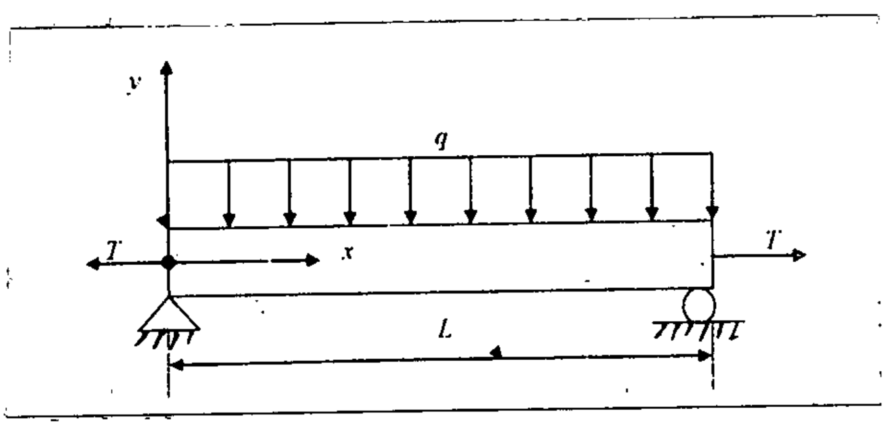
SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Derive the finite difference formula of first derivative with an error of $O(h^4)$ using central finite difference approximation. **(10)**

(b) The deflection y in a simply supported beam with a uniform load q and a tensile axial load T is given by **(25)**

$$\frac{d^2y}{dx^2} - \frac{Ty}{EI} = \frac{qx(L-x)}{2EI}$$



Where,

x = location along the beam (in)

T = tension applied (lbs)

E = Young's modulus of elasticity of the beam (psi)

I = second moment of area (in^4)

q = uniform loading intensity (lb./in)

L = length of beam (in)

Given,

T = 7200 lbs., q = 5400 lbs./in, L = 75 in, $E = 30 \times 10^6$ psi, I = 120 in^4 and

$y(x = 0; x = L) = 0$

Find the deflection of the beam at x = 45 in. Use a step size of Δx = 15 in and approximate the derivatives by central divided difference approximation.

Contd P/2

ME 261/MME

2. (a) What is Richardson Extrapolation Technique? Show that for Simpson's method, Richardson Extrapolation takes the following form, where the symbols have their usual meaning. **(10)**

$$I = \frac{\left(\frac{h_1}{h_2}\right)^4 I_{h_2} - I_{h_1}}{\left(\frac{h_1}{h_2}\right)^4 - 1}$$

(b) The total mass of a variable density rod is given by **(25)**

$$m = \int_0^L \rho(x) A_c(x)\, dx$$

where, m = mass, ρ = density, A_c = cross-sectional area, x = distance along the rod, and L = length of the rod. The following data have been measured for a 12-m long rod. Determine the mass in kilograms to the best possible accuracy.

x, m	0	3	4	6	8	10	11	12
ρ, g/cm^3	4.00	3.89	3.80	3.60	3.41	3.30	3.19	3.07
A_c, cm^2	100	106	110	120	133	150	165	185

3.

x	2.5	3.5	5	6	7.5
y	13	11	8.5	8.2	7

(a) Obtain a least-squares fit to the above experimental data points using the approximating function, $y = ax^b$. **(15)**

(b) Repeat the least-squares fitting using the approximating function, **(15)**

$$y = a_0 + a_1 x + a_2 x^2$$

(c) Determine which of the obtained fitted curves best represents the given experimental data. **(5)**

4. Show that the local truncation error associated with the Simpson's 1/3 rule of integration is $-\frac{h^5}{90} f^{(4)}(\xi)$. Does the order of error remain the same in case of global truncation error? Explain. **(15)**

(b) Consider the following data **(20)**

x	1	2	3	5	7	8
$f(x)$	3	6	19	99	291	444

Calculate $f(4)$ using Newton's 3rd order interpolating polynomial.

Contd P/3

ME 261/MME

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Define relative error. How do you compute relative error for an approximate number in practice? **(10)**

(b) What is meant by "machine dependent error" in numerical computation? Explain the rule followed by the computing machine to introduce the error in the numerical results. **(10)**

(c) The function $y(x) = 2.0 \sin x + 3.00\, \ln x + x^2$ is to be evaluated for $x = 1.26$. The constants and the value of 'x' are correct up to the number of significant digits shown. Find the absolute and percentage error in 'y'. **(15)**

6. (a) What do you understand by solving a problem numerically using 'iterative' methods? Mention the name of two major types of this methods used to find root of the equations and state their differences. **(7)**

(b) Determine the root of the following equation using bisection method with two initial guesses of $x = 0.2$ and 3. **(12)**

$$f(x) = \frac{1}{x} - \frac{x}{\sin(x) + 2} = 0$$

Perform the computation until the percentage relative error is less than 3%. 'x' is in unit of radians.

(c) Employ the Newton's method to determine the root for **(16)**

$$f(x) = x^2 + \cos(2x) \,.\, e^{-x} - 1 = 0$$

using an initial guess of $x_0 = 0.5$ and perform the computation until the percentage relative error is less than 0.1%. 'x' is in unit of radians. From your solution, show that Newton's method converges quadratically.

7. (a) Why pivoting is necessary in elimination method of solution? **(5)**

(b) Solve the following system of equations by the Gaussian Elimination method using partial pivoting. **(15)**

$$x_1 + x_2 - 2x_3 = 3$$
$$4x_1 - 2x_2 + x_3 = 5$$
$$3x_1 - x_2 + 3x_3 = 8$$

Keep at least four digits after decimal in your calculations.

(c) Use LU decomposition method to invert matrix $[A]$ given below: **(15)**

$$[A] = \begin{bmatrix} 4 & 1 & 6 \\ 1 & 3 & 1 \\ 5 & 2 & 5 \end{bmatrix}$$

Contd P/4

8. (a) Use Gauss-Seidal method to solve the following system: **(17)**

$$15x_1 - 3x_2 - x_3 = 3800$$

$$-3x_1 + 18x_2 - 6x_3 = 1200$$

$$-4x_1 - x_2 + 12x_3 = 2350$$

Assume all initial guesses are zero and continue your computations until the percentage relative error falls below 5%.

(b) Find the solution of the initial value problem at $t = 0.2$: **(18)**

$$y' = 3y + 3t \qquad \text{with } y(0) = 1$$

(i) Using Euler's method with h = 0.2

(ii) Using 4^{th} order R-K method with h = 0.2

(iii) Compare the results with the exact solution:

$$y(t) = \frac{4}{3}e^{3t} - t - \frac{1}{3}$$

and find the percentage errors for the results obtained in (i) and (ii).

L-2/T-2/MME **Date: 26/10/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2020-2021

Sub: **MATH 275** (Probability and Statistic)

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE** questions.

1. (a) Suppose the manufacturer's specifications for the length of a certain type of computer cable are 2000 ± 10 millimeters. In this industry, it is known that small cable is just as likely to be defective (not meeting specifications) as large cable. That is, the probability of randomly producing a cable with length exceeding 2010 millimeters is equal to the probability of producing a cable with length smaller than 1990 millimeters. The probability that the production procedure meets specifications is known to be 0.99. **(10)**

   (i) What is the probability that a cable selected randomly is too large?

   (ii) What is the probability that a randomly selection cable is larger than 1990 millimeters?

   (b) In the senior year of a high school graduating class of 100 students, 42 studied mathematics, 68 studied psychology, 54 studied history, 22 studied both mathematics and history, 25 studied both mathematics and psychology, 7 studied history but neither mathematics nor psychology, 10 studied all three subjects, and 8 did not take any of the three. Randomly select student from the class and find the probabilities of the following events. **(10)**

   (i) A person enrolled in psychology takes all three subjects.

   (ii) A person not taking psychology is taking both history and mathematics.

   (c) Determine the value of α so that each of the following functions can serve as a probability distribution of the discrete random variable X: **(15)**

   (i) $f(x) = \alpha(x^2 + 4)$, for $x = 0, 1, 2, 3$.

   (ii) $f(x) = \alpha\binom{2}{x}\binom{3}{3-x}$, for $x = 0, 1, 2$.

2. (a) The proportion of the budget for a certain type of industrial company that is allotted to environmental and pollution control is coming under scrutiny. A data collection project determines that the distribution of these properties is given by **(10)**

$$f(y) = \begin{cases} 5(1-y)^4, & 0 \le y \le 1, \\ 0, & \text{elsewhere} \end{cases}$$

   (i) Verify that the above is a valid density function.

   (ii) What is the probability that a company chosen at random expends less than 10% of its budget on environmental and pollution controls?

Contd P/2

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Contd... Q. No. 2

(b) A tobacco company produces blends of tobacco, with each blend containing various proportions of Turkish, domestic and other tobaccos. The proportions of Turkish and domestic in a blend are random variables with joint density function (X = Turkish and Y = domestic) **(10)**

$$f(x,y)=\begin{cases}24xy, & 0\le x,y\le 1, \quad x+y\le 1,\\ 0, & \text{elsewhere}\end{cases}$$

(i) Find the marginal density function for the proportion of the domestic tobacco.

(ii) Find the probability that the proportion of Turkish tobacco is less than $1/8$ if it is known that the blend contains $3/4$ domestic tobacco.

(c) The fraction X of male runners and the fraction Y of female runners who compete in marathon races are describe by the joint density function **(15)**

$$f(x,y)=\begin{cases}8xy, & 0\le y\le x\le 1,\\ 0, & \text{elsewhere}\end{cases}$$

Find the covariance of X and Y.

3. (a) A large chain retailer purchases a certain kind of electronic device from a manufacturer. The manufacturer indicates that the defective rate of the device is 3%. **(15)**

(i) The inspector randomly picks 20 items from a shipment. What is the probability that there will be at least one defective item among these 20?

(ii) Suppose that the retailer receives 10 shipments in a month and the inspector randomly tests 20 devices per shipment. What is the probability that there will be exactly 3 shipments each containing at least one defective device among the 20 that are selected and tested from the shipment?

(b) The probabilities are 0.4, 0.2, 0.3, and 0.1, respectively, that a delegate to a certain convention arrived by air, bus, automobile, or train. What is the probability that among 9 delegates randomly selected at this convention, 3 arrived by air, 3 arrived by bus, 1 arrived by automobile, and 2 arrived by train? **(10)**

(c) At a busy time, a telephone exchange is very near capacity, so callers have difficulty placing their calls. It may be of interest to know the number of attempts necessary in order to make a connection. Suppose p = 0.05 be the probability of a connection during a busy time. Find the probability that 5 attempts are necessary for a successful call. **(10)**

4. (a) In a certain industrial facility, accidents occur infrequently. It is known that the probability of an accident on any given day is 0.005 and accidents are independent of each other. **(10)**

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Contd... Q. No. 4(a)

(i) What is the probability that in any given period of 400 days there will be an accident on one day?

(ii) What is the probability that there are at most three days with an accident?

(b) The Edwards's Theater chain has studied its movie customers to determine how much money they spend on concessions. The study revealed that the spending distribution is approximately normally distributed with a mean of \$4.11 and a standard deviation of \$1.37. What percentage of customers will spend less than \$3.00 on concessions? (Necessary Table 1 is attached) **(10)**

(c) Two independent experiments are run in which two different types of paint are compared. Eighteen specimens are painted using type A, and the drying time, in hours, is recorded for each. The same is done with type B. The population standard deviations are both known to be 1.0. Assuming that the mean drying time is equal for the two types of paint, find $P(\overline{X}_A - \overline{X}_B > 1)$, where $\overline{X}_A$ and $\overline{X}_B$ are average drying times for samples of size $n_A = n_B = 18$. (Necessary Table 1 is attached) **(15)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) A survey, data on daily wages paid to workers of two factors C and D are as follows: **(18)**

Daily Wages	20-30	30-40	40-50	50-60	60-70	70-80	80-90
Factor C	15	30	44	60	30	14	7
Factor D	25	40	60	35	20	15	5

Compute: (i) Which factory pays higher average wages?

(ii) Which factory has greater variability about paying wages?

(b) For a symmetric and Mesokurtic distribution of 200 heights, given that mean and standard deviation are 40 and 15. It was however discovered that 2 items 43 and 35 were wrongly written in place of correct values 34 and 53 respectively. Calculate corrected mean, standard deviation, β_1 and β_2. **(17)**

6. (a) Find the Karl Person's Bowley's, and Kelly's coefficient of skewness from the following data. Is there any difference among them? Justify your answer. **(18)**

Variable	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40
Frequency	2	5	7	13	21	16	8	3

Contd P/4

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Contd... Q. No. 6

(b) Calculate the regression co-efficients of the following data and fit the regression lines: **(17)**

Height of a person in inches (x)	Weight of a person in lbs (y)
52	82
55	90
59	95
62	106
63	120
66	132
70	140
71	135

7. (a) Find the coefficient of correlation between the marks obtained by sixty candidates at an examination in two subjects, Mathematics and Statistics, and comment on your result. (২0)

Marks in Statistics	Marks in Mathematics				Total
	5-15	15-25	25-35	35-45	
0-10	1	1	-	-	2
10-20	3	6	5	1	15
20-30	1	8	9	2	20
30-40	-	3	9	3	15
40-50	-	-	4	4	8
Total	5	18	27	10	60

(b) Suppose we want compare the average yearly income in Chittagong and Dhaka, two cities in Bangladesh. It is known from experience that the variance of yearly incomes in Chittagong is 40000 TK and the variance for yearly incomes in Dhaka is 90000 TK. A random sample of 20 families was taken in Chittagong, yielding a mean yearly income of 47000 TK, while a random sample of 30 families was taken in Dhaka, yielding a mean yearly income of 52000 TK. At the $\alpha = 0.01$ significance level, test whether or not there is a significant different in average yearly income between the two cities. (Given that $z = \pm 2.33$) **(15)**

8. (a) What do you mean by analysis of variance? There varieties of coal are analyzed by four chemists and the ash-content in the varieties are found to be as follows: **(18)**

Varieties	Chemist			
	I	II	III	IV
A	9	7	6	5
B	7	4	5	4
C	6	5	6	7

Do the varieties differ significantly in their ash content? For $v_1 = 2$, $v_2 = 9$, $f_{0.05} = 4.26$)

(b) Two independent samples of 8 and 7 items respectively have the following values of the variable (weight in ounces): **(17)**

Sample 1	9	11	13	11	15	9	12	14
Sample 2	10	12	10	14	9	8	10	-

Is the difference between the means of the samples significant? ($v = 13$, $t_{0.05} = 2.16$)

For question No 4 (b) and 4 (c)

Table 1: Area under the Standard Normal curve from 0 to z.

Z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.50000	.50399	.50798	.51197	.51595	.51994	.52392	.52790	.53188	.53586
0.1	.53983	.54380	.54776	.55172	.55567	.55962	.56356	.56749	.57142	.57535
0.2	.57926	.58317	.58706	.59095	.59483	.59871	.60257	.60642	.61026	.61409
0.3	.61791	.62172	.62552	.62930	.63307	.63683	.64058	.64431	.64803	.65173
0.4	.65542	.65910	.66276	.66640	.67003	.67364	.67724	.68082	.68439	.68793
0.5	.69146	.69497	.69847	.70194	.70540	.70884	.71226	.71566	.71904	.72240
0.6	.72575	.72907	.73237	.73565	.73891	.74215	.74537	.74857	.75175	.75490
0.7	.75804	.76115	.76424	.76730	.77035	.77337	.77637	.77935	.78230	.78524
0.8	.78814	.79103	.79389	.79673	.79955	.80234	.80511	.80785	.81057	.81327
0.9	.81594	.81859	.82121	.82381	.82639	.82894	.83147	.83398	.83646	.83891
1.0	.84134	.84375	.84614	.84849	.85083	.85314	.85543	.85769	.85993	.86214
1.1	.86433	.86650	.86864	.87076	.87286	.87493	.87698	.87900	.88100	.88298
1.2	.88493	.88686	.88877	.89065	.89251	.89435	.89617	.89796	.89973	.90147
1.3	.90320	.90490	.90658	.90824	.90988	.91149	.91309	.91466	.91621	.91774
1.4	.91924	.92073	.92220	.92364	.92507	.92647	.92785	.92922	.93056	.93189
1.5	.93319	.93448	.93574	.93699	.93822	.93943	.94062	.94179	.94295	.94408
1.6	.94520	.94630	.94738	.94845	.94950	.95053	.95154	.95254	.95352	.95449
1.7	.95543	.95637	.95728	.95818	.95907	.95994	.96080	.96164	.96246	.96327
1.8	.96407	.96485	.96562	.96638	.96712	.96784	.96856	.96926	.96995	.97062
1.9	.97128	.97193	.97257	.97320	.97381	.97441	.97500	.97558	.97615	.97670
2.0	.97725	.97778	.97831	.97882	.97932	.97982	.98030	.98077	.98124	.98169
2.1	.98214	.98257	.98300	.98341	.98382	.98422	.98461	.98500	.98537	.98574
2.2	.98610	.98645	.98679	.98713	.98745	.98778	.98809	.98840	.98870	.98899
2.3	.98928	.98956	.98983	.99010	.99036	.99061	.99086	.99111	.99134	.99158
2.4	.99180	.99202	.99224	.99245	.99266	.99286	.99305	.99324	.99343	.99361
2.5	.99379	.99396	.99413	.99430	.99446	.99461	.99477	.99492	.99506	.99520
2.6	.99534	.99547	.99560	.99573	.99585	.99598	.99609	.99621	.99632	.99643
2.7	.99653	.99664	.99674	.99683	.99693	.99702	.99711	.99720	.99728	.99736
2.8	.99744	.99752	.99760	.99767	.99774	.99781	.99788	.99795	.99801	.99807
2.9	.99813	.99819	.99825	.99831	.99836	.99841	.99846	.99851	.99856	.99861
3.0	.99865	.99869	.99874	.99878	.99882	.99886	.99889	.99893	.99896	.99900