KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering

B.Sc. Engineering **3rd** year **1st** Term Examination, **2021**

ME 3105

(Heat Transfer I)

Time: 3 Hours | Total Marks: 210

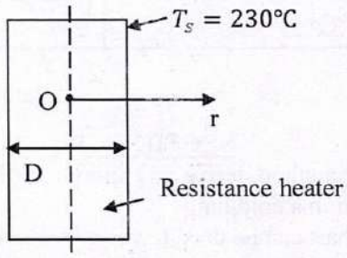
N.B.: i) Answer any THREE questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.
iii) Assume reasonable data if any missing.

SECTION – A

1(a) What is conduction? State and explain Fourier law of heat conduction. 07

1(b) Derive the three dimensional heat conduction equation in Cartesian coordinate. 15

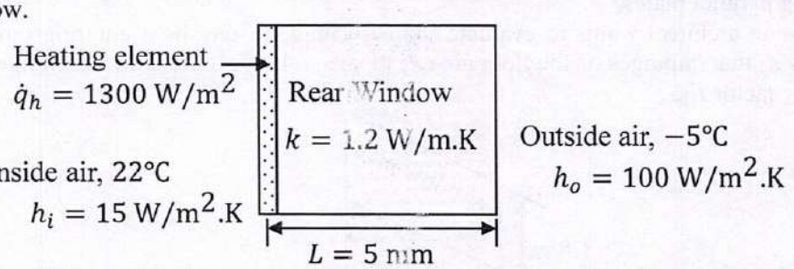
1(c) A resistance heater wire with thermal conductivity of $k = 20$ W/m.K, diameter of D = 4 m and heat generation rate $\dot{e}_{gen} = 35\ \text{W/cm}^3$ is used to boil water. If the outer surface temperature of the resistance wire is $T_s = 230°C$, determine the temperature distribution equation along the radius and center temperature. 13



2(a) How does insulation thickness effect on heat loss after insulating the plane wall, cylindrical pipe and spherical shell and why? 07

2(b) A hot steam pipe having an inside surface temperature of 300°C has an inside diameter of 8 cm and a wall thickness of 5.5 mm. It is covered with a 9 cm layer of insulation having k = 0.5 W/m^{0}C, followed by a 4 cm layer of insulation having k = 0.25 W/m.^{0}C. The outside temperature of the insulation is 30°C. Calculate the heat lost per meter of length. Assume k = 40 W/m^{0}C for the pipe. 14

2(c) To defog the rare window of an automobile, a very thin transparent heating element is attached to the inner surface of the window. A uniform heat flux of 1300 W/m^2 is provided to the heating element for defogging a rear window with thickness of 5 mm. The interior temperature of the automobile is 22°C and convection heat transfer coefficient is 15 W/m^2.K. The outside ambient temperature is −5°C and convection heat transfer coefficient is 100 W/m^2.K. If the thermal conductivity of the window is 1.2 W/m.K, determine the inner surface temperature of the window. 14



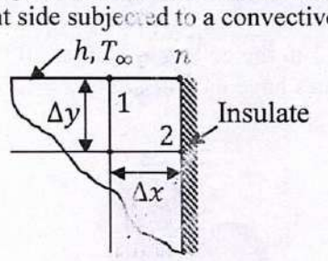
3(a) What is fin efficiency? Derive an expression for heat flow through a long circular fin when the fin tip approach the surrounding fluid temperature. 13

3(b) In what condition fin effectiveness will be higher? 04

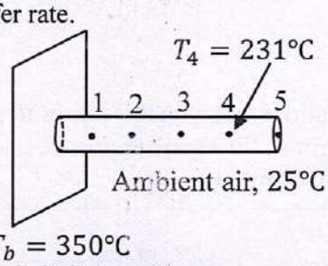
3(c) What is the proper length of fin? Explain. 05

3(d) A straight fin of rectangular profile has a thermal conductivity of 15 W/m°C, thickness of 2.0 mm and length of 25 mm. The base of the fins is maintained at a temperature of 200°C while the fin is exposed to a convection environment at 23°C with h = 30 W/m^2.^{0}C. Calculate the heat lost per meter of fin depth. 13

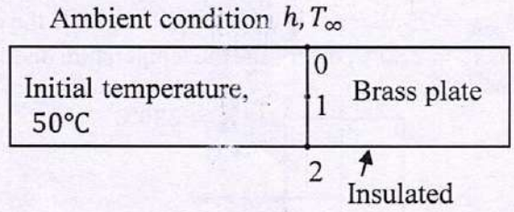
4(a) Derive the nodal temperature equation for the case of an exterior corner node with one adjacent side insulated and one adjacent side subjected to a convective heat transfer as shown in figure. 10



4(b) A circular fin of uniform cross section, with diameter of 10 mm and length of 50 mm, is attached to wall with fine base temperature of 350°C. The fin is made of material with thermal conductivity of 240 W/m.K and it exposed to an ambient air condition of 25°C and the convection heat transfer coefficient is 250 W/m².K. Assume steady one dimensional heat transfer along the fin and nodal spacing to be uniformly 10 mm, (i) Using the energy balance approach obtain the finite difference equation to determine nodal temperature, (ii) determine the nodal temperature along the fin and assume temperature at nodal point 4 is equal to 231.0°C, and (iii) calculate the heat transfer rate. 12



4(c) Write down the implicit and explicit finite difference equation of a hot brass plate with the following condition shown in figure. Also mention what will be the stability criteria for the explicit method. Assume any time step. 13



SECTION – B

5(a) Using Lumped-heat capacity method derive an expression of temperature distribution when a hot billet is suddenly dropped in a cold bath. 13

5(b) How transient temperature chart can be used to solve two dimensional problems? 07

5(c) A 10 cm thick wood wall [$\alpha = 0.82 \times 10^{-7}$ m²/s and $k = 0.15$ W/m.°C] is initially at a uniform temperature of 20°C. The wood may ignite at 400°C. If the surface is exposed to hot gases at $T_\infty = 500°C$ and the heat transfer coefficient between the gas and the surface is $h = 50$ W/m².°C, how long will it take for the surface of wood to reach 400°C? 15

6(a) What is thermal radiation? Describe the Plank's law of radiation. 08

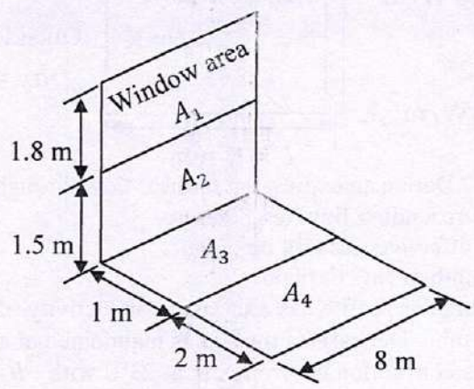
6(b) Show that the Spectral emissive power of a black body is π −times its spectral radiation intensity. 15

6(c) Define the following terms: 12
(i) Emissivity, (ii) Gray body, (iii) Diffuse solar radiation and (iv) Solar constant.

7(a) What is view factor? Explain the crossed string method of view factor. 08

7(b) Using radiation network method, derive an expression for radiation heat exchange between two long parallel plates. 12

7(c) Suppose an architect wants to evaluate the percentage of day light entering through a store window A_1 that impinges on the floor area A_4 located relative to A_1 as shown in figure. Evaluate the view factor $F_{1\text{-}4}$. 15



8(a) Explain the effect of radiation on temperature measurement. 08

8(b) What is the reradiating surface? Draw the radiation network of a 3 zone enclosure with a reradiating surface. 14

8(c) In a test room 3 m by 3 m by 3 m the celling is kept at 80°C while the walls and floor are at 15°C. Assuming that all surfaces have an emissivity $\varepsilon = 0.7$, determine the rate of heat loss from the ceiling by radiation. 13

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering

B.Sc. Engineering **3rd** year **1st** Term Examination, **2021**

ME 3117

(Machine Design I)

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) A 40 mm diameter solid steel shaft, used as a torque transmitter, is replaced with a hollow shaft having a 40 mm OD and a 36 mm ID. If both materials have the same strength, what is the percentage reduction in torque transmission? What is the percentage reduction in shaft weight? 15

1(b) An aluminum alloy cylindrical roller with diameter 25 mm and length 50 mm rolls on the inside of a cast iron ring having an inner radius of 100 mm, which is 50 mm thick. Find the maximum contact force F that can be used if the shear stress is not to exceed of 28 MPa. 20

2 A ductile hot rolled steel bar has a minimum yield strength in tension and compression of 350 MPa. Using the appropriate failure theories, determine the factors of safety for the following plane stress states: 35

i) $\sigma_x = 90$ MPa, $\sigma_y = -70$ MPa, $\tau_{xy} = -40$ MPa

ii) $\sigma_x = 120$ MPa, $\tau_{xy} = -85$ MPa

iii) $\sigma_x = -50$ MPa, $\sigma_y = 20$MPa, $\tau_{xy} = -20$ MPa

3(a) A single-threaded 25 mm power screw is 25 mm in diameter with a pitch of 5 mm. A vertical load on the screw reaches a maximum of 5 kN. The coefficient of friction are 0.06 for the collar and 0.09 for the threads. The frictional diameter of the collar is 45 mm. Find the overall efficiency and the torque to "raise" and "lower" the load. 18

3(b) An $M14 \times 2$ hex-head bolt with a nut is used to clamp together two 15 mm steel plates. 17

i) Determine a suitable length for bolt, rounded up to the nearest 5 mm.

ii) Determine the bolt stiffness.

iii) Determine the stiffness of the members.

4 A helical compression spring is to be made of oil-tempered wire of 4 mm diameter with a spring index of $C = 10$. The ends of the spring is left plain. The free length of the spring should be 80 mm. A force of 50 N should deflect the spring 12 mm. Determine: 35

i) The spring rate,

ii) The total number of coils needed,

iii) The solid length,

iv) The factor of safety based on the yielding of the spring if it is compressed to its solid length.

v) Is the spring stable? If not what should be the diameter of a guide cylinder to operate the spring?

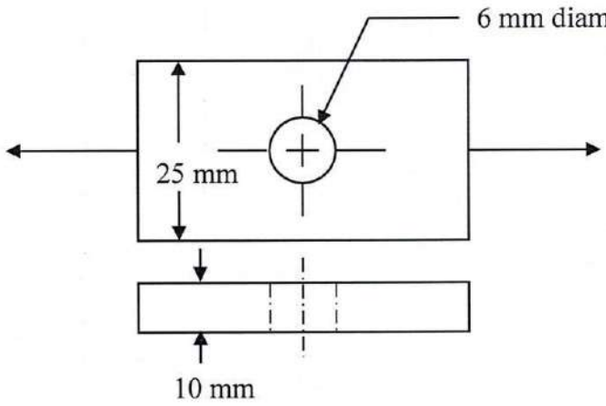
SECTION – B

5 A 25 mm solid round bar has a groove 2.5 mm deep with a 2.5 mm radius machined into it. The bar is made of AISI 1018 CD steel and is subjected to a purely reversing torque of 200 N.m. For the S-N curve of this material, let $f = 0.9$. 35

i) Estimate the number of cycles to failure.

ii) If the bar is placed in an environment with a temperature of 450^0F, estimate the number of cycles to failure.

6 The cold drawn AISI 1040 steel bar shown in figure is subjected to a completely reversed axial load fluctuating between 28 kN in compression to 28 kN in tension. Estimate the fatigue factor of safety based on achieving infinite life, and the yielding factor of safety. If finite life is predicted, estimate the number of cycles to failure. 35

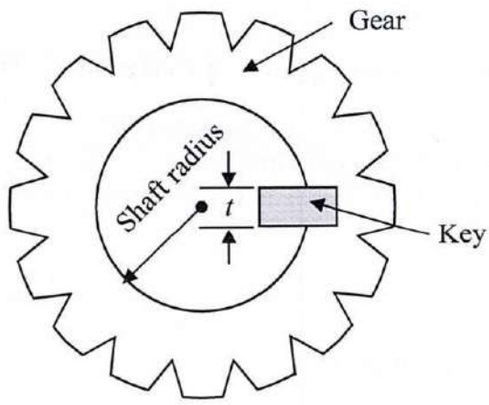


7 A shaft is loaded in bending and torsion such that $M_a = 80$ N.m, $T_a = 50$ N.m, $M_m = 60$ N.m and $T_m = 35$ N.m. For the AISI 1050 CD steel shaft, the fully corrected endurance limit is $S_e = 200$ MPa. Let $K_f = 2.2$ and $K_{fs} = 1.8$. Considering a suitable design factor, determine the minimum acceptable diameter of the shaft using: 35

i) DE – Gerber criterion
ii) DE – ASME Elliptic criterion
iii) DE – Soderberg criterion
iv) DE – Goodman criterion

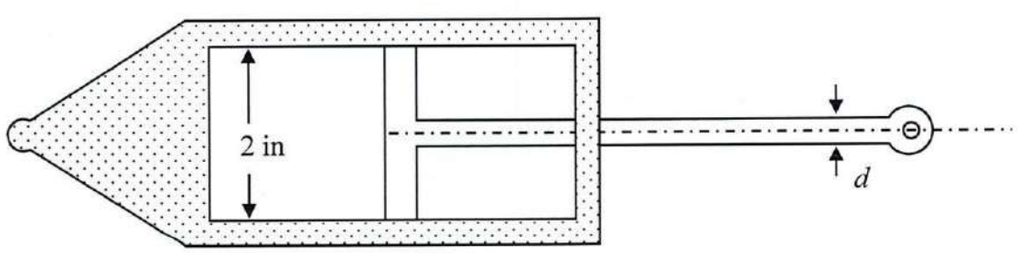
Also discuss and compare the results.

8(a) A AISI 1045 CD steel shaft has a diameter of $1\frac{3}{8}$ inch. The shaft rotates at 800 rev/min and transmits 45 hp through a gear. Find an appropriate key for the gear with a factor of safety of 1.8. 17



8(b) The hydraulic cylinder shown in the figure has a 2 in bore and is to operate at a pressure of 1500 psi with the clevis mount shown, the piston rod should be sized as a column with both ends rounded for any plane of buckling. The rod is to be made of force AISI 1030 steel. 18

i) Using $n_d = 2.5$, select a preferred size for the rod diameter if the column length is 50 in.
ii) Find the size of the rod for a column length of 16 in.



KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering

B.Sc. Engineering **3rd** year **1st** Term Examination, **2021**

ME 3121

(Numerical Computation for Mechanical Engineers)

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 interpolation? Show the relation between simple and divided differences. 07

1(b) Deduce the expression for Newton's general interpolation formula. 13

1(c) From the following table of values of x and $f(x)$, determine the value of $f(0.29)$. 15

x	0.20	0.22	0.24	0.26	0.28	0.30
$f(x)$	1.6596	1.6698	1.6804	1.6912	1.7024	1.7139

2(a) Deduce the expression of Gauss third formula. Where it is used? 13

2(b) From the following table of values of x and $y = e^x$, compare the obtained values of y when $x = 1.91$ by using Stirling's and Bessel's formulae. 22

x	1.7	1.8	1.9	2.0	2.1	2.2
$y = e^x$	5.4739	6.0496	6.6859	7.3891	8.1662	9.0250

3(a) What is transcendental function? Write the computational steps to find the root using bisection method. 18

3(b) Find a root of an equation $f(x) = x^3 - x - 1$ using Newton Raphson method. Explain the situation when Newton Raphson method fails. 17

4(a) What are the methods for solving system of linear algebraic equation? Describe any direct method for solving these equations. 17

4(b) Solve the following equations any iterative method. 18

$$2x + 6y - z = 85$$
$$6x + 15y + 2z = 72$$
$$x + y + 54z = 110$$

SECTION – B

5(a) What is meant by initial value problem and boundary value problem? Find $y(1.0)$ using modified Euler's method by solving the initial value problem $y' = -2xy^2, y(0) = 1$ with step length 0.2. 17

5(b) Using the Runge – Kutta method to solve 18

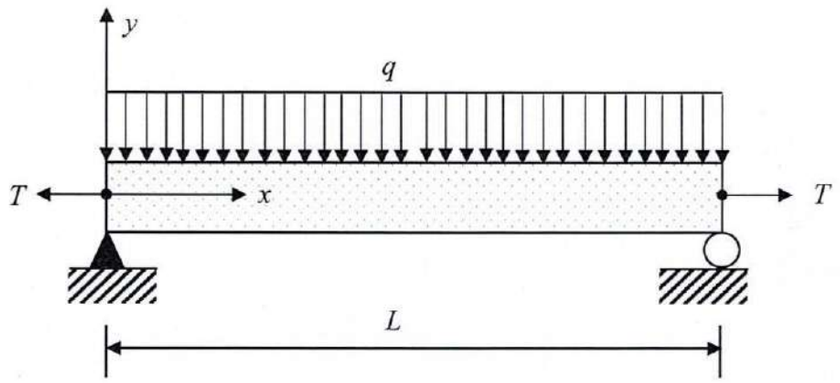
$$10\frac{dy}{dx} = x^2 + y^2, \quad y(0) = 1.0$$

for the interval $0 < x \leq 0.4$ with $h = 0.2$.

6(a) The deflection y in a simply supported beam with a uniform load q and a tensile axial load T (as shown in figure) is given by 18

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

where $T = 720$ N, $q = 540$ N/m, $E = 30$ MPa, $I = 120$ m^4 and $L = 75$ cm. Find the deflection of the beam at $x = 50$ m. Use a step size of $\Delta x = 25$ cm and approximate the derivatives by central divided difference approximation.



6(b) What is meant by correlation coefficient? Explain the situation when the value of correlation coefficient $r = \pm 1$. 05

6(c) Find the value of a, b and c so that $Y = a + bx + cx^2$ is the best fit to the data:

x	0	1	2	3	4
y	1	0	3	10	21

7(a) Write the importance of Eigen value and Eigen vector. Also find the largest Eigen value and corresponding Eigen vectors of the following matrix. 15

$$\begin{bmatrix} 1 & 6 & 1 \\ 1 & 2 & 0 \\ 0 & 0 & 3 \end{bmatrix}$$

7(b) Discretize the following differential quantities: 05

$$\frac{\partial^2 T}{\partial x^2} \quad \text{and} \quad \frac{\partial^2 T}{\partial x \partial y}$$

7(c) Distinguish between explicit scheme and implicit scheme. 05

7(d) Explain the following terms: 10

(i) Standard and diagonal five point rule

(ii) Gauss – Seidal method and SOR method

8(a) What is stability in solving partial differential equation by finite difference method? Find the condition of stability in solving parabolic equation. 18

8(b) Heat is conducted through a rod of 2 cm diameter and 20 cm long in steady state where heat is generated within the rod at 8.2×10^7 W/m^3. At length = 0, the temperature is maintained at 200^{0}C, while at length = 20 cm heat dissipates by convection with heat transfer coefficient of 250 W/m^2 ^{0}C into an ambient at temperature of 50^{0}C. Find the temperature distribution along the rod dividing it into 5 intervals. Assume thermal conductivity of rod material as 30 W/m^{0}C. 17

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering

B.Sc. Engineering 3rd year 1st Term Examination, **2021**

ME 3119

(Statistics & Quality Control)

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.
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SECTION – A

1(a) Describe various methods of data analysis and data presentation using descriptive statistics. 10

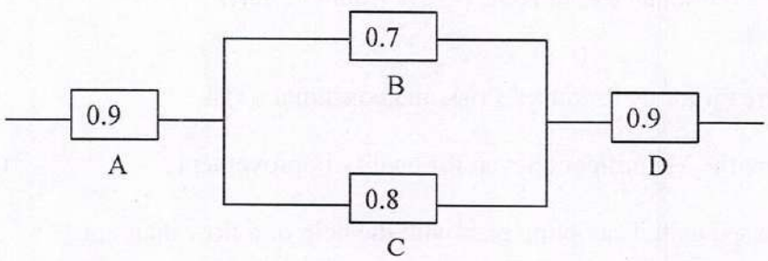
1(b) Write a short note on: 10
i) Histogram ii) Frequency Polygon
iii) Bar Chart iii) Ogive

1(c) Find the probability of not getting a 7 or 11 total on either of two tosses of a pair of fair dice. 15

2(a) A certain machine produce item in a lot 5 defective, 10 partly defective (that fail after a certain time) and 25 acceptable item. If randomly an item is chosen and put into use, if it does not immediately fail, what is the probability it is acceptable and not defective. 10

2(b) Write a short note on: 10
i) Independent event ii) Dependent event
iii) Mutually exclusive event iv) Conditional probability

2(c) Suppose the diagram of an electrical system is given in figure as follows. What is the probability that the system works? Assume the components fail independently. 15



3(a) Describe the properties of Binomial, Poisson and Normal distribution. 10

3(b) In an industrial process the diameter of a ball bearing is an important component part. The buyer sets specification on the diameter to be 3.0 ± 0.01 cm. The implication is that in the process the diameter of a ball bearing has a normal distribution with mean $\mu = 3.0$ and standard deviation $\sigma = 0.005$. On average, how many manufactured ball bearings will be scrapped? 15

3(c) Find the probability that in a family of 4 children there will be: 10
i) at least one boy,
ii) at least one boy and at least one girl.
Assume that the probability of a male birth is 1/2.

4(a) Why hypothesis testing is done? Define type – I and type – II errors? 10

4(b) The manufacturer of a patent vaccine claimed that it was 90% effective for a period of six months. In a sample of 200 people who are given vaccine, the vaccine provided relief for 160 people. Determine whether the manufacturer's claim is legitimate by using 0.01 as the level of significance. 13

4(c) An electrical firm manufactures light bulbs that have a length of life that is approximately normally distributed with a mean of 800 hrs and a standard deviation of 40 hrs. Test the hypothesis that $\mu = 800$ hrs against the alternative $\mu \neq 800$ hrs if a random sample of 30 bulbs has been an average life 788 hrs. Use a 0.05 level of significance. 12

SECTION – B

5(a) Define quality. Mention the dimensions of quality. 06

5(b) Explain QC circle. What are the requirement for a successful QC circle? 09

5(c) Samples of $n = 5$ units are taken from a process every hour. The X and R values for a particular quality characteristics are determined. After 25 samples have been collected, we calculate $\bar{X} = 500$ and $\bar{R} = 4.56$. 20

i. What are the three sigma control limit for $\bar{x}$ and R chart?
ii. Both charts exhibit control. Estimate the process standard deviation.
iii. If the specifications are 19 ± 5, what are your conclusions regarding process capability?
iv. If the process mean shifts to 24, what is the probability of not detecting this shift on the first subsequent sample?

6(a) What is meant by acceptance sampling? Discuss the effect of sample size and acceptance number in OC curve. 10

6(b) Discuss the advantages and disadvantages of sampling inspection over 100% inspection. 10

6(c) A single sampling plan has the following specification $N = 5000$, $n = 50$ and $c = 2$. Find out: 15

i) Probability of acceptance for percent defective $P = 1,3,5$ and 7 and draw OC curve.
ii) Product risk at AQL = 15% from OC curve.

7(a) What are meant by Producer's risk and consumer's risk? 10

7(b) What are the Magnificent Seven for quality improvement? 12

7(c) Explain sequential sampling plan with the help of a flow diagram. 13

8(a) Describe the switching rule in MIL STD 105E. 06

8(b) Describe double sampling plan with flow chart. 09

8(c) A double sampling plan with $n_1 = 50$, $C_1 = 2$, $n_2 = 100$ and $C_2 = 4$. If the incoming lots have fraction non-conforming $P = 0.05$. Now calculate: 20

i) The probability of acceptance on first sample.
ii) The probability of rejection after 1st sample.
iii) The probability of going for 2nd sample.
iv) The probability of acceptance after 2nd sample.
v) Total probability of acceptance.
vi) Total probability of rejection.