CHAPTER-V
SOFTWARE DEVELOPMENT

5.1 PLANNING

In order to analyze the failure data collected, as explained in Chapter-III, two parameter Weibull distribution has been selected because of its established merit in the literature as well as the nature of the failure data of two different sets of mechanical systems available for the present investigation. After applying the maximum likelihood method for the estimation of shape parameter, \( \beta \), and scale parameter, \( \theta \), two Eqs. (3.45) and (3.46) have been derived. Since the analytic estimation of these parameters is not possible, one has to think about the numerical solution.

In the past, these parameters have been found using Secant and Regula-Falsi methods but an objection to the Secant method has been raised. If the function is far from linear near the root, the successive iterates can fly off to points far from the root. Another pathological case can arise when an iterate duplicates a previous one, resulting in an endless loop that never reaches the true value of the root. Therefore, Newton-Raphson's method, one of the most widely used methods of solving Equations, has been used in the present work to find out the two parameters of Weibull distribution because at least in the neighborhood of a root, this method is more rapidly convergent than the Secant and Regula-Falsi methods. Moreover, Newton-Raphson's method is quadratically convergent, by which we mean that the error of each step approaches a constant \( K \) times the square of the error of the previous step. The net result of this is that the number of decimal places of accuracy nearly doubles at each iteration.
5.2 CONTENTS OF SOFTWARE

A software package has been developed in C++ programming language which is illustrated through the Flow-chart 5.1 and its listing in Program 5.1. This software has been used to solve the governing Eqs. (3.45) & (3.46) numerically for scale and shape parameters, respectively, using Newton-Raphson’s algorithm given in Eq. (3.47).

The software package developed is versatile in the sense that it produces the value of various functions in reliability such as reliability function, \( R(T) \), failure distribution function, \( F(T) \), failure density, \( f(T) \), and failure rate, \( \lambda(T) \), estimates life expectancy, \( \bar{T} \), variance, \( \sigma^2 \), standard deviation, \( \sigma_T \), finds out stabilization time, \( T_s \), at which system is assumed to attain almost a constant failure rate, evaluates 10\(^{th}\) percentile, \( T_{10} \), which predicts the life time when a 10\(^{th}\) of the given population of system fails, gives out the arithmetic means of \( R(T) \), \( F(T) \), \( f(T) \) & \( \lambda(T) \), and forecasts the annual requirement of replacement systems/subsystems, while making use of Eqs. (3.50) – (3.63).
FLOWCHART 5.1

Start

Read N number of input values on arrays of T,F,C

A=D=G=I=K=M=P=TF=0
b = 1

i = 0

A = A + F[i] *(T[i])^b * log(T[i])
D = D + C[i] *(T[i])^b * log(T[i])
G = G + F[i] *(T[i])^b
I = I + C[i] *(T[i])^b
K = K + F[i] *log(T[i])
M = M + F[i] *(T[i])^b * (log(T[i]))^2
P = P + C[i] *(T[i])^b * (log(T[i]))^2

If i < N ?

Y/N

Yes

i = i + 1

No

A
\[ F_1 = \frac{(A+D)}{(G+1)} - \frac{1}{b} - \frac{(K/TF)}{F_2} = \frac{((M+P) \cdot (G+1)) - ((A+D)^2)/(G+1)^2)}{((A+D)^2)/(G+1)^2} + 1/(b^2) \]
\[ h = (-F_1/F_2) \]
\[ b = b + h \]

If \( h \leq 0.000001 \) AND \( h > 0 \)?

Yes

\[ G = I = 0 \]
\[ i = 0 \]

No

\[ G = G + F[i] \cdot (T[i])^b \]
\[ I = I + C[i] \cdot (T[i]^b \]

If \( i < N \)?

Yes

No

\[ Q = ((G+1)/TF)^{1/b} \]
c

MRt = 0
MFt = 0
Mt = 0
Myt = 0
i = 0

IF I < N ?

Y/N

No

Yes

g1 = gamma (1+1/b)
g2 = gamma (1+2/b)
Mean = Q * g1
Vr = Q^2 * (g2 - g1^2)
SD = Vr^1/2
Tl = Mean^2 / (3*SD)
Perct = .1
TP = Q * (-log (1-perct))

Print
k, b, Q, Mean, Vr
SD, Tl, TP, MRt/N
MFt/N, MRt/N, Myt/N

Stop

i = i + 1
Rtp = (T[i]/Q)^b
Rt = e^b
Ft = 1 - Rt
ftp = (T[i]/Q)^b
ft = (h/Q) * (ftp) * Rt
yt = (h/Q) * ftp

Print
T[i], Rt, Ft, ft, yt,

MRt = MRt + Rt
MFt = MFt + Ft
Mt = Mt + ft
Myt = Myt + yt
SOFTWARE DEVELOPMENT FOR RELIABILITY ANALYSIS
BASED ON WEIBULL DISTRIBUTION, PARAMETERS ARE ESTIMATED
BY APPLYING MAXIMUM LIKELIHOOD METHOD AND NEWTON-RAPHSON
METHODS
FOR UNGROUPED, GROUPED, COMPLETE, SINGLY CENSORED DATA OF TYPE-I OR
TYPE-II AND MULTIPLY CENSORED DATA

```c
#include<stdio.h>
#include<math.h>
float gamma(float g);
void main(int argc, char argv[])
{
    FILE *df;
    char buf[30];
    float A,D,G,I,K,M,P,T,F1,F2,h,Q,Rtp,Rt,ftp,Ft,ft,Mean,g1,Vr,SD;
    float T1,g2,TP,M Rt,MFt,Mft,Myt;
    double T[100],b,perct;
    int F[100],C[100],N=0,i=0,k;
    if (argc != 2)
    {
        printf("Invalid no of arguments...
Usage: ppJ <datafile>\n");
        return;
    }
    df = fopen(argv[1],"r");
    while(fscanf(df,"%s %lf%ld%d",buf,&T[i],&F[i],&C[i]) != EOF)
    {
        printf("%d %d %d \n",T[i],F[i],C[i]);
        i++;
    }
    printf("\n");
    fclose(df);
}
float gamma(float g)
{
    return pow(g,2)*exp(-pow(g,2)*0.5);
}
```
N=i;
b=J;
k=O;
while(1)
{
    A=D=G=I=K=M=P=TF=O;
k++;
    for(i=O;i<N;i++)
    {
        A = A + F[i]*(pow(T[i],b))*(log(T[i]));
        D = D + C[i]*(pow(T[i],b))*(log(T[i]));
        G = G + F[i]*(pow(T[i],b));
        I = I + C[i]*(pow(T[i],b));
        K = K + F[i]*(log(T[i]));
        M = M + F[i]*(pow(T[i],b))*(log(T[i]))*(log(T[i]));
        P = P + C[i]*(pow(T[i],b))*(log(T[i]))*(log(T[i]));
        TF=TF + F[i];
        //printf("%2d %13.5f%13.5f%13.5f%13.5f%5.0f\n",i,A,D,G,I,K,TF);
    }
    FI = (A+D)/(G+I)-(I/b)-(K/TF);
    F2 = (((M+P)*(G+I)-((A+D)*(A+D)))/(G+I)*(G+I))+1/(b*b);
    //printf("nF1 = %f F2 = %fn",F1,F2);
    h = (-F1/F2);
    b = b+h;
    //printf("nh = %f b = %fn",h,b);
    if ( (h <= 0.000001) && (h > 0) )
        break;
    }
    G = I = 0;
    for(i=0;i<N;i++)
\{ 
G = G + F[i]*(pow(T[i],b));
I = I + C[i]*(pow(T[i],b));
\}
Q = pow((G+J)/TF,(J/b));
printf("n LIFE RELIABILITY FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAILURE FAIL
g2 = gamma(g2);
g1 = gamma(g1);

Mean = Q * g1;
Vr = Q * Q * (g2 - (g1 * g1));
SD = sqrt(Vr);
T1 = Mean * Mean / (3 * SD);
perct = 1;
TP = Q * pow(-log(1 - perct), (1 / b));

float gamma(float g)
{
  float gama;
  /*
  TABULATION OF VALUES OF GAMMA FUNCTION CORRESPONDING TO THE VALUES RANGES FROM 1 TO 2 WITH INCREMENT OF 0.01
  */
  float z[101] = {1.00000, 0.99432, 0.98884, 0.98355, 0.97844, ...
gama=1;
while (g > 2)
{

gama=gama*2;
}

return gama*(z[floor((g-1)*100)]) ;