

## Method # 1: Chi-square minimization

Fitting a dataset  $(x_i, y_i, s_i)$  using a curve  $y=f(x)=a*\exp(bx)$ , where values of the parameters  $a$  and  $b$  are unknown, but defined within a set of range.

Dataset  $(x_i, y_i, s_i)$  is the following:

$i$	1	2	3	4	5	6	7
$x_i$	1	2	3	4	5	6	7
$y_i$	4	5	8	16	30	38	70
$\sigma_i$	2	2	3	3	4	5	5

Define  $\chi^2(a, b) = \sum [(y_i - f(x_i)) / \sigma_i]^2$

Prob1: Tabulate and plot  $\chi^2(a=2.101, b)$  vs  $b$  (in steps of 0.1).

- Find the value of  $b$  for which  $\chi^2(a=2.101, b)$  is minimum  $\chi^2$ .
- Find the values of  $b$  for which  $\chi^2$  value is  $\chi^2 + 1$
- Find the values of  $b$  for which  $\chi^2$  value is  $\chi^2 + 4$
- Find the values of  $b$  for which  $\chi^2$  value is  $\chi^2 + 9$

Prob2: Tabulate and plot  $\chi^2(a, b=0.498)$  vs  $a$  (in steps of 0.1).

- Find the value of  $a$  for which  $\chi^2(a, b=0.498)$  is minimum  $\chi^2$ .
- Find the values of  $a$  for which  $\chi^2$  value is  $\chi^2 + 1$
- Find the values of  $a$  for which  $\chi^2$  value is  $\chi^2 + 4$
- Find the values of  $a$  for which  $\chi^2$  value is  $\chi^2 + 9$

Prob3: Tabulate and plot  $\chi^2(a, b)$  vs  $a, b$  (both in steps of 0.1).

- Find the values of  $(a, b)$  for which  $\chi^2(a, b)$  is minimum  $\chi^2$ . Plot  $a$  vs  $b$ .
- Find the values of  $(a, b)$  for which  $\chi^2$  value is  $\chi^2 + 1$ . Plot  $a$  vs  $b$ .
- Find the values of  $(a, b)$  for which  $\chi^2$  value is  $\chi^2 + 4$ . Plot  $a$  vs  $b$ .
- Find the values of  $(a, b)$  for which  $\chi^2$  value is  $\chi^2 + 9$ . Plot  $a$  vs  $b$ .

**CODE:**

```

/*****
*****Chi-square fitting*****
*****/
#include<stdio.h>
#include<math.h>
double f(double a, double b, double x){
    return a*exp(b*x);
}
double chi(double a, double b, int n, double x[n], double y[n], double sig[n], double
f(double a, double b, double x)){
    double sum=0;
    int i;
    for(i=0;i<n;i++){
        sum=sum+pow((y[i]-f(a,b,x[i]))/sig[i],2);
    }
    return sum;
}

main(){

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int n=7;
double x[7]={1,2,3,4,5,6,7};
double y[7]={4,5,8,16,30,38,70};
double sig[7]={2,2,3,3,4,5,5};
double a=2.101, b;
double h=0.000001;
int N=(2-0.1)/h;
FILE *fp=NULL;
fp=fopen("chi2.txt","w");
int i=0;
for(b=0.1;b<=2;b=b+h){
    fprintf(fp,"%lf\t%lf\n",b,chi(a,b,n,x,y,sig,f));
    i++;
}
FILE *fp1=NULL;
fp1=fopen("chi2.txt","r");
double bmin, chi2min, amin;
fscanf(fp1,"%lf\t%lf\n",&bmin,&chi2min);
int minIndex=0;
for(i=0;i<N;i++){
    double btemp;
    double chitemp;
    fscanf(fp1,"%lf\t%lf\n",&btemp,&chitemp);
    if(chitemp<chi2min){
        chi2min=chitemp;
        bmin=btemp;
        minIndex=i;
    }
}
printf("The min. value of Chi2 is %lf for b=%lf\n\n",chi2min,bmin);
fp1=fopen("chi2.txt","r");
for(i=0;i<N;i++){
    double btemp;
    double chitemp;
    fscanf(fp1,"%lf\t%lf\n",&btemp,&chitemp);
    if(fabs(chitemp-chi2min-1)<=0.0005&&i<minIndex){
        printf("\n%lf\t%lf",btemp,chitemp);
        break;
    }
}
fp1=fopen("chi2.txt","r");
for(i=0;i<N;i++){
    double btemp;
    double chitemp;
    fscanf(fp1,"%lf\t%lf\n",&btemp,&chitemp);
    if(fabs(chitemp-chi2min-1)<=0.0005&&i>minIndex){
        printf("\n%lf\t%lf",btemp,chitemp);
        break;
    }
}
fp1=fopen("chi2.txt","r");
for(i=0;i<N;i++){
    double btemp;
    double chitemp;

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        fscanf(fp1, "%lf\t%lf\n", &btemp, &chitemp);
        if(fabs(chitemp-chi2min-4)<=0.0005&&i<minIndex){
            printf("\n%lf\t%lf", btemp, chitemp);
            break;
        }
    }
    fp1=fopen("chi2.txt", "r");
    for(i=0;i<N;i++){
        double btemp;
        double chitemp;
        fscanf(fp1, "%lf\t%lf\n", &btemp, &chitemp);
        if(fabs(chitemp-chi2min-4)<=0.0005&&i>minIndex){
            printf("\n%lf\t%lf", btemp, chitemp);
            break;
        }
    }
    fp1=fopen("chi2.txt", "r");
    for(i=0;i<N;i++){
        double btemp;
        double chitemp;
        fscanf(fp1, "%lf\t%lf\n", &btemp, &chitemp);
        if(fabs(chitemp-chi2min-9)<=0.0005&&i<minIndex){
            printf("\n%lf\t%lf", btemp, chitemp);
            break;
        }
    }
    fp1=fopen("chi2.txt", "r");
    for(i=0;i<N;i++){
        double btemp;
        double chitemp;
        fscanf(fp1, "%lf\t%lf\n", &btemp, &chitemp);
        if(fabs(chitemp-chi2min-9)<=0.0005&&i>minIndex){
            printf("\n%lf\t%lf", btemp, chitemp);
            break;
        }
    }
}
/*****
Part 2
*****/
fp=fopen("chi3.txt", "w");
b=0.498;
i=0;
for(a=1;a<=4;a=a+h){
    fprintf(fp, "%lf\t%lf\n", a, chi(a,b,n,x,y,sig,f));
    i++;
}
fp1=fopen("chi3.txt", "r");
fscanf(fp1, "%lf\t%lf\n", &amin, &chi2min);
minIndex=0;
for(i=0;i<N;i++){
    double atemp;
    double chitemp;
    fscanf(fp1, "%lf\t%lf\n", &atemp, &chitemp);
    if(chitemp<chi2min){

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        chi2min=chitemp;
        amin=atemp;
        minIndex=i;
    }
}
printf("\n\nThe min. value of Chi2 is %lf for a=%lf\n\n",chi2min,amin);
fp1=fopen("chi3.txt","r");
for(i=0;i<N;i++){
    double atemp;
    double chitemp;
    fscanf(fp1,"%lf\t%lf\n",&atemp,&chitemp);
    if(fabs(chitemp-chi2min-1)<=0.0005&&i<minIndex){
        printf("\n%lf\t%lf",atemp,chitemp);
        break;
    }
}
fp1=fopen("chi3.txt","r");
for(i=0;i<N;i++){
    double atemp;
    double chitemp;
    fscanf(fp1,"%lf\t%lf\n",&atemp,&chitemp);
    if(fabs(chitemp-chi2min-1)<=0.0005&&i>minIndex){
        printf("\n%lf\t%lf",atemp,chitemp);
        break;
    }
}
fp1=fopen("chi3.txt","r");
for(i=0;i<N;i++){
    double atemp;
    double chitemp;
    fscanf(fp1,"%lf\t%lf\n",&atemp,&chitemp);
    if(fabs(chitemp-chi2min-4)<=0.0005&&i<minIndex){
        printf("\n%lf\t%lf",atemp,chitemp);
        break;
    }
}
fp1=fopen("chi3.txt","r");
for(i=0;i<N;i++){
    double atemp;
    double chitemp;
    fscanf(fp1,"%lf\t%lf\n",&atemp,&chitemp);
    if(fabs(chitemp-chi2min-4)<=0.0005&&i>minIndex){
        printf("\n%lf\t%lf",atemp,chitemp);
        break;
    }
}
fp1=fopen("chi3.txt","r");
for(i=0;i<N;i++){
    double atemp;
    double chitemp;
    fscanf(fp1,"%lf\t%lf\n",&atemp,&chitemp);
    if(fabs(chitemp-chi2min-9)<=0.0005&&i<minIndex){
        printf("\n%lf\t%lf",atemp,chitemp);
        break;
    }
}

```

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    }
}
fp1=fopen("chi3.txt","r");
for(i=0;i<N;i++){
    double atemp;
    double chitemp;
    fscanf(fp1,"%lf\t%lf\n",&atemp,&chitemp);
    if(fabs(chitemp-chi2min-9)<=0.0005&&i>minIndex){
        printf("\n%lf\t%lf",atemp,chitemp);
        break;
    }
}
}
/*****
Part 3
*****/
fp=fopen("chi4.txt","w");
h=0.001;
i=0;
N=(2-0.1)/h*(4-1)/h;
for(a=1;a<=4;a=a+h){
    for(b=0.1;b<=2;b=b+h){
        fprintf(fp,"%lf\t%lf\t%lf\n",a,b,chi(a,b,n,x,y,sig,f));
        i++;
    }
}
fp1=fopen("chi4.txt","r");
fscanf(fp1,"%lf\t%lf\t%lf\n",&amin,&bmin,&chi2min);
minIndex=0;
for(i=0;i<N;i++){
    double atemp;
    double btemp;
    double chitemp;
    fscanf(fp1,"%lf\t%lf\t%lf\n",&atemp,&btemp,&chitemp);
    if(chitemp<chi2min){
        chi2min=chitemp;
        amin=atemp;
        bmin=btemp;
        minIndex=i;
    }
}
printf("\n\nThe min. value of Chi2 is %lf for a=%lf and
b=%lf\n\n",chi2min,amin,bmin);
FILE *fp2=fopen("chi2+1.txt","w");
fp1=fopen("chi4.txt","r");
for(i=0;i<N;i++){
    double atemp;
    double btemp;
    double chitemp;
    fscanf(fp1,"%lf\t%lf\t%lf\n",&atemp,&btemp,&chitemp);
    if(fabs(chitemp-chi2min-1)<=0.08){
        fprintf(fp2,"%lf\t%lf\t%lf",atemp,btemp,chitemp);
        //break;
    }
}
}

```

```

fp2=fopen("chi2+4.txt","w");
fp1=fopen("chi4.txt","r");
for(i=0;i<N;i++){
    double atemp;
    double btemp;
    double chitemp;
    fscanf(fp1,"%lf\t%lf\t%lf\n",&atemp,&btemp,&chitemp);
    if(fabs(chitemp-chi2min-4)<=0.01){
        fprintf(fp2,"\n%lf\t%lf\t%lf",atemp,btemp,chitemp);
        //break;
    }
}
fp2=fopen("chi2+9.txt","w");
fp1=fopen("chi4.txt","r");
for(i=0;i<N;i++){
    double atemp;
    double btemp;
    double chitemp;
    fscanf(fp1,"%lf\t%lf\t%lf\n",&atemp,&btemp,&chitemp);
    if(fabs(chitemp-chi2min-9)<=0.01){
        fprintf(fp2,"\n%lf\t%lf\t%lf",atemp,btemp,chitemp);
        //break;
    }
}
}

```

**OUTPUT:**

```

The min. value of Chi2 is 2.371180 for b=0.499864

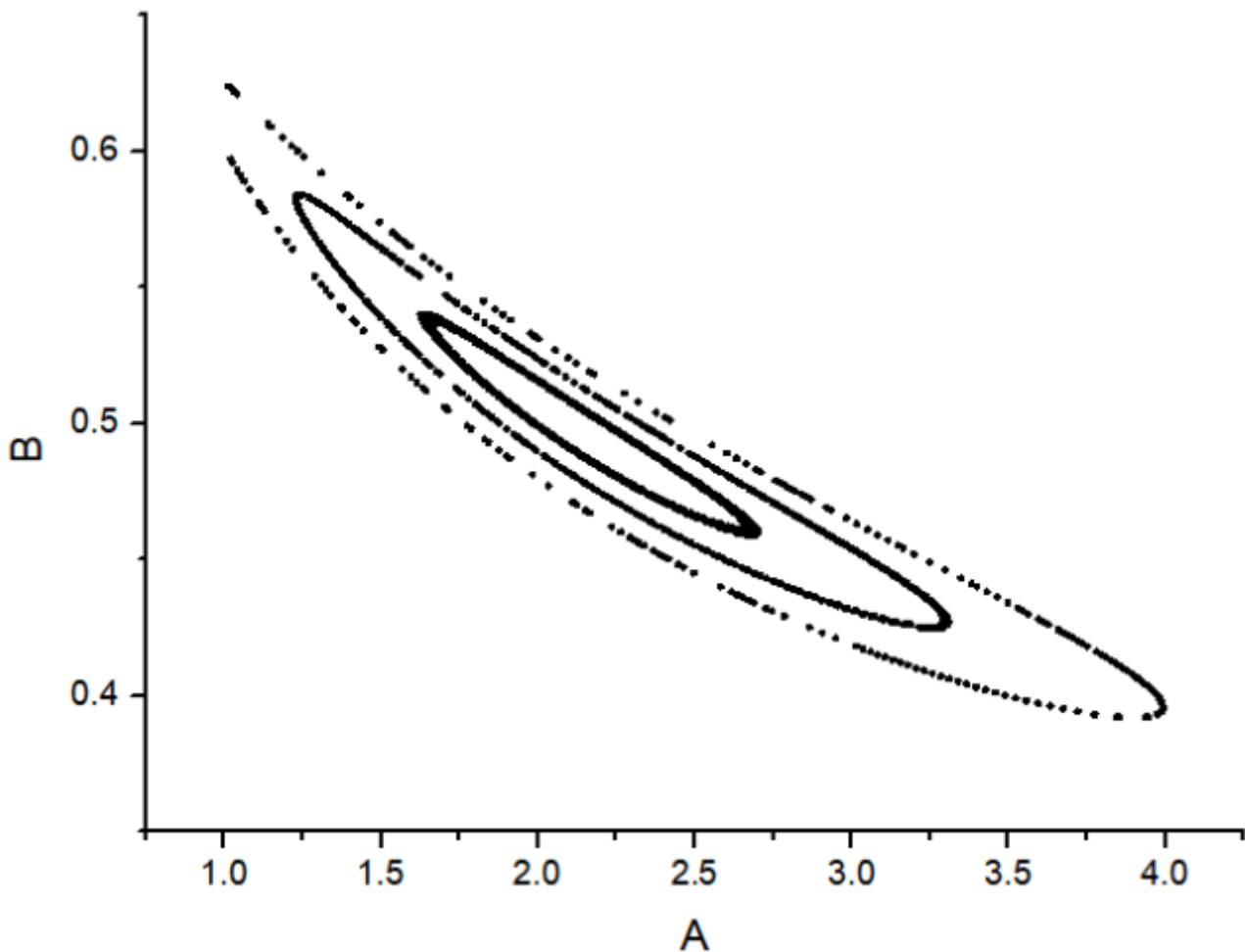
0.491051      3.371599
0.508207      3.370841
0.481697      6.371488
0.516115      6.371070
0.471736      11.371469
0.523633      11.371266

The min. value of Chi2 is 2.368701 for a=2.126080

2.013055      3.369184
2.239241      3.368205
1.899975      6.369195
2.352349      6.368228
1.786887      11.369157
2.465447      11.368238

The min. value of Chi2 is 2.368703 for a=2.126000 and b=0.498000

```



[Manas Sharma](#)

I'm a physicist specializing in theoretical, computational and experimental condensed matter physics. I like to develop Physics related apps and softwares from time to time. Can code in most of the popular languages. Like to share my knowledge in Physics and applications using this Blog and a YouTube channel.

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