

Computational Mathematics Lab

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DATA STRUCTURES LAB

PRACTICAL RECORD

Paper Code : e
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PRACTICAL DETAILS

Experiments according to the lab syllabus prescribed by GGSIPU

Exp. No.	Experiment Name	Performance Date	Date Checked	Remarks	Marks

1 Program for finding roots of $f(x) = 0$ using Newton Raphson Method

```
#include <math.h>
#include <stdio.h>
#define EPSILON 0.0000001
#define f(x) ((352 * x * x * x) - (64 * x * x) + (198 * x) - 36)
#define f1(x) ((1056 * x * x) - (128 * x) + 198)
double newtonRaphson(double x) {
    double h = f(x) / f1(x);
    if (f(x) == 0 || fabs(h) < EPSILON)
        return x;
    return newtonRaphson(x - h);
}
int main() {
    printf("Root for f(x) = 352x^3 - 64x^2 + 198x - 36 is %lf",
        newtonRaphson(-4));
}
```

Root for $f(x) = 352x^3 - 64x^2 + 198x - 36$ is 0.181818

2 Program for finding roots of $f(x) = 0$ using bisection method

```
#include <math.h>
#include <stdio.h>
#include <stdlib.h>
#define EPSILON 0.0000001
#define f(x) ((352 * x * x * x) - (64 * x * x) + (198 * x) - 36)
double bisection(double a, double b) {
    double x;
    if (f(a) * f(b) > 0) {
        printf("The values of function at the respective initial guesses must have "
            "opposite signs");
        exit(1);
    }
    x = (a + b) / 2;
    if (f(x) == 0 || fabs(b - a) < EPSILON)
        return x;
    if (f(x) > 0)
        return bisection(x, b);
    return bisection(a, x);
}
int main() {
    printf("Root for f(x) = 352x^3 - 64x^2 + 198x - 36 is %lf",
        bisection(1.6, -4));
}
```

Root for $f(x) = 352x^3 - 64x^2 + 198x - 36$ is 0.181818

3 Program for finding roots of $f(x) = 0$ using secant method

```
#include <math.h>
#include <stdio.h>
#define EPSILON 0.0000001
#define f(x) ((352 * x * x * x) - (64 * x * x) + (198 * x) - 36)
double secant(double a, double b) {
    double x1;
    x1 = (a * f(b) - b * f(a)) / (f(b) - f(a));
    if (f(x1) == 0 || fabs(a - b) < EPSILON)
        return x1;
    return secant(b, x1);
}
int main() {
    printf("Root for f(x) = 352x^3 - 64x^2 + 198x - 36 is %lf", secant(1.6, -4));
}
```

Root for $f(x) = 352x^3 - 64x^2 + 198x - 36$ is 0.181818

4 Program to implement Lagrange Interpolation.

```
#include <stdio.h>

int main() {
    double xp, yp = 0, p;
    int i, j, n;

    printf("Number of inputs: ");
    scanf("%d", &n);

    double x[n], y[n];
    printf("Input sample space:\n");

    for (i = 0; i < n; i++) {
        printf("x%d: ", i);
        scanf("%lf", x + i);
        printf("y%d: ", i);
        scanf("%lf", y + i);
    }

    printf("Enter interpolation point x: ");
    scanf("%lf", &xp);

    for (i = 0; i < n; i++) {
        p = 1;
        for (j = 0; j < n; j++) {
            if (i != j) {
                p *= (xp - x[j]) / (x[i] - x[j]);
            }
        }
        yp += p * y[i];
    }
    printf("Interpolated value for %lf is %lf.", xp, yp);
}
```

```
Number of inputs: 4
Input sample space:
x0: 0
y0: 2
x1: 1
y1: 3
x2: 2
y2: 12
x3: 5
y3: 147
Enter interpolation point x: 3
Interpolated value for 3.000000 is 35.000000.
```

5 Program to implement Newton's Divided Difference formula.

```
#include <stdio.h>

int main() {
    int n, i, j = 1;
    double xp, yp, f1, f2 = 0;

    printf("Enter the number of inputs: ");
    scanf("%d", &n);

    double x[n], y[n];

    printf("Enter input values:\n");
    for (i = 0; i < n; i++) {
        printf("x%d=", i);
        scanf("%lf", x + i);
        printf("y%d=", i);
        scanf("%lf", y + i);
    }

    yp = y[0];

    printf("Enter interpolation point x: ");
    scanf("%lf", &xp);

    do {
        for (i = 0; i < n - 1; i++)
            y[i] = ((y[i + 1] - y[i]) / (x[i + 1] - x[i]));

        f1 = 1;

        for (i = 0; i < j; i++) {
            f1 *= (xp - x[i]);
        }

        f2 += (y[0] * f1);
        j++;
    } while ((--n) > 1);

    yp += f2;

    printf("Interpolated value for %lf is %lf.", xp, yp);
}
```

```

Enter the number of inputs: 4
Enter input values:
x0=3
y0=9
x1=5
y1=12
x2=9
y2=666
x3=15
y3=10245
Enter interpolation point x: 999
Interpolated value for 999.000000 is 9525764925.000002.

```

6 Program for solving numerical integration by trapezoidal method.

```

#include <math.h>
#include <stdio.h>

#define f(x) ((352 * x * x * x) - (64 * x * x) + (198 * x) - 36)

double trapezoidal_integral(double a, double b, double n) {
    double h = (b - a) / n;

    double s = (f(a) + f(b)) / 2;

    // Add the other heights

    for (int i = 1; i < n; i++)
        s += f(a + i * h);

    return s * h;
}

int main() {
    printf("The area under the curve f(x) = 352x^3 - 64x^2 + 198x - 36 from x=3 "
           "to x=4 is %lf",
           trapezoidal_integral(3, 4, 10000));
}

```

The area under the curve $f(x) = 352x^3 - 64x^2 + 198x - 36$ from $x=3$ to $x=4$ is 1425.444900

7 Program for solving numerical integration by Simpson's 1/3 rule.

```

#include <math.h>
#include <stdio.h>

#define f(x) ((352 * x * x * x) - (64 * x * x) + (198 * x) - 36)

double simpsons_1_3(double a, double b, double n) {
    double h = (b - a) / n;

```

```

double s = f(a) + f(b);

// Add the other heights

for (int i = 1; i < n; i += 2)
    s += 4 * f(a + i * h);

for (int i = 2; i < n; i += 2)
    s += 2 * f(a + i * h);

return (h / 3) * s;
}

int main() {
    printf("The area under the curve  $f(x) = 352x^3 - 64x^2 + 198x - 36$  from  $x=3$  "
           "to  $x=4$  is %lf",
           simpsons_1_3(3, 4, 10000));
}

```

The area under the curve $f(x) = 352x^3 - 64x^2 + 198x - 36$ from $x=3$ to $x=4$ is 1424.963267

8 Program for solving numerical integration by Simpson's 3/8 rule.

```
#include <math.h>
#include <stdio.h>

#define f(x) ((352 * x * x * x) - (64 * x * x) + (198 * x) - 36)

double simpsons_1_3(double a, double b, double n) {
    double h = (b - a) / n;

    double s = f(a) + f(b);

    // Add the other heights

    for (int i = 1; i < n; i++)
        s += 3 * f(a + i * h);

    for (int i = 3; i < n; i += 3)
        s -= f(a + i * h);

    return (h / 8) * 3 * s;
}

int main() {
    printf("The area under the curve f(x) = 352x^3 - 64x^2 + 198x - 36 from x=3 "
        "to x=4 is %lf",
        simpsons_1_3(3, 4, 10000));
}
```

The area under the curve $f(x) = 352x^3 - 64x^2 + 198x - 36$ from $x=3$ to $x=4$ is 1425.048025

9 Program for finding inverse of linear equations using Gauss Jordan method.

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

double **inverse(double **matrix, int order) {
    double **inverse = calloc(order, sizeof(double *));
    for (int i = 0; i < order; i++) {
        inverse[i] = calloc(2 * order, sizeof(double));
        inverse[i][order + i] = 1;
        memcpy(inverse[i], matrix[i], order * sizeof(double));
    }

    for (int i = 0; i < order; i++) {
        for (int j = 0; j < order; j++) {
            if (i == j)
                continue;
            double r = inverse[j][i] / inverse[i][i];

            for (int k = 0; k < order * 2; k++)
                inverse[j][k] -= r * inverse[i][k];
        }
    }

    for (int i = 0; i < order; i++) {
        for (int j = 0; j < order; j++)
            inverse[i][j + order] /= inverse[i][i];
    }

    return inverse;
}

int main() {
    const int ORDER = 3;

    double **matrix = malloc(ORDER * sizeof(double *));
    for (int i = 0; i < ORDER; i++)
        matrix[i] = malloc(ORDER * sizeof(double));

    matrix[0][0] = 92, matrix[0][1] = 4.5, matrix[0][2] = 61; //  $92x + 4.5y + 61z = 0$ 
    matrix[1][0] = -2, matrix[1][1] = 0, matrix[1][2] = 92387; //  $-2x + 92387z = 0$ 
    matrix[2][0] = -2, matrix[2][1] = 0, matrix[2][2] = -23; //  $-2x - 23z = 0$ 

    double **inv = inverse(matrix, ORDER);

    for (int i = 0; i < ORDER; i++) {
        for (int j = 0; j < ORDER; j++)
            printf("%lf ", inv[i][j + ORDER]);
        printf("\n");
        free(inv[i]);
        free(matrix[i]);
    }
}
```

```

    }
    free(inv);
    free(matrix);
}

```

```

-0.000000 -0.000124 -0.499876
0.222222 0.002398 10.219825
-0.000000 0.000011 -0.000011

```

10 Program for finding eigen values using power method.

```

#include <math.h>
#include <stdio.h>
#include <stdlib.h>

#define EPSILON 0.0000001

double *eigen(double **matrix, int order) {
    double mxerr = 0;
    double *prev = calloc(order, sizeof(double));
    *prev = 1;

    do {
        double *eigen = calloc(order, sizeof(double));

        for (int i = 0; i < order; i++)
            for (int j = 0; j < order; j++)
                eigen[i] += matrix[i][j] * prev[j];

        double mx = fabs(eigen[0]);
        for (int i = 1; i < order; i++)
            mx = fabs(eigen[i]) > mx ? fabs(eigen[i]) : mx;

        for (int i = 0; i < order; i++)
            eigen[i] /= mx;

        double error[order];

        for (int i = 0; i < order; i++)
            error[i] = fabs(eigen[i] - prev[i]);

        mxerr = error[0];
        for (int i = 1; i < order; i++)
            mxerr = error[i] > mxerr ? error[i] : mxerr;

        free(prev);
        prev = eigen;
    } while (mxerr > EPSILON);

    return prev;
}

```

```

int main() {
    const int ORDER = 3;

    double **matrix = malloc(ORDER * sizeof(double *));
    for (int i = 0; i < ORDER; i++)
        matrix[i] = malloc(ORDER * sizeof(double));

    matrix[0][0] = 21, matrix[0][1] = -99, matrix[0][2] = 0;
    matrix[1][0] = -12, matrix[1][1] = 64, matrix[1][2] = 0;
    matrix[2][0] = 9, matrix[2][1] = -0.5, matrix[2][2] = 4;

    double *egn = eigen(matrix, ORDER);

    for (int i = 0; i < ORDER; i++) {
        printf("%lf ", egn[i]);
        free(matrix[i]);
    }
    free(egn);
    free(matrix);
}

```

1.000000 -0.627508 0.117712

11 Program for solving ordinary differential equation using Renge Kutta method.

```
#include <stdio.h>

double f(double x, double y) { return (y * y - x) / (y + x * y * y); };

double rungen_kutta_4(double x0, double y0, double xn, int steps) {
    double h = (xn - x0) / steps;

    while (steps--) {
        double k1 = f(x0, y0) * h;
        double k2 = f(x0 + h / 2, y0 + k1 / 2) * h;
        double k3 = f(x0 + h / 2, y0 + k2 / 2) * h;
        double k4 = f(x0 + h, y0 + k3) * h;

        double k = (k1 + k4 + 2 * (k2 + k3)) / 6;

        x0 += h, y0 += k;
    }

    return y0;
}

int main() {
    double x0 = 0, y0 = 5, xn = 1784;
    int steps = 1000000;

    printf("Value of y at x=%0.4lf is y=%0.4lf", xn,
        rungen_kutta_4(x0, y0, xn, steps));
}
```

Value of y at x=1784.0000 is y=-14.6222