**Assignment No: 2**

Part 1:
Find the Integration using the monte carlo simulation technique and using analytic technique. For monte carlo simulation technique you have to write code in C programming language. You are not allowed to use any built in API for determining the integral. Compare the results obtained from monte carlo simulation with the analytic result for different number of random numbers.

$$\int_{0}^{\pi/4} sin(x) \, dx$$

Answer:

Analytically we can see that $\int_{0}^{\pi/4} sin(x) \, dx$

$$= [- cox(x)]_{0}^{\pi/4}$$
$$= [- cos(\pi/4) + cos(0)]$$
$$= 0.2928$$

Now equation for monte-carlo simulation is $(b - a) \dfrac{\sum\limits_{i=1}^{n} g(X_i)}{n}$

Here, $b = upper\ limit\ of\ the\ integration$

$a = lower\ limit\ of\ the\ integration$

$n = step\ size$

$g(X_i) = sin(X_i)$

The experimental results we get from this equation is given below :

| n | 10 | 20 | 30 | 40 | 50 | 100 |
|---|----|----|----|----|----|-----|
| value | 0.351743 | 0.301378 | 0.307744 | 0.299260 | 0.276402 | 0.28661 |

Code for this experiment :

```cpp
#include <bits/stdc++.h>

using namespace std;

const int maxn = 101010;
const double pi = 3.1416;

int main()
{
    ios_base::sync_with_stdio(0);
    cin.tie(0);

    srand(118);

    double a = 0;
    double b = pi / 4.0;

    for (int n = 10; n <= 100; n += 10)
    {
        double integral = 0;

        for (int i = 0; i < n; ++i)
        {
            double X = a + (rand() / (double)RAND_MAX) * (b - a);
            integral += (b - a) * (sin(X) / n);
        }

        cout << "Step size: " << n << " Integral Value: " << integral << endl;
    }

    cout << "Analytic result: " << (-cos(b) + cos(a)) << endl;

    return 0;
}
```

Part 2:

Generate the probability table using computer programs for the following distribution:
Exponential Distribution (for Even Student Id): The parameter average rate $\gamma = 1$

Answer:
For exponential distribution with $\gamma = 1$ :
If $x \geq 0\ then\ f(x) = e^{-x}$
If $x \leq 0\ then\ f(x) = 0$

So $\int\limits_{-\infty}^{\tilde{}} f(x)\, dx$ becomes $\int\limits_{0}^{\tilde{}} f(x)\, dx = \int\limits_{0}^{\tilde{}} e^{-x}dx$

The code to generate z table from above integration is given below:

```cpp
#include <bits/stdc++.h>

using namespace std;

const int maxn = 101010;
const double pi = 3.1416;
vector <double> col, row;

double monte_carlo(double a, double b)
{
    srand(118);

    double ret = 0;

    for (int i = 0; i < 1000; ++i)
    {
        double X = a + (rand() / (double)RAND_MAX) * (b - a);
        ret += (b - a) * (exp(-X) / 1000);
    }

    return ret;
}

int main()
{
    ios_base::sync_with_stdio(0);
    cin.tie(0);
```

```cpp
    for (int i = 0; i < 10; ++i)
        col.push_back(i * 0.01);

    for (int i = 0; i < 31; ++i)
        row.push_back(i * 0.1);

    cout << "          ";
    for (int j = 0; j < col.size(); ++j)
        cout << setprecision(2) << fixed << col[j] << "   ";
    cout << endl;

    for (int i = 0; i < row.size(); ++i)
    {
        cout << setprecision(2) << fixed << row[i] << "   ";
        for (int j = 0; j < col.size(); ++j)
        {
            double z = row[i] + col[j];
            double b = exp(z), a = 0;
            cout << setprecision(2) << fixed << monte_carlo(a, z) << "
";
        }
        cout << endl;
    }

    return 0;
}
```
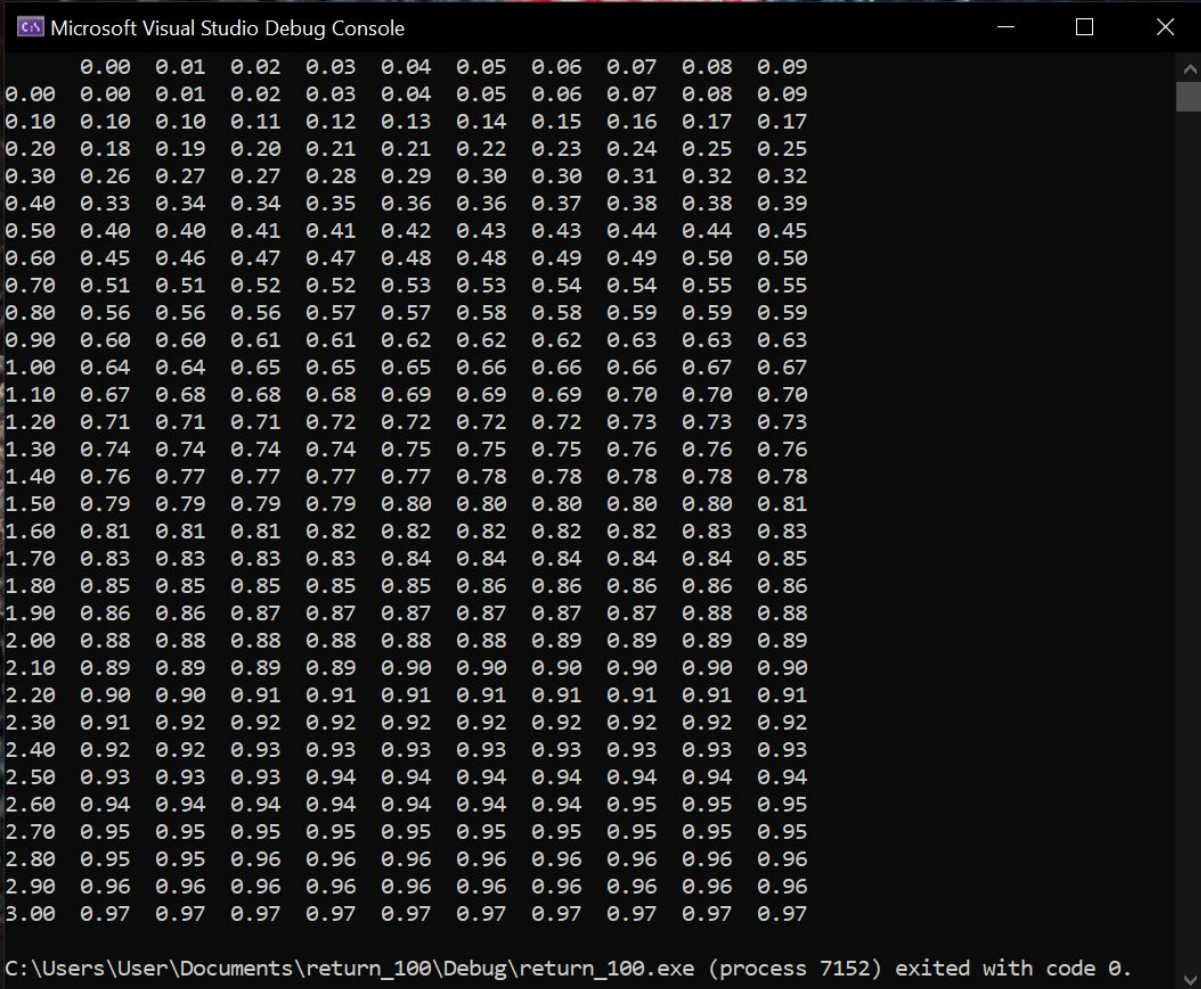
Generated Z table :

```
       0.00  0.01  0.02  0.03  0.04  0.05  0.06  0.07  0.08  0.09
0.00   0.00  0.01  0.02  0.03  0.04  0.05  0.06  0.07  0.08  0.09
0.10   0.10  0.10  0.11  0.12  0.13  0.14  0.15  0.16  0.17  0.17
0.20   0.18  0.19  0.20  0.21  0.21  0.22  0.23  0.24  0.25  0.25
0.30   0.26  0.27  0.27  0.28  0.29  0.30  0.30  0.31  0.32  0.32
0.40   0.33  0.34  0.34  0.35  0.36  0.36  0.37  0.38  0.38  0.39
0.50   0.40  0.40  0.41  0.41  0.42  0.43  0.43  0.44  0.44  0.45
0.60   0.45  0.46  0.47  0.47  0.48  0.48  0.49  0.49  0.50  0.50
0.70   0.51  0.51  0.52  0.52  0.53  0.53  0.54  0.54  0.55  0.55
0.80   0.56  0.56  0.56  0.57  0.57  0.58  0.58  0.59  0.59  0.59
0.90   0.60  0.60  0.61  0.61  0.62  0.62  0.62  0.63  0.63  0.63
1.00   0.64  0.64  0.65  0.65  0.65  0.66  0.66  0.66  0.67  0.67
1.10   0.67  0.68  0.68  0.68  0.69  0.69  0.69  0.70  0.70  0.70
1.20   0.71  0.71  0.71  0.72  0.72  0.72  0.72  0.73  0.73  0.73
1.30   0.74  0.74  0.74  0.74  0.75  0.75  0.75  0.76  0.76  0.76
1.40   0.76  0.77  0.77  0.77  0.77  0.78  0.78  0.78  0.78  0.78
1.50   0.79  0.79  0.79  0.79  0.80  0.80  0.80  0.80  0.80  0.81
1.60   0.81  0.81  0.81  0.82  0.82  0.82  0.82  0.82  0.83  0.83
1.70   0.83  0.83  0.83  0.83  0.84  0.84  0.84  0.84  0.84  0.85
1.80   0.85  0.85  0.85  0.85  0.85  0.86  0.86  0.86  0.86  0.86
1.90   0.86  0.86  0.87  0.87  0.87  0.87  0.87  0.87  0.88  0.88
2.00   0.88  0.88  0.88  0.88  0.88  0.88  0.89  0.89  0.89  0.89
2.10   0.89  0.89  0.89  0.89  0.90  0.90  0.90  0.90  0.90  0.90
2.20   0.90  0.90  0.91  0.91  0.91  0.91  0.91  0.91  0.91  0.91
2.30   0.91  0.92  0.92  0.92  0.92  0.92  0.92  0.92  0.92  0.92
2.40   0.92  0.92  0.93  0.93  0.93  0.93  0.93  0.93  0.93  0.93
2.50   0.93  0.93  0.93  0.94  0.94  0.94  0.94  0.94  0.94  0.94
2.60   0.94  0.94  0.94  0.94  0.94  0.94  0.94  0.95  0.95  0.95
2.70   0.95  0.95  0.95  0.95  0.95  0.95  0.95  0.95  0.95  0.95
2.80   0.95  0.95  0.96  0.96  0.96  0.96  0.96  0.96  0.96  0.96
2.90   0.96  0.96  0.96  0.96  0.96  0.96  0.96  0.96  0.96  0.96
3.00   0.97  0.97  0.97  0.97  0.97  0.97  0.97  0.97  0.97  0.97

C:\Users\User\Documents\return_100\Debug\return_100.exe (process 7152) exited with code 0.
```