MA - 202
Lab-9

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1. Suppose you are given a physical system whose time evolution is governed by the differential equation $\frac{d^2x}{dt^2} + \alpha\frac{dx}{dt} + w_0^2 x = f\sin(wt)$. Write a C-program to perform the following.

Code:--

```c
#include <stdio.h>

#include <stdlib.h>

#include <math.h>

double alpha, f, w0, w, t;

double dxdt(double x, double y)

{

    return y;
}

double dydt(double x, double y)

{

    return -alpha * dxdt(x, y) - w0 * w0 * x - f * sin(w * t);
    ;
}
```

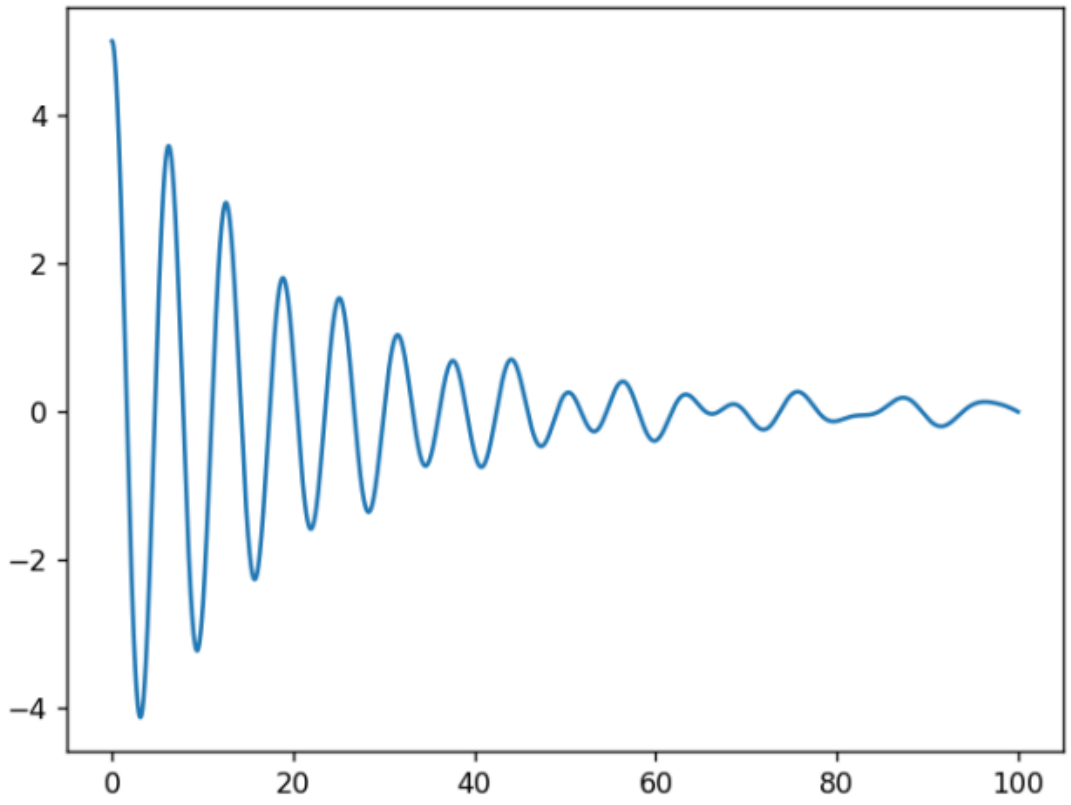
```
// calculates Runge Kutta 4-th order , Error has order of O(h^5)

void rk4(double x0, double y0, double h)

{

    FILE *ptr = NULL;

    ptr = fopen("lab9.txt", "w");

    double t0 = 0;

    int n = (int)(100 - t0) / h;

    for (int i = 1; i <= n; i++)

    {

        fprintf(ptr, "%.20lf %.20lf\n", x0, y0);

        double k1x = h * y0;

        double k1v = h * dydt(x0, y0);

        double k2x = h * (y0 + k1v / 2);

        double k2v = h * dydt(x0 + k1x / 2, y0 + k1v / 2);

        double k3x = h * (y0 + k2v / 2);

        double k3v = h * dydt(x0 + k2x / 2, y0 + k2v / 2);

        double k4x = h * (y0 + k3v);

        double k4v = h * dydt(x0 + k3x, y0 + k3v);

        y0 = y0 + (k1v / 6) + (k2v / 3) + (k3v / 3) + (k4v / 6);

        x0 = x0 + (k1x / 6) + (k2x / 3) + (k3x / 3) + (k4x / 6);
```

```
        t0 = t0 + h;
    }
}

int main()

{

    double x0, y0;

    printf("Enter x(0): ");

    scanf("%lf", &x0);

    printf("Enter x'(0): ");

    scanf("%lf", &y0);

    printf("Enter alpha: \n");

    scanf("%lf", &alpha);

    printf("Enter w0: ");

    scanf("%lf", &w0);

    printf("Enter w: ");

    scanf("%lf", &w);

    printf("Enter f: ");

    scanf("%lf", &f);

    rk4(x0, 0, 0.001);
}
```

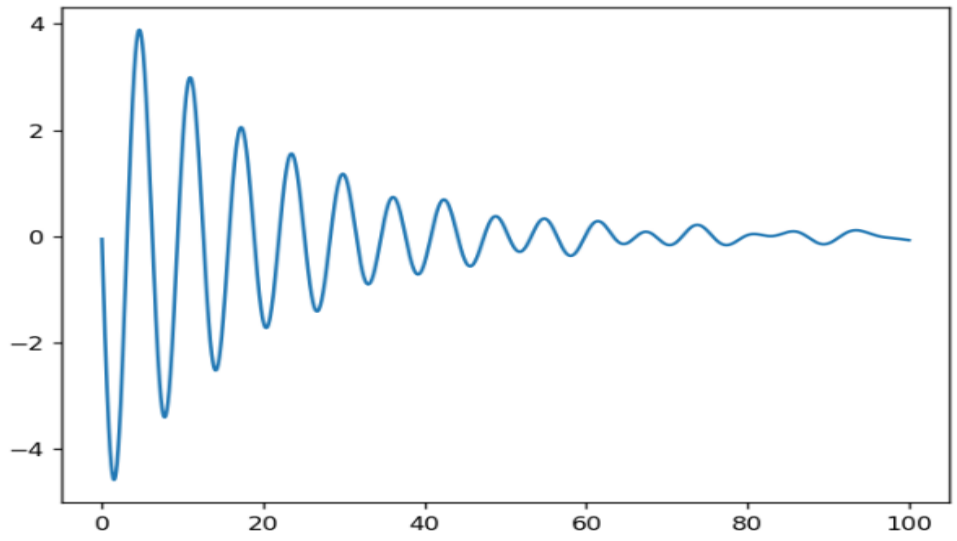
For initial conditions $x(0) = A$ and $\dot{x}(0) = 0$, and $\alpha = 0.1, w_0 = 1, w = 0.6, f = 0.1$, numerically find the values of $x(t)$ and $\dot{x}(t)$ at any time t. Make a parametric plot by plotting $x(t)$ on X-axis and $\dot{x}(t)$ on Y-axis, for time $t = 0$ to $t = 100$. Comment on what you find. You can take any value of A as you like. See what happens when A is changed.

Sol:- Let A= 5

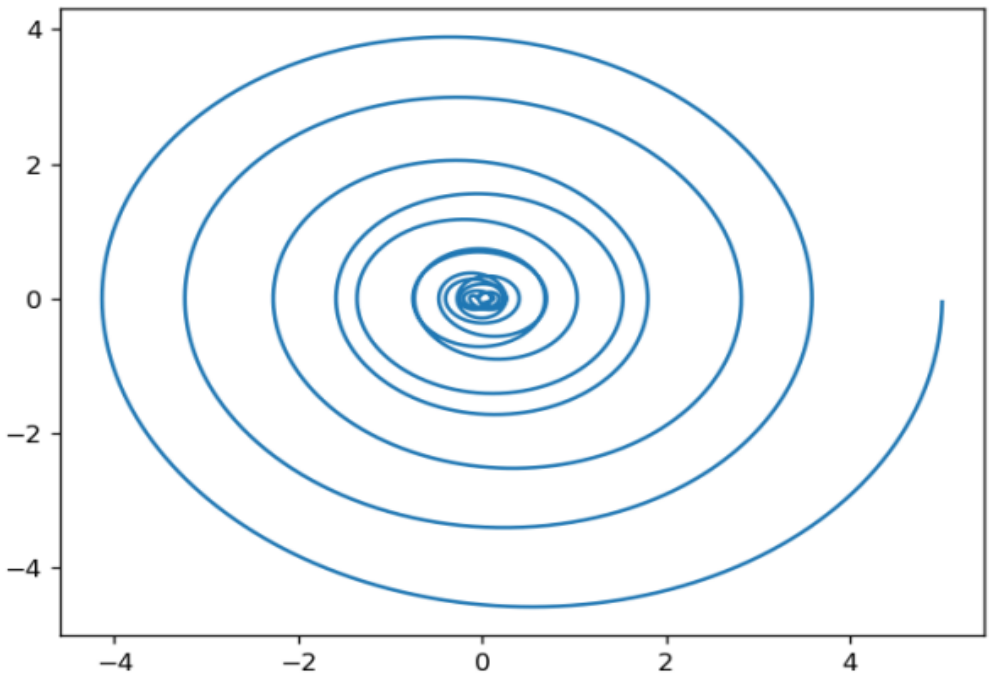
1. **X VS T**



2. **Y VS T**

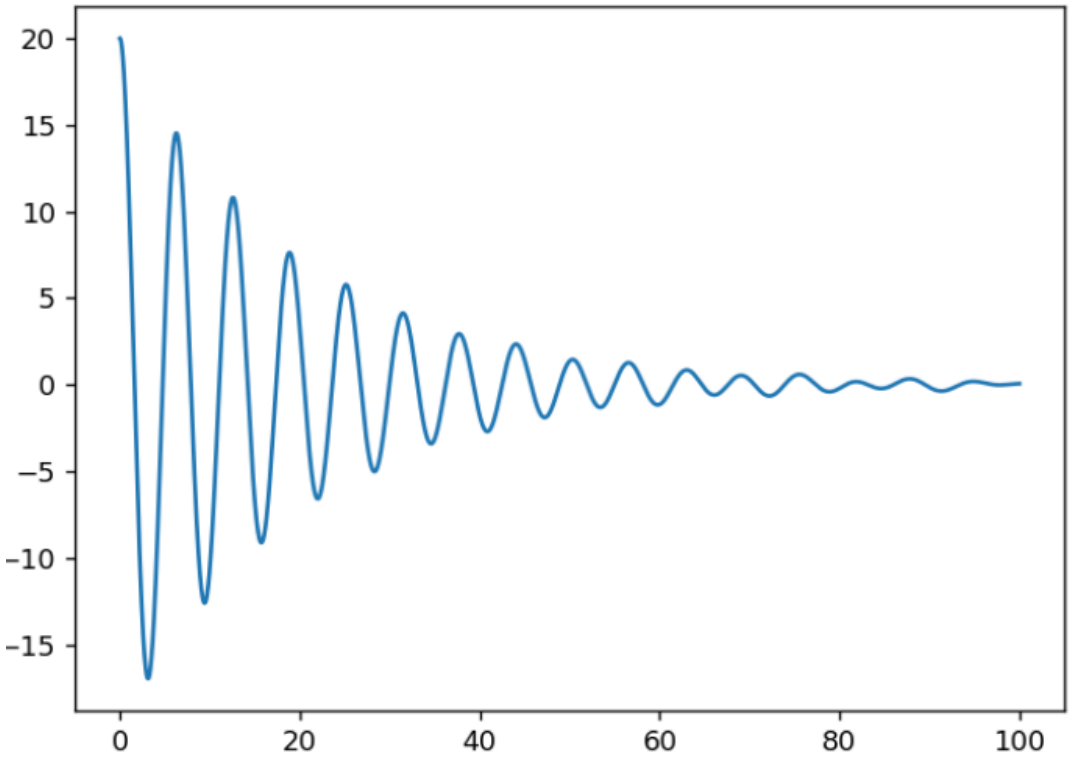


3. **X VS Y**

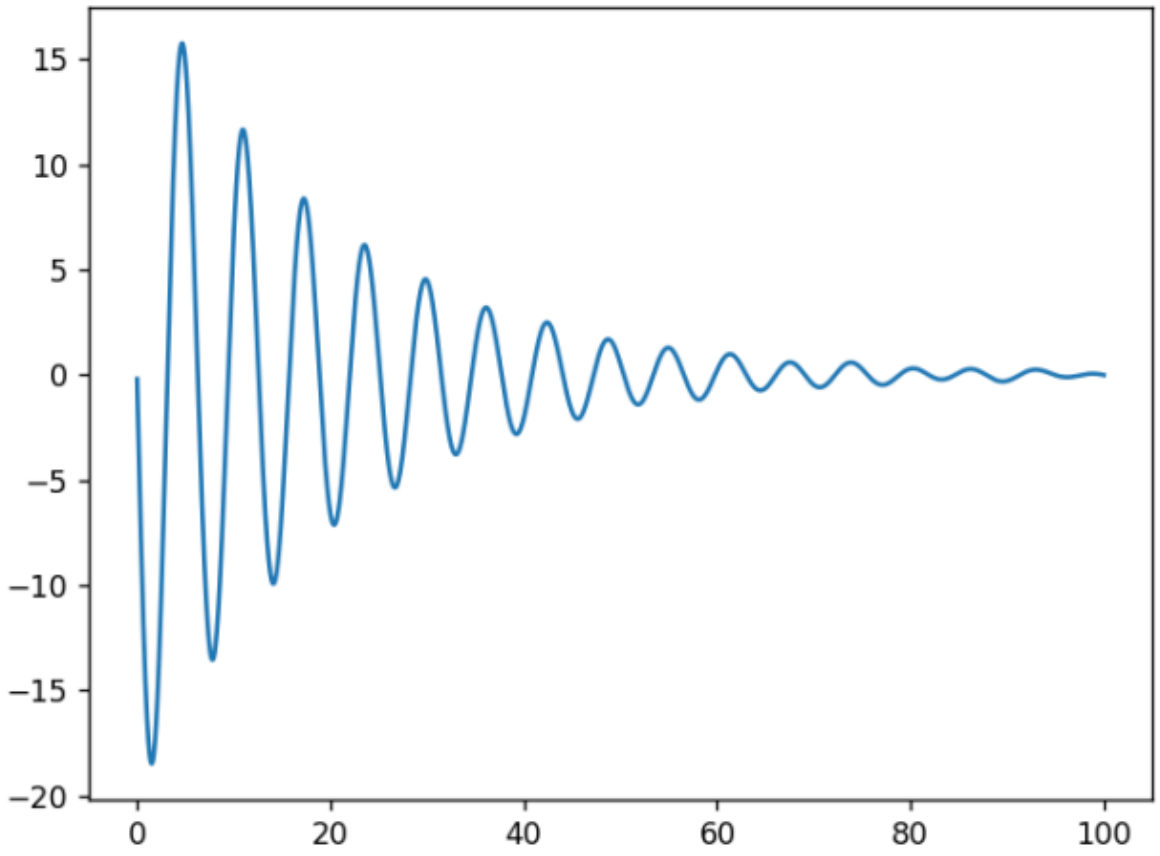


Let A= 20

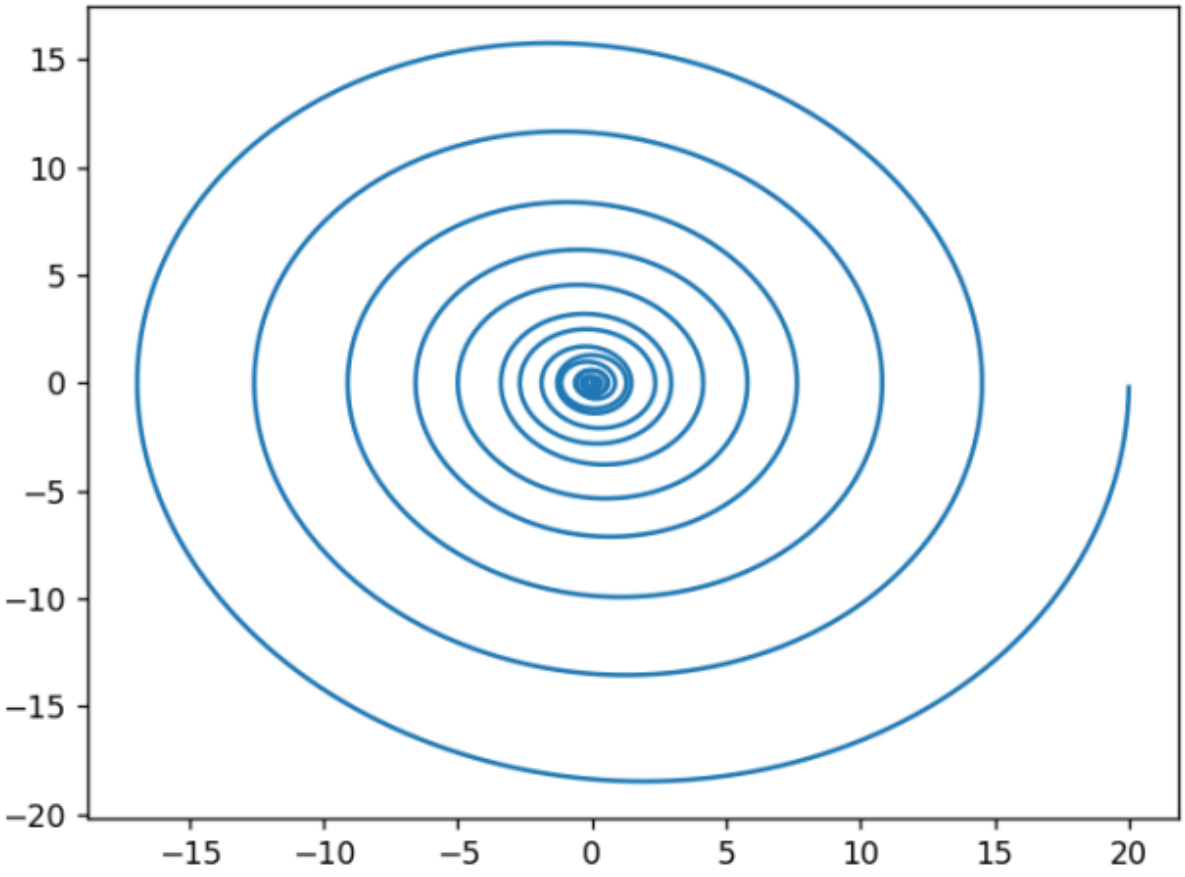
1. **X VS T**



2. Y VS T



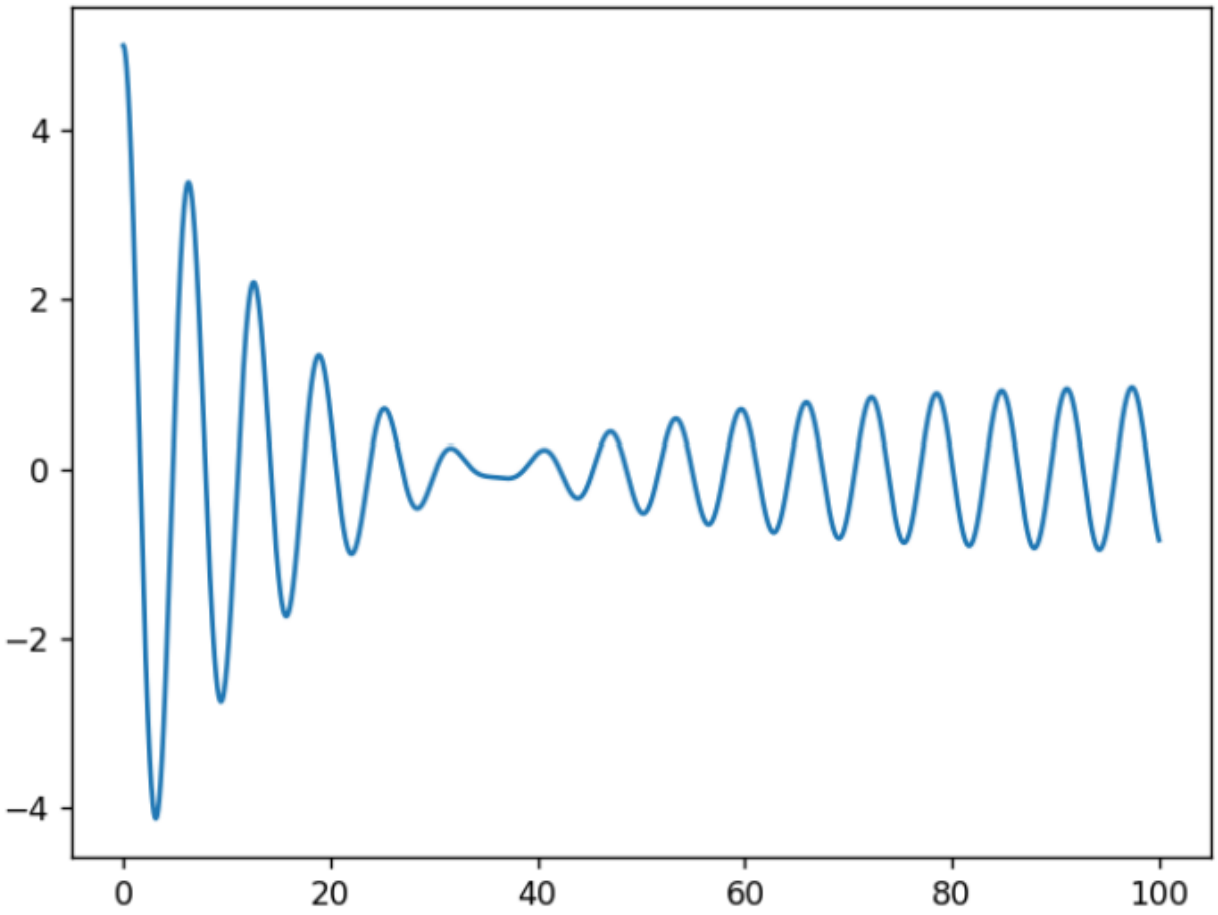
3. **X VS Y**



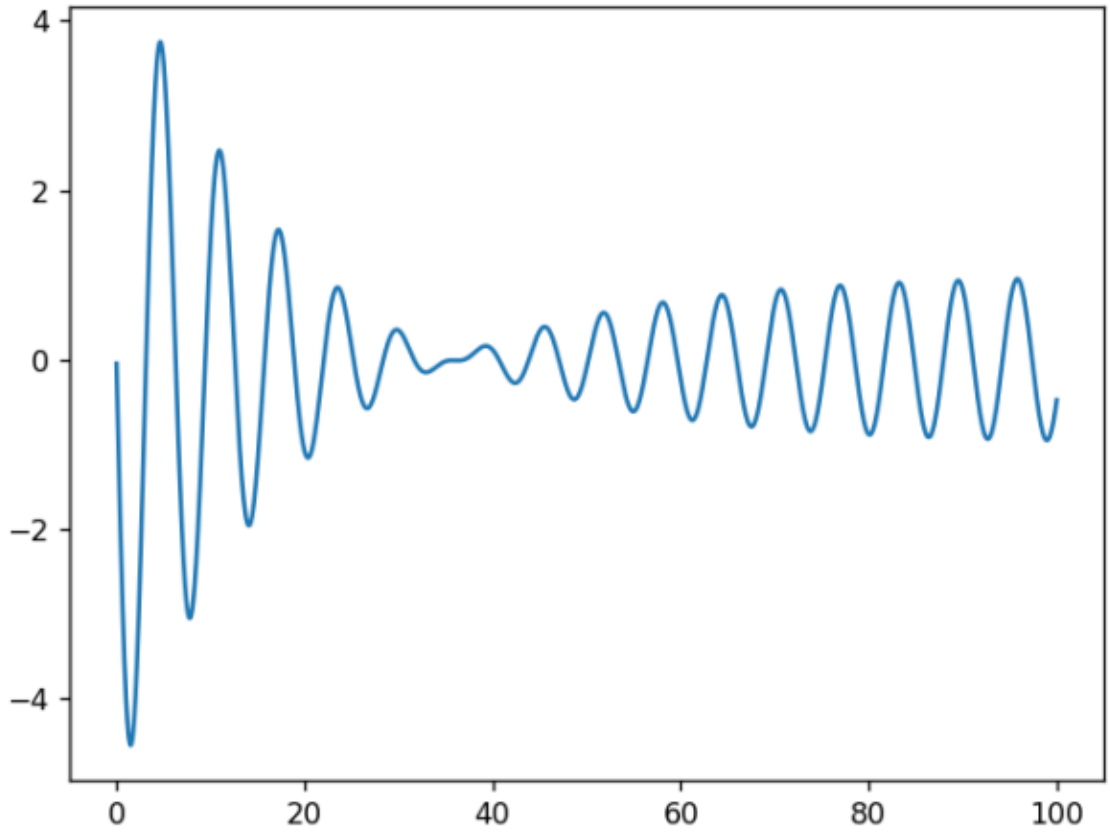
3. Do same as above but now use $\alpha = 0.1, w_0 = 1, w = 1, f = 0.1$. See what happens and comment on the reason.

Let A = 5,

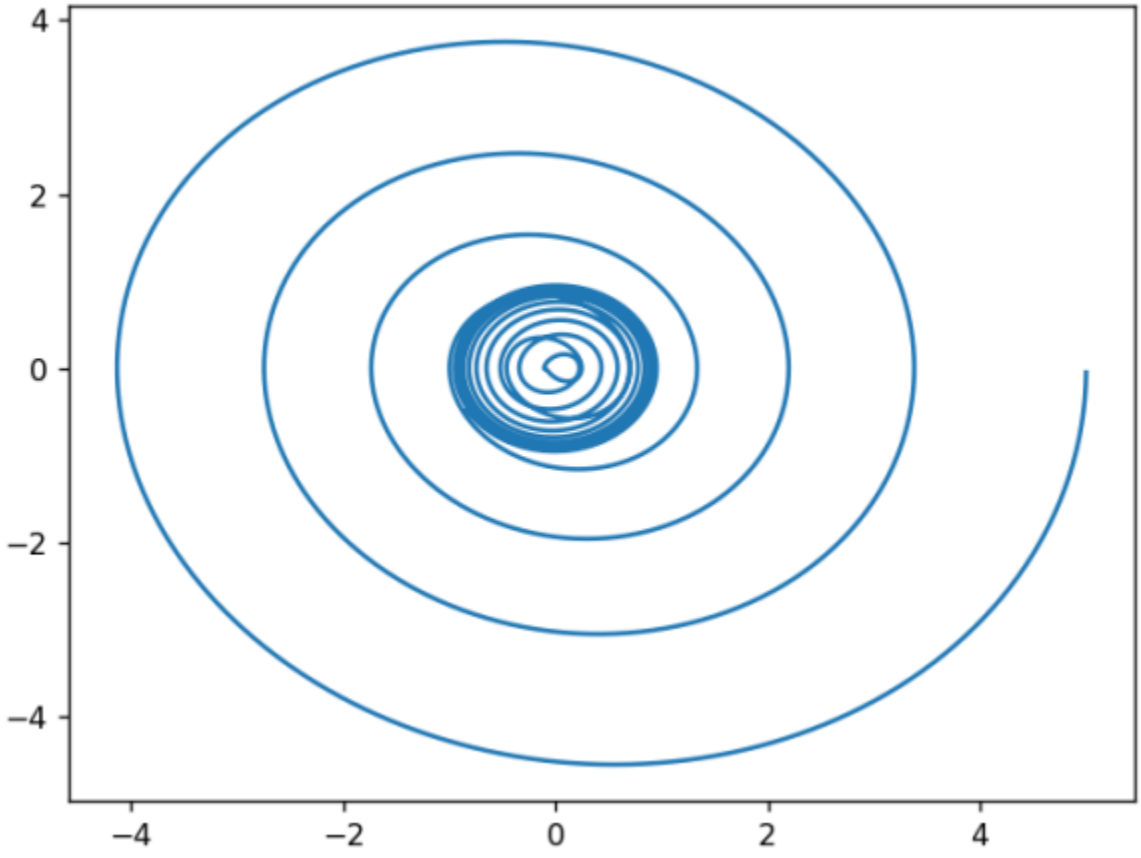
1. **X VS T**



2. Y VS T

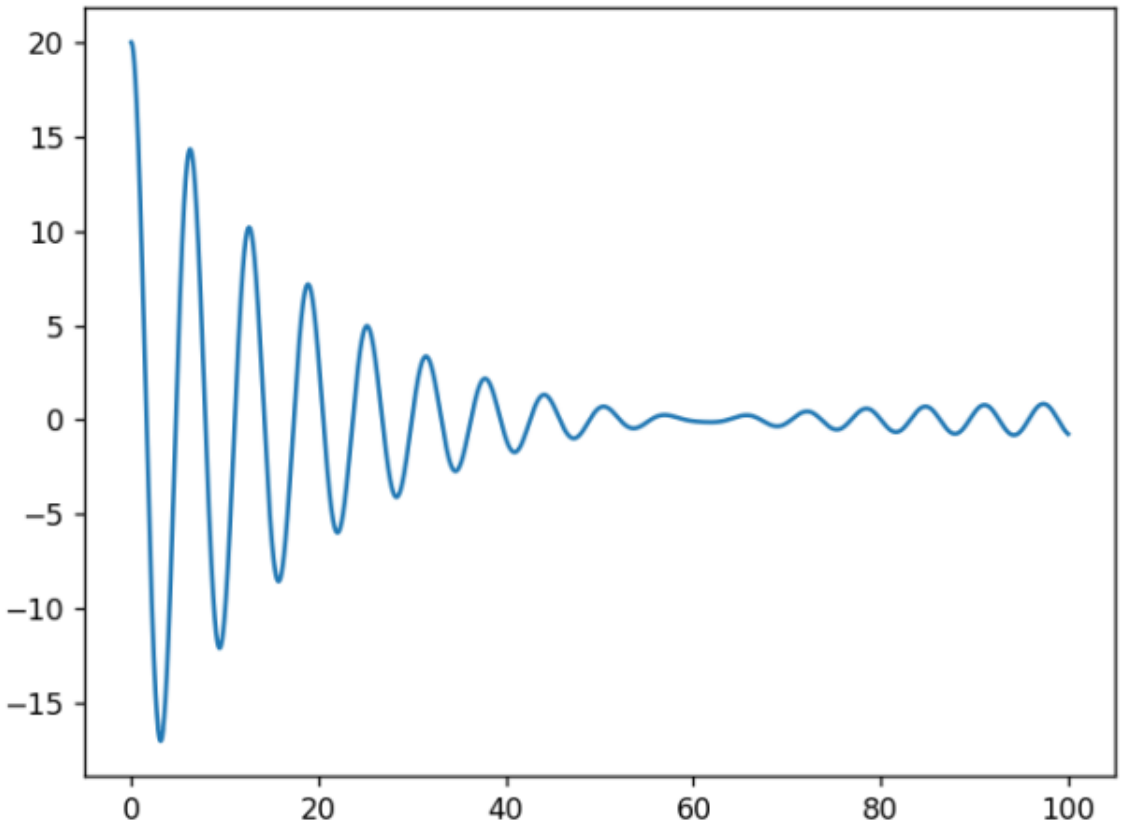


3. **X VS Y**

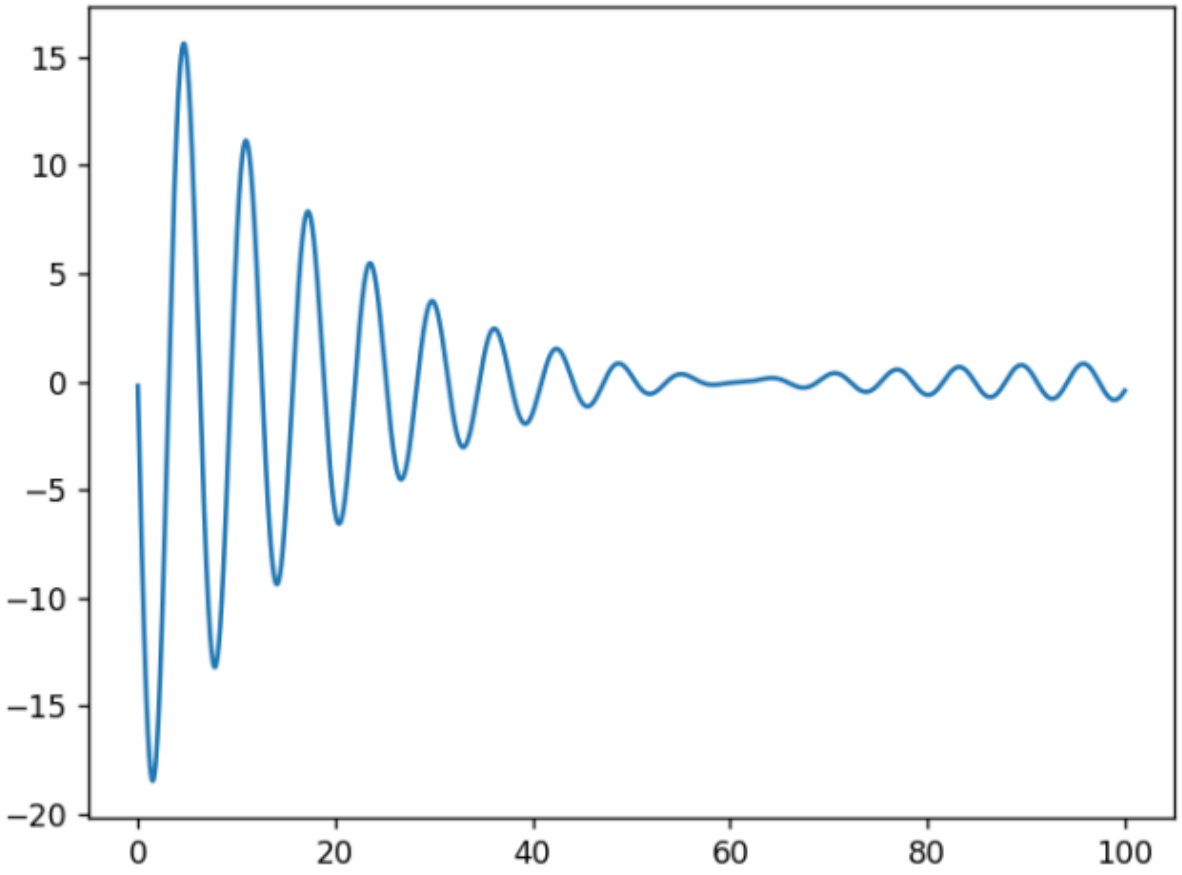


Let A= 20,

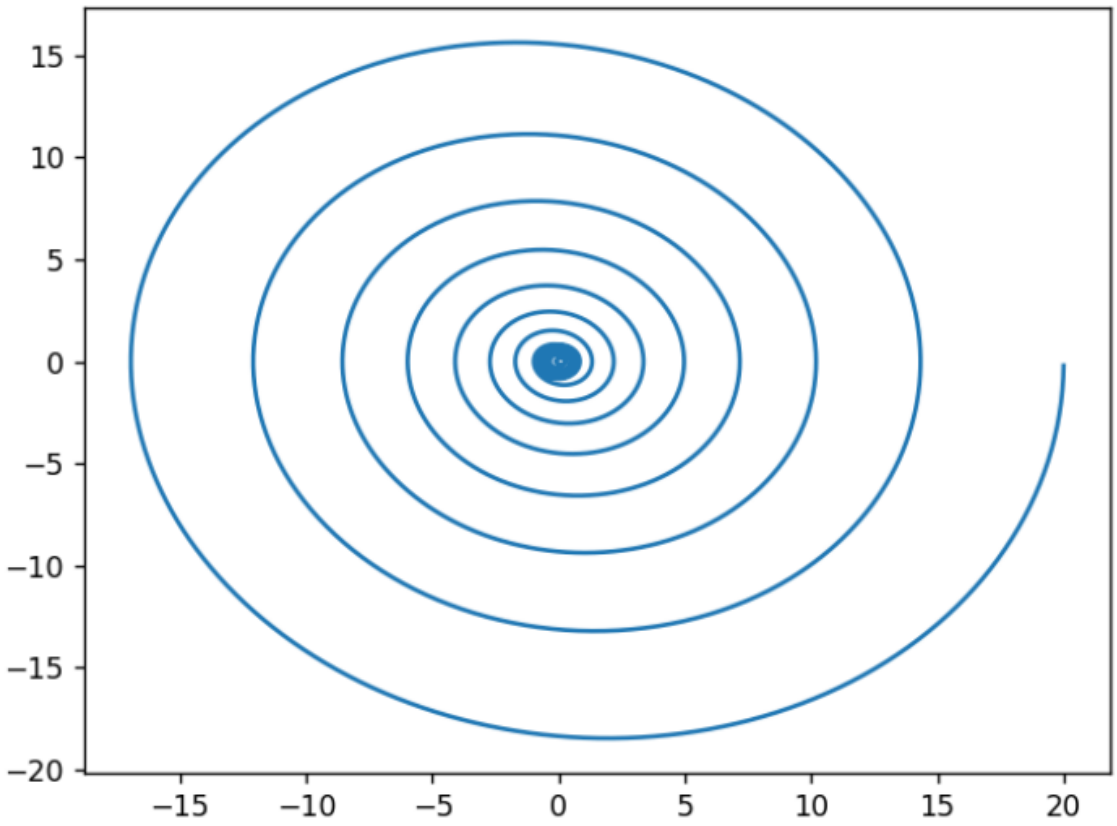
1. **X VS T**



2. **Y VS T**



3. **X VS Y**



Conclusion:--