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```
% assignment#4
```

Q1

```
clearvars,clc,close all;whos

% Define the IVP parameters
t0 = 0;      % Initial time
x0 = 1;      % Initial value of x at t = t0
t_final = 1; % The time at which we want to find the solution
h = 0.1;     % Step size

% Define the function f(t, x) = dx/dt
f = @(t, x) t ; % Example: replace this with any other differential equation

% Initialize variables
t = t0;
x = x0;

% Perform the RK4 iterations
while t < t_final
    if t + h > t_final
        h = t_final - t; % Adjust the last step to end exactly at t_final
    end

    % Calculate the k values
    k1 = h * f(t, x);
    k2 = h * f(t + h/2, x + k1/2);
    k3 = h * f(t + h/2, x + k2/2);
    k4 = h * f(t + h, x + k3);

    % Update x and t
    x = x + (k1 + 2*k2 + 2*k3 + k4) / 6;
    t = t + h;
end

% Display the RK4 result
disp(['RK4 x(', num2str(t_final), ') = ', num2str(x)])
```

```
RK4 x(1) = 1.5
```

Q2

```
clearvars,clc,close all; whos

% Define parameters
t0 = 0;         % Initial time
x0 = 0;         % Initial height
v0 = 0;         % Initial velocity
t_final = 10;   % Final time
h = 0.01;       % Time step size

% Initialize arrays to store the solutions
t_values = t0:h:t_final;
x_values = zeros(size(t_values));
v_values = zeros(size(t_values));

% Set initial conditions
x_values(1) = x0;
v_values(1) = v0;

% RK4 method to solve the system of ODEs
for i = 1:length(t_values) - 1
    t = t_values(i);
    x = x_values(i);
    v = v_values(i);

    m = 321 - 24 * t;
    if m <= 0
        break;
    end

    F = @(v) (5370 - 981 - (v^(3/2) / log(2 + v))) / m;

    k1_v = h * F(v);
    k1_x = h * v;

    k2_v = h * F(v + 0.5 * k1_v);
    k2_x = h * (v + 0.5 * k1_v);

    k3_v = h * F(v + 0.5 * k2_v);
    k3_x = h * (v + 0.5 * k2_v);

    k4_v = h * F(v + k3_v);
    k4_x = h * (v + k3_v);

    v_values(i + 1) = v + (k1_v + 2 * k2_v + 2 * k3_v + k4_v) / 6;
    x_values(i + 1) = x + (k1_x + 2 * k2_x + 2 * k3_x + k4_x) / 6;

    % Display the current step results on terminal
    fprintf('t = %.2f, x = %.4f, v = %.4f\n', t, x_values(i+1), v_values(i+1))

end

% Plot the results
figure;
subplot(2, 1, 1);
plot(t_values, x_values, 'b-');
xlabel('Time (s)','interpreter','latex');
ylabel('Height (x)','interpreter','latex');
```

```
title('Height vs. Time','interpreter','latex');
grid on;

subplot(2, 1, 2);
plot(t_values, v_values, 'r-');
xlabel('Time (s)','interpreter','latex');
ylabel('Velocity (v)','interpreter','latex');
title('Velocity vs. Time','interpreter','latex');
grid on;
```

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t = 0.00, x = 0.0007, v = 0.1367
t = 0.01, x = 0.0027, v = 0.2736
t = 0.02, x = 0.0062, v = 0.4105
t = 0.03, x = 0.0109, v = 0.5475
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t = 9.99, x = 943.5079, v = 234.7030
```

Q3

```
clc,clearvars,close all;
% Define the ODE as an anonymous function
ode = @(t, x) sin(x + t^2) ;

% Define the time span and initial condition
tspan = [-4, 4];
x0 = 0;

% Solve the ODE using ode45
[t, x] = ode45(ode, tspan, x0);

% Create a grid for the vector field
[x_grid, t_grid] = meshgrid(linspace(-4, 4, 20), linspace(-4, 4, 20));

% Compute the vector field
dxdt = sin(x_grid + t_grid.^2);

% Normalize the vector field for better visualization
dxdt_norm = dxdt ./ sqrt(dxdt.^2 + 1);

% Display the values of t and x at each step
disp(' t       x');
disp('--------------');
for i = 1:length(t)
    fprintf(' %.2f    %.4f\n', t(i), x(i));
end

% Plot the solution and the vector field
figure;
```

```
hold on;

% Plot the vector field using quiver
quiver(t_grid, x_grid, ones(size(t_grid)), dxdt_norm, 'r');

% Plot the solution curve
plot(t, x, 'b', 'LineWidth', 2);

% Set plot labels and title
xlabel('t','interpreter','latex');
ylabel('x','interpreter','latex');
title('Solution and Vector Field of dx/dt = sin(x + t^2)','interpreter','latex');
xlim([-4 4]);
ylim([-4 4]);
grid on;
hold off;
```

Q4

```
clc,clearvars,close all; whos
% Define parameters
a = 1.5;    % Growth rate of prey in the absence of predators
c = 0.8;    % Death rate of predator in the absence of prey
b = 0.1;    % Effect of predators on prey growth rate
d = 0.1;    % Effect of prey on predator's growth rate
x0 = 30;    % Initial population of prey
y0 = 10;    % Initial population of predator

% Define the ODEs
ode = @(t, y) [a*y(1) - b*y(1)*y(2); -c*y(2) + d*y(1)*y(2)];

% Define the time span
tspan = [0, 20]; % Time span for simulation

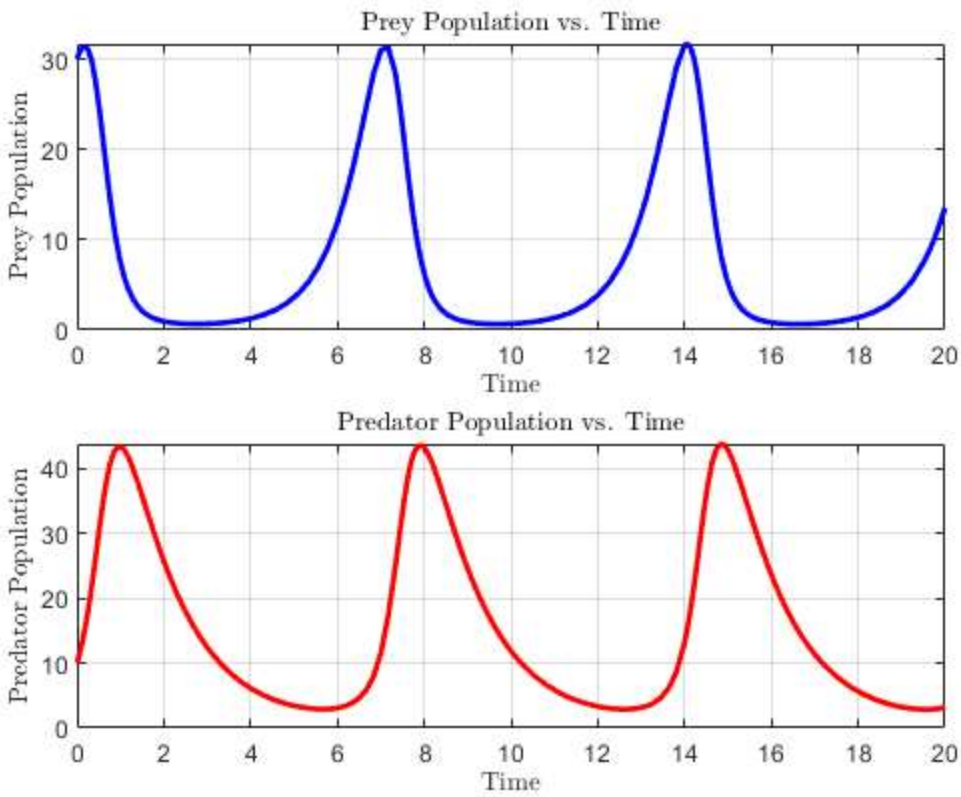
% Solve the ODEs using ode45
[t, y] = ode45(ode, tspan, [x0; y0]);

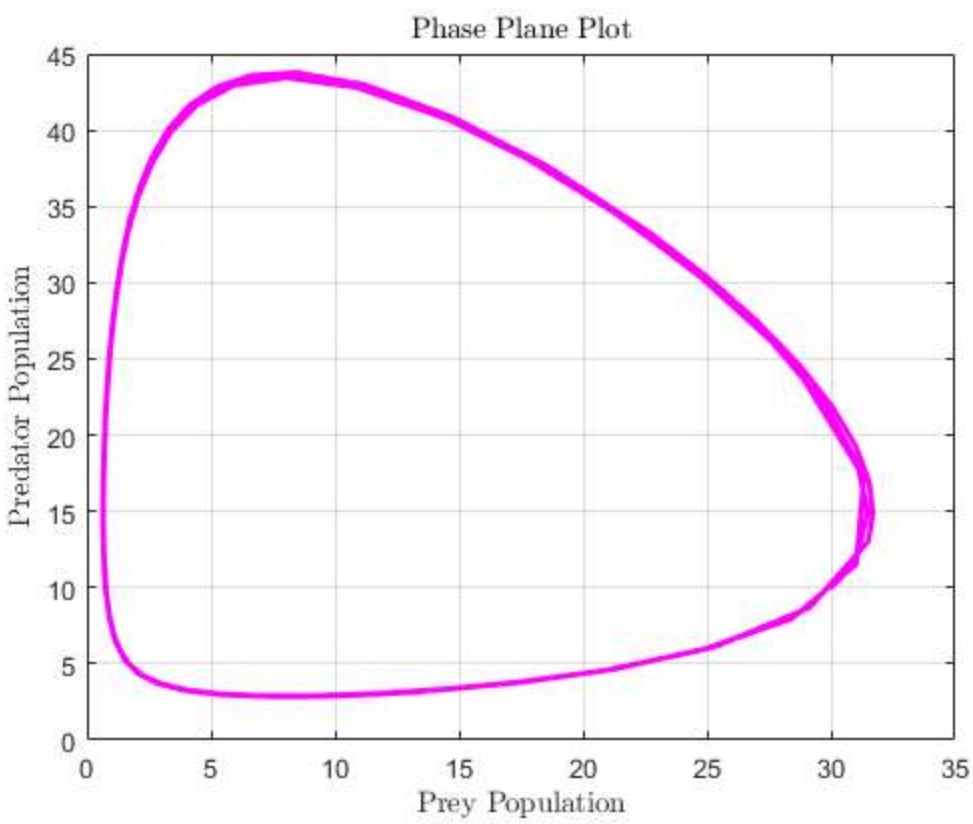
% Plot populations as functions of time
figure;
subplot(2, 1, 1);
plot(t, y(:, 1), 'b-', 'LineWidth', 2);
xlabel('Time','interpreter','latex');
ylabel('Prey Population','interpreter','latex');
title('Prey Population vs. Time','interpreter','latex');
grid on;

subplot(2, 1, 2);
plot(t, y(:, 2), 'r-', 'LineWidth', 2);
xlabel('Time','interpreter','latex');
ylabel('Predator Population','interpreter','latex');
title('Predator Population vs. Time','interpreter','latex');
grid on;

% Phase-plane plot
figure;
plot(y(:, 1), y(:, 2), 'm', 'LineWidth', 2);
xlabel('Prey Population','interpreter','latex');
```

```
ylabel('Predator Population','interpreter','latex');
title('Phase Plane Plot','interpreter','latex');
grid on;
```





Q5

```
clc,close all, clearvars, whos
% Define symbolic variables
syms x(t) omega

% Define the differential equation
ode = diff(x, t, 2) + omega^2 * x == 0;

% Solve the differential equation
sol = dsolve(ode);

% Display the general solution
disp('General Solution:');
disp(sol);

% Define initial conditions
x0 = sym('x0');
v0 = sym('v0');
Dx = diff(x, t); % Derivative of x with respect to t

% Solve the differential equation with initial conditions
conds = [x(0) == x0, Dx(0) == v0];
sol_with_conds = dsolve(ode, conds);

% Display the solution with initial conditions
disp('Solution with Initial Conditions:');
disp(sol_with_conds);

% Convert symbolic solution to MATLAB function
x_t = matlabFunction(sol_with_conds, 'Vars', [t, omega, x0, v0]);

% Define parameters
omega_val = 1; % Example value for omega
x0_val = 1;    % Example initial displacement
v0_val = 0;    % Example initial velocity

% Define time range for the plot
t_vals = linspace(0, 10, 1000);

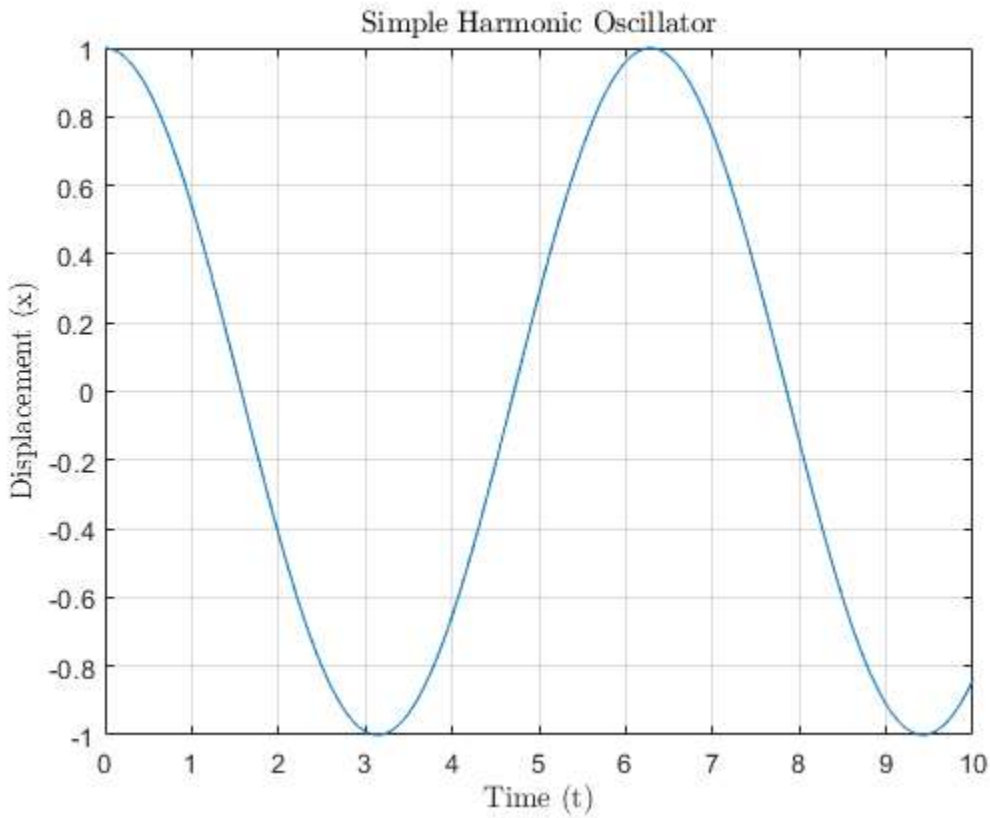
% Evaluate the solution for the given parameters
x_vals = x_t(t_vals, omega_val, x0_val, v0_val);

% Plot the solution
figure;
plot(t_vals, x_vals);
xlabel('Time (t)','interpreter','latex');
ylabel('Displacement (x)','interpreter','latex');
title('Simple Harmonic Oscillator','interpreter','latex');
grid on;
```

```
General Solution:
C1*exp(-omega*t*1i) + C2*exp(omega*t*1i)

Solution with Initial Conditions:
```

```
(exp(-omega*t*1i)*(omega*x0 + v0*1i))/(2*omega) - (exp(omega*t*1i)*(- omega*x0 + v0*1i))/(2*omega)
```



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