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% MAE 384 PART 4 FOURIER ANALYSIS
clc;

% Parameters
beta0 = 0.3; % Base transmission rate
A = 5; % Amplitude of periodic variation
gamma = 0.1; % Recovery rate
S0 = 990; I0 = 10; R0 = 0; % Initial conditions
h = 0.1; % Time step
T = 30; % Total time (days)
omega1 = 2 * pi / 365; % Daily periodicity
omega2 = 2 * pi / 100; % Weekly periodicity

% Initialize time and compartments
t_model = 0:h:T; % Time vector
S = zeros(size(t_model));
I = zeros(size(t_model));
R = zeros(size(t_model));
S(1) = S0;
I(1) = I0;
R(1) = R0;

% Ensure N is an integer
N = length(t_model);
if mod(N, 1) ~= 0
    N = floor(N); % Adjust to ensure integer value
end

% SIR Model Simulation (Daily Periodicity)
for k = 1:(N-1)
    beta_t = beta0 * (1 + A * sin(omega1 * t_model(k))); % Time-varying beta
    dS = -beta_t * S(k) * I(k) / (S(k) + I(k) + R(k));
    dI = beta_t * S(k) * I(k) / (S(k) + I(k) + R(k)) - gamma * I(k);
    dR = gamma * I(k);

    S(k+1) = S(k) + h * dS;
    I(k+1) = I(k) + h * dI;
    R(k+1) = R(k) + h * dR;
end

% Plot S(t), I(t), R(t) for Daily Periodicity
figure;
plot(t_model, S, 'DisplayName', 'S(t)');
hold on;
plot(t_model, I, 'DisplayName', 'I(t)');
plot(t_model, R, 'DisplayName', 'R(t)');
xlabel('Time (days)');
ylabel('Population');
title('SIR Model with Daily Periodicity (\omega = 2\pi/365)');
legend;
hold off;
```

```
% Perform FFT for Daily Periodicity
fft_I = fft(I);
freq = (0:(N/2)-1) / T; % Frequency vector (only positive frequencies)
fft_I_magnitude = abs(fft_I(1:floor(N/2))); % Magnitude of FFT (positive
frequencies only)

% Plot Frequency Spectrum for I(t)
figure;
plot(freq, fft_I_magnitude);
xlabel('Frequency (1/day)');
ylabel('Magnitude');
title('Frequency Spectrum of I(t) - Daily Periodicity');

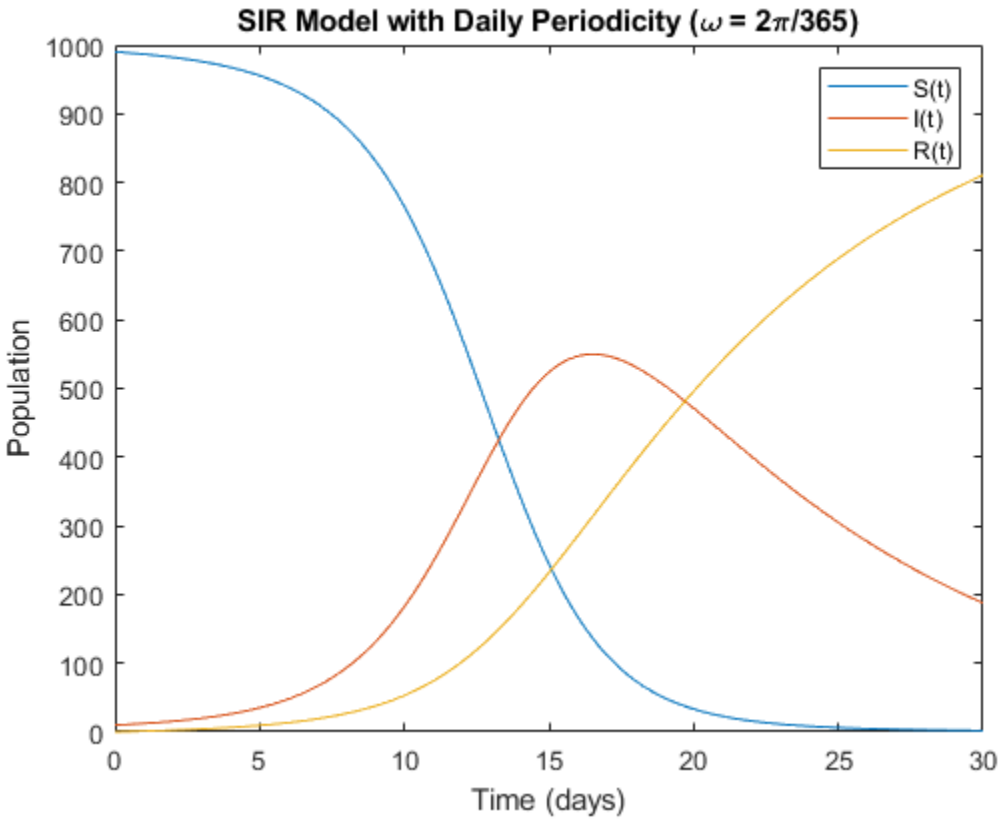
% SIR Model Simulation (Weekly Periodicity)
S(:) = S0; I(:) = I0; R(:) = R0; % Reset initial conditions
for k = 1:(N-1)
    beta_t = beta0 * (1 + A * sin(omega2 * t_model(k))); % Time-varying beta
    dS = -beta_t * S(k) * I(k) / (S(k) + I(k) + R(k));
    dI = beta_t * S(k) * I(k) / (S(k) + I(k) + R(k)) - gamma * I(k);
    dR = gamma * I(k);

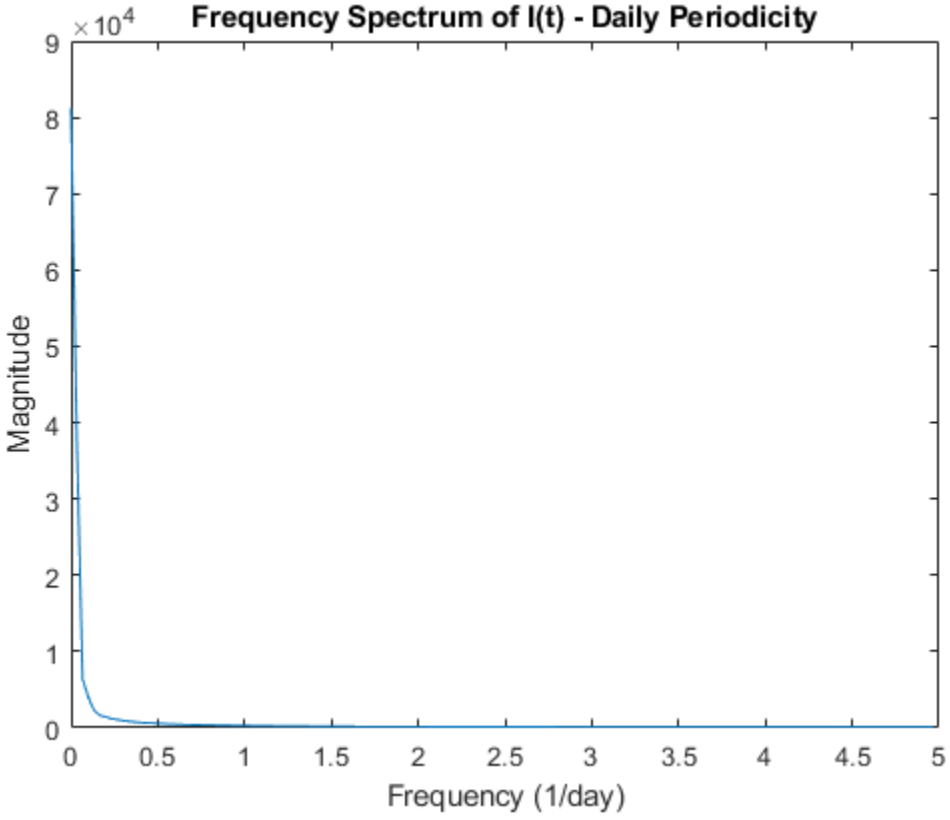
    S(k+1) = S(k) + h * dS;
    I(k+1) = I(k) + h * dI;
    R(k+1) = R(k) + h * dR;
end

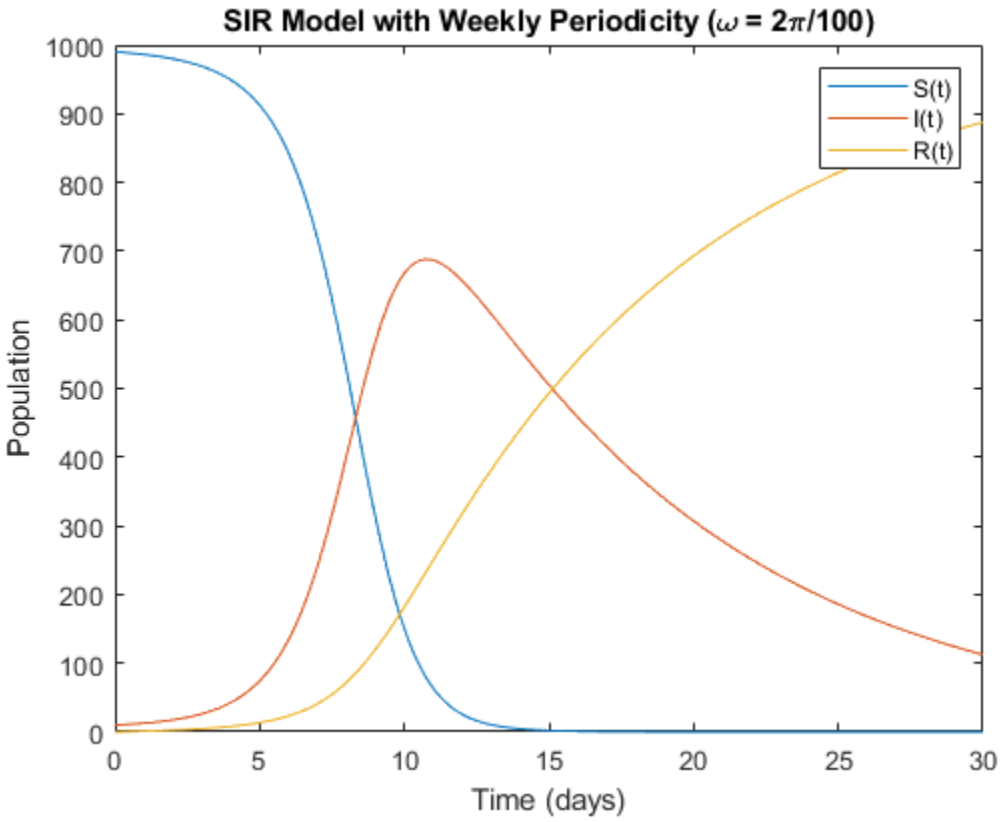
% Plot S(t), I(t), R(t) for Weekly Periodicity
figure;
plot(t_model, S, 'DisplayName', 'S(t)');
hold on;
plot(t_model, I, 'DisplayName', 'I(t)');
plot(t_model, R, 'DisplayName', 'R(t)');
xlabel('Time (days)');
ylabel('Population');
title('SIR Model with Weekly Periodicity (\omega = 2\pi/100)');
legend;
hold off;

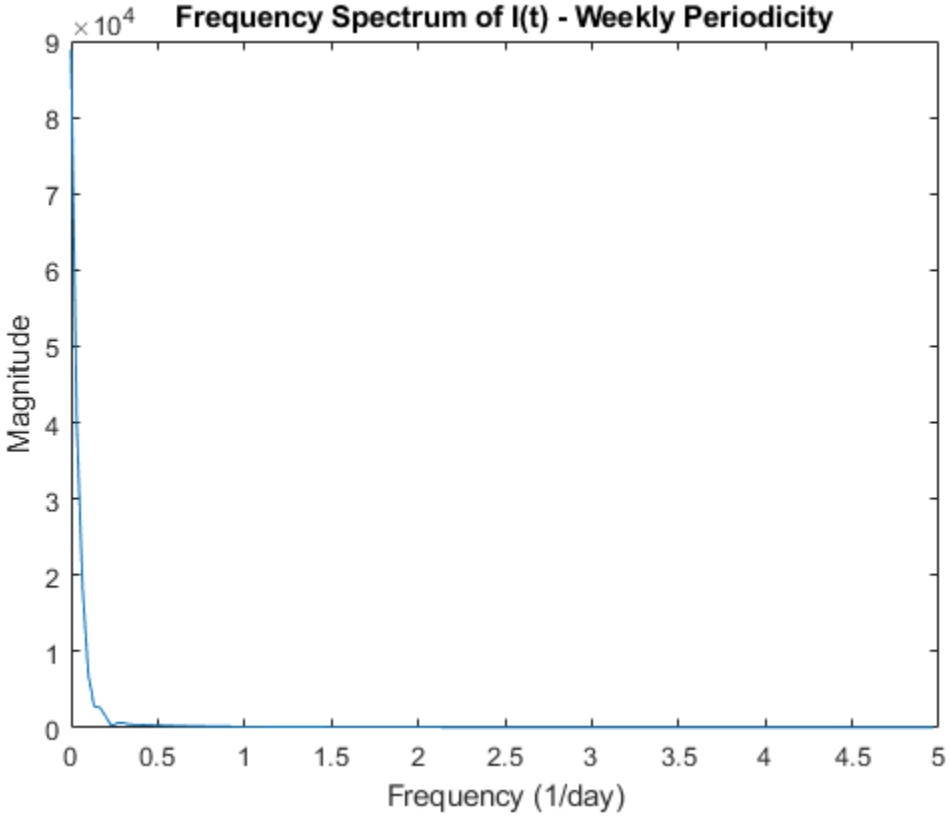
% Perform FFT for Weekly Periodicity
fft_I_weekly = fft(I);
fft_I_weekly_magnitude = abs(fft_I_weekly(1:floor(N/2))); % Magnitude of FFT

% Plot Frequency Spectrum for I(t) - Weekly Periodicity
figure;
plot(freq, fft_I_weekly_magnitude);
xlabel('Frequency (1/day)');
ylabel('Magnitude');
title('Frequency Spectrum of I(t) - Weekly Periodicity');
```


SIR Model with Daily Periodicity ($\omega = 2\pi/365$)
S(t)
I(t)
R(t)
Population
Time (days)
0
100
200
300
400
500
600
700
800
900
1000
0
5
10
15
20
25
30


Frequency Spectrum of I(t) - Daily Periodicity
$\times 10^4$
Magnitude
Frequency (1/day)
0
1
2
3
4
5
6
7
8
9
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5


SIR Model with Weekly Periodicity ($\omega = 2\pi/100$)
S(t)
I(t)
R(t)
Population
Time (days)
0
100
200
300
400
500
600
700
800
900
1000
0
5
10
15
20
25
30


Frequency Spectrum of I(t) - Weekly Periodicity
$\times 10^4$
Magnitude
Frequency (1/day)
0
1
2
3
4
5
6
7
8
9
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

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