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% MAE 384 PART 3 LEAST SQUARES
clc;

% Parameters
beta_true = 0.3;
gamma = 0.1;
S0 = 990;
I0 = 10;
R0 = 0;
h = 1;
T = 30;

% Initialize variables
t_model = 0:h:T;
S = zeros(size(t_model));
I = zeros(size(t_model));
R = zeros(size(t_model));
S(1) = S0;
I(1) = I0;
R(1) = R0;

% SIR model simulation
for k = 1:length(t_model)-1
    dS = -beta_true * S(k) * I(k) / (S(k) + I(k) + R(k));
    dI = beta_true * 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

% Observed data: ln(I(t))
lnI_obs = log(I(2:end));
t_obs = t_model(2:end); % Exclude t=0 for log calculation

% Linear least squares
A = [t_obs', ones(length(t_obs), 1)]; % Design matrix
coeff = A \ lnI_obs'; % Solve linear system
k_est = coeff(1);
lnI0_est = coeff(2);

% Parameter estimation
I0_est = exp(lnI0_est);
beta_est = (k_est + gamma) / (S0 / 1000);

% Repeat for 10 days of data
t_obs_short = t_obs(1:10);
lnI_obs_short = lnI_obs(1:10);
A_short = [t_obs_short', ones(length(t_obs_short), 1)];
coeff_short = A_short \ lnI_obs_short';
k_est_short = coeff_short(1);
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lnI0_est_short = coeff_short(2);

I0_est_short = exp(lnI0_est_short);
beta_est_short = (k_est_short + gamma) / (S0 / 1000);

% Display results
fprintf('Full Data (30 Days):\n');
fprintf('Estimated I0: %.4f\n', I0_est);
fprintf('Estimated Beta: %.4f\n', beta_est);

fprintf('Short Data (10 Days):\n');
fprintf('Estimated I0: %.4f\n', I0_est_short);
fprintf('Estimated Beta: %.4f\n', beta_est_short);
```

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Full Data (30 Days):
Estimated I0: 15.6396
Estimated Beta: 0.2213
Short Data (10 Days):
Estimated I0: 10.1540
Estimated Beta: 0.2764
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