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clear; clc; close all;

% ASEN 6060 - HW 3 Problem 1
% Spring 2025
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% Truncated system mass ratio for demonstration
mu = 0.0122;

% Set tolerance for numerical integrator
TOL = 1e-12;

% Set options for ode113
options = odeset('RelTol', TOL, 'AbsTol', TOL);

% Arbitrary initial state for demonstration
state0 = [1, 0, 0, 1, 0, 0]; % [m, m/s]
phi0 = eye(6); % STM matrix evaluated at initial condition is identity
phi0_row = reshape(phi0, [6, 6]);

state_phi_0 = [state0; phi0_row];

t = 1; % Arbitrary period for demonstration

[t_out, state_out] = ode113(@(t,state)CR3BP_full(state, mu), [0, t],
state_phi_0, options);

function state_phi_dot = CR3BP_full(state_phi, mu)
    % Full state vector and state transition matrix differential equation
    % Inputs:
    % state_phi - Augmented state vector and STM [42x1]. The state vector -
    % [x0, y0, z0, x0_dot, y0_dot, z0_dot]. The STM - is 6x6 with each
    % element described as - phi_ij = dxi(tf)/dxj(t0). The phi matrix is
    % reshaped such that all the rows are concatenated vertically. For
    % example -
    % phi_mat = [phi11, phi12, phi13, ..., phi16;
    %            [phi21, phi22, phi23, ..., phi26;
    %            ...
    %            [phi61, phi62, phi63, ..., phi66]
    % becomes
    % phi_row = [phi11, phi12, ..., phi16, phi21, phi22, ..., phi66]'
    %
    % mu - system mass ratio [-]
    %
    % Output
    % state_phi_dot - Augmented state vector dot and STM_dot [42x1]. The
    % augmentation and reshaping scheme remains the same as the input.
```

```
    x = state_phi(1);
    y = state_phi(2);
    z = state_phi(3);
    xdot = state_phi(4);
    ydot = state_phi(5);
    zdot = state_phi(6);

    r1 = sqrt((x + mu)^2 + (y)^2 + (z)^2);
    r2 = sqrt((x - 1 + mu)^2 + (y)^2 + (z)^2);

    state_dot(1, 1) = xdot;
    state_dot(2, 1) = ydot;
    state_dot(3, 1) = zdot;

    state_dot(4, 1) = 2*ydot + x - (1 - mu)*(x + mu)/(r1^3) - mu * (x - 1 +
mu)/(r2^3);
    state_dot(5, 1) = -2*xdot + y - (1 - mu)*y/(r1^3) - mu*y/(r2^3);
    state_dot(6, 1) = -(1 - mu)*z/(r1^3) - mu*z/(r2^3);

    % Calc pseudo-potentials
    uxx = u_xx(mu, [x, y, z]);
    uyy = u_yy(mu, [x, y, z]);
    uxy = u_xy(mu, [x, y, z]);
    uzz = u_zz(mu, [x, y, z]);
    U_mat = [uxx, uxy 0; uxy, uyy 0; 0 0 uzz];
    Omega = [0 2 0; -2 0 0; 0 0 0];
    A = [zeros(3), eye(3);
        U_mat, Omega];

    % Get only the phi elements into a row
    phi_row = state_phi(7:end);

    % Converting phi to matrix
    phi_mat = reshape(phi_row, [6,6])';

    % Get phi_dot
    phi_dot_mat = A * phi_mat;

    % Convert back to row
    phi_dot_row = reshape(phi_dot_mat', [36,1]);

    % Augment state and phi (in row form)
    state_phi_dot = [state_dot; phi_dot_row];

end
```

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