Contents

- Problem 1a
- Problem 1b
- Problem 2a
- Problem 3a
- Problem 3b
- Problem 3c
- Problem 3d
- Problem 3e


```
clear
close all
clc
```

Problem 1a

```
disp('-----Start Problem 1 ------------------')
% Earth -> Moon -> s/c -> sun -> Jupiter (Collinear)

% Assume 1-D position vectors along y axis. Positive y is right
r_sun_jupiter    = 778279959;                    % [km]
r_sun_earth      = -149597898;                   % [km]
r_earth_moon     = 384400;                       % [km]
r_sun_moon       = r_sun_earth + r_earth_moon;
r_moon_sc        = 77500;                        % [km]
r_sun_sc         = r_sun_moon + r_moon_sc;

% Gravitational constant
G                = 6.6743e-11*(1/1000)^3;        % [km^3/kg-s^2]

% Masses
m_sc             = 130;                          % [kg]
m_earth          = 398600.4415/G;                % [kg]
m_jupiter        = 126712767.8578/G;
m_moon           = 4902.8005821478/G;
m_sun            = 132712440017.99/G;

% Center of Mass Calculation [km]
disp('Center of mass location')
COM              = (r_sun_jupiter*m_jupiter + r_sun_earth*m_earth + ...
                    r_sun_moon*m_moon + r_sun_sc*m_sc)/ + (...
                    m_jupiter + m_earth + m_moon + m_sc + m_sun)
```

```
-----Start Problem 1 ------------------
Center of mass location

COM =

          741929.958019775
```

Problem 1b

```
% Relative position vectors
r_earth_sc        = r_sun_sc - r_sun_earth;
r_jupiter_sc      = r_sun_sc - r_sun_jupiter;

% Accelerations on spacecraft due to bodies
```

```
disp('Acceleration on s/c due to Earth')
a_earth_sc        = -G*m_earth*r_earth_sc/(norm(r_earth_sc)^3)
disp('Acceleration on s/c due to moon')
a_moon_sc         = -G*m_moon*r_moon_sc/(norm(r_moon_sc)^3)
disp('Acceleration on s/c due to Jupiter')
a_jupiter_sc      = -G*m_jupiter*r_jupiter_sc/(norm(r_jupiter_sc)^3)
disp('Acceleration on s/c due to Sun')
a_sun_sc          = -G*m_sun*r_sun_sc/(norm(r_sun_sc)^3)
disp('Net Acceleration on s/c')
a_net             = a_earth_sc + a_sun_sc + a_moon_sc + a_jupiter_sc

disp('-----End Problem 1 ------------------')
```

```
Acceleration on s/c due to Earth

a_earth_sc =

     -1.86827951052256e-06

Acceleration on s/c due to moon

a_moon_sc =

     -8.16283135425232e-07

Acceleration on s/c due to Jupiter

a_jupiter_sc =

      1.47323235925438e-10

Acceleration on s/c due to Sun

a_sun_sc =

      5.96687121560359e-06

Net Acceleration on s/c

a_net =

      3.28245589289172e-06

-----End Problem 1 ------------------
```

Problem 2a

```
disp('-----Start Problem 2 ------------------')

% More position vectors
r_sc_sun          = -r_sun_sc;
r_moon_sun        = -r_sun_moon;
r_sc_earth        = -r_earth_sc;
r_sc_jupiter      = r_sun_jupiter - r_sun_sc;
r_moon_jupiter    = r_sun_jupiter - r_sun_moon;
r_moon_earth      = -r_earth_moon;

disp('Dominant acceleration: ')
a_dominant        = G*(m_sc + m_moon)*r_moon_sc/(norm(r_moon_sc)^3)

disp('Total direct acceleration: ')
a_direct          = G*m_sun*(r_sc_sun/norm(r_sc_sun)^3) + ...
                    G*m_jupiter*(r_sc_jupiter/norm(r_sc_jupiter)^3) + ...
                    G*m_earth*(r_sc_earth/norm(r_sc_earth)^3)
```

```
disp('Total indirect acceleration: ')
a_indirect       = G*m_sun*(r_moon_sun/norm(r_moon_sun)^3) + ...
                   G*m_jupiter*(r_moon_jupiter/norm(r_moon_jupiter)^3) + ...
                   G*m_earth*(r_moon_earth/norm(r_moon_earth)^3)

disp('Total pertubation acceleration: ')
a_total_pert     = a_direct - a_indirect

disp('Pertubation acceleration due to Earth: ')
a_pert_earth     = G*m_earth*(r_sc_earth/norm(r_sc_earth)^3) - G*m_earth*(r_moon_earth/norm(r_moon_earth)^3)
disp('Pertubation acceleration due to Jupiter: ')
a_pert_jupiter   = G*m_jupiter*(r_sc_jupiter/norm(r_sc_jupiter)^3) -  G*m_jupiter*(r_moon_jupiter/norm(r_moon_jupiter)^3)
disp('Pertubation acceleration due to Sun: ')
a_pert_sun       = G*m_sun*(r_sc_sun/norm(r_sc_sun)^3) - G*m_sun*(r_moon_sun/norm(r_moon_sun)^3)
disp('-----End Problem 2 ------------------')
```

```
-----Start Problem 2 ------------------
Dominant acceleration:

a_dominant =

      8.16283135425232e-07

Total direct acceleration:

a_direct =

      4.09873902831695e-06

Total indirect acceleration:

a_indirect =

      3.26326245217686e-06

Total pertubation acceleration:

a_total_pert =

      8.35476576140096e-07

Pertubation acceleration due to Earth:

a_pert_earth =

      8.29279894596545e-07

Pertubation acceleration due to Jupiter:

a_pert_jupiter =

      2.46192006662886e-14

Pertubation acceleration due to Sun:

a_pert_sun =

      6.19665692435073e-09

-----End Problem 2 ------------------
```

Problem 3a

```
disp('-----Start Problem 3 ------------------')
```

```
Gm_charon       = 119.480; % [km^3/s^2]
Gm_pluto        = 981.601; % [km^3/s^2]
r_pc            = 19596;   % Positive xhat direction [km]

disp('Pluto, Charon Center of Mass: ')
COM_pc          = Gm_charon*r_pc/(Gm_charon + Gm_pluto)

disp('Position vector from Center of Mass to Pluto: ')
r_cm_pluto      = -COM_pc % Negative xhat direction
disp('Position vector from Center of Mass to Charon: ')
r_cm_charon     = r_pc + r_cm_pluto
```

```
-----Start Problem 3 ------------------
Pluto, Charon Center of Mass:

COM_pc =

          2126.39222727483

Position vector from Center of Mass to Pluto:

r_cm_pluto =

         -2126.39222727483

Position vector from Center of Mass to Charon:

r_cm_charon =

          17469.6077727252
```

Problem 3b

```
% Inertial Velocities along y axis
rdot_charon     = .211319;
rdot_pluto      = -.025717;

% Inertial velocity in y axis
rdot_pc         = rdot_charon - rdot_pluto; % [km/s]

% Specific Angular Momentum
h               = cross([r_pc;0;0],[0;rdot_pc;0]);

% Angular Velocity
disp('Angular Velocity of Charon relative to Pluto: ')
thetadot        = norm(h)/norm(r_pc)^2
```

```
Angular Velocity of Charon relative to Pluto:

thetadot =

      1.20961420698102e-05
```

Problem 3c

```
disp('Linear momentum of the system: ')
p               = Gm_pluto*rdot_pluto/G + Gm_charon*rdot_charon/G

disp('Velocity of center of mass: ')
v_cm            = p/(Gm_pluto/G + Gm_charon/G)
```

```
Linear momentum of the system:

p =

      6.83397959336591e+16

Velocity of center of mass:

v_cm =

      4.14247725644182e-06
```

Problem 3d

```
disp('C3 is: ')
C3                = Gm_pluto*r_cm_pluto*rdot_pluto/G + Gm_charon*r_cm_charon*rdot_charon/G
```

```
C3 is:

C3 =

      7.41287973673515e+24
```

Problem 3e

```
T                 = 1/2*(Gm_pluto/G)*rdot_pluto^2 + 1/2*(Gm_charon/G)*rdot_charon^2;
U                 = 1/2*G*(Gm_pluto/G)*(Gm_charon/G)/r_pc

disp('C4 is: ')
C4                = T - U
```

```
U =

      4.48360201818764e+19

C4 is:

C4 =

     -2.39681934576845e+15
```

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