```
clear
close all
clc
format long g
```

Problem 1- i) - Acceleration of asteroid relative to Sun

```
% Semi-major axis of Jupiters orbit
a               = 778279959;                % [km]

% Gravitational Parameters: mu = G*m [km^3/s^2]
mu_sun          = 132712440017.99;
mu_asteroid     = 10;
mu_jupiter      = 126712767.8578;

% Define 2-D position vectors [x-y] plane
% Assume equilateral triangle of 60 deg
r_sun_jupiter   = [a;0];                    % [km]
r_sun_asteroid  = [a*cosd(60); a*sind(60)]; % [km]

% Dominant acceleration of asteroid wrt sun [km/s^2]
a_sa_dominant      = -(mu_sun + mu_asteroid)*r_sun_asteroid...
                  /(norm(r_sun_asteroid)^3)
```

```
a_sa_dominant = 2×1
     -1.0954938498391e-07
    -1.89745100730055e-07
```

```
% Magnitude of dominant acceleration of asteroid wrt sun
a_sa_dominant_mag  = norm(a_sa_dominant)
```

```
a_sa_dominant_mag = 
      2.1909876996782e-07
```

```
% Position vector from asteroid to Jupiter [km]
r_asteroid_jupiter = r_sun_jupiter - r_sun_asteroid;

% Direct perturbing acceleration due to Jupiter on asteroid wrt sun [km/s^2]
a_sa_direct           = mu_jupiter*r_asteroid_jupiter/(norm(r_asteroid_jupiter)^3)
```

```
a_sa_direct = 2×1
       1.045968696341e-10
    -1.81167092518919e-10
```

```
% Magnitude of direct perturbing acceleration on asteroid wrt sun
a_sa_direct_mag        = norm(a_sa_direct)
```

```
a_sa_direct_mag = 
       2.091937392682e-10
```

```
% Indirect perturbing acceleration due to Jupiter on asteroid wrt sun [km/s^2]
a_sa_indirect            = mu_jupiter*r_sun_jupiter/(norm(r_sun_jupiter)^3)
```

```
a_sa_indirect = 2×1
       2.091937392682e-10
                        0
```

```
% Net perturbing acceleration on asteroid wrt sun
a_sa_pertubing           = a_sa_direct - a_sa_indirect
```

```
a_sa_pertubing = 2×1
   -1.045968696341e-10
  -1.81167092518919e-10
```

```
% Magnitude of perturbing acceleration on asteroid wrt sun
a_sa_pertubing_mag        = norm(a_sa_pertubing)
```

```
a_sa_pertubing_mag =
    2.091937392682e-10
```

```
% Net acceleration of asteroid wrt sun
a_sa_net                  = a_sa_dominant + a_sa_pertubing
```

```
a_sa_net = 2×1
  -1.09653981853544e-07
  -1.89926267822574e-07
```

```
% Magnitude of net acceleration of asteroid wrt sun
a_sa_net_mag               = norm(a_sa_net)
```

```
a_sa_net_mag =
   2.19307963707088e-07
```

Problem 1- ii) - Acceleration of asteroid relative to Jupiter

```
% Relevant position vectors
r_asteroid_sun          = -r_sun_asteroid;
r_jupiter_sun           = -r_sun_jupiter;
r_jupiter_asteroid      = -r_asteroid_jupiter;

% Dominant acceleration of asteroid wrt Jupiter [km/s^2]
a_ja_dominant           = -(mu_jupiter + mu_asteroid)*r_jupiter_asteroid...
                           /(norm(r_jupiter_asteroid)^3)
```

```
a_ja_dominant = 2×1
   1.04596877888743e-10
  -1.81167106816381e-10
```

```
% Magnitude of dominant acceleration of asteroid wrt Jupiter
a_ja_dominant_mag       = norm(a_ja_dominant)
```

```
a_ja_dominant_mag =
   2.09193755777486e-10
```

```
% Direct perturbing acceleration due to sun on asteroid wrt Jupiter [km/s^2]
a_ja_direct             = mu_sun*r_asteroid_sun/(norm(r_asteroid_sun)^3)
```

```
a_ja_direct = 2×1
  -1.09549384975655e-07
  -1.89745100715758e-07
```

```
% Magnitude of direct perturbing acceleration on asteroid wrt Jupiter
a_ja_direct_mag        = norm(a_ja_direct)
```

```
a_ja_direct_mag =
```

```
2.19098769951311e-07
```

```
% Indirect perturbing acceleration due to sun on asteroid wrt Jupiter [km/s^2]
a_ja_indirect           = mu_sun*r_jupiter_sun/(norm(r_jupiter_sun)^3)
```

```
a_ja_indirect = 2×1
    -2.19098769951311e-07
                        0
```

```
% Net perturbing acceleration on asteroid wrt Jupiter
a_ja_pertubing          = a_ja_direct - a_ja_indirect
```

```
a_ja_pertubing = 2×1
     1.09549384975655e-07
    -1.89745100715758e-07
```

```
% Magnitude of perturbing acceleration on asteroid wrt Jupiter
a_ja_pertubing_mag       = norm(a_ja_pertubing)
```

```
a_ja_pertubing_mag =
     2.19098769951311e-07
```

```
% Net acceleration of asteroid wrt Jupiter
a_ja_net                 = a_ja_dominant + a_ja_pertubing
```

```
a_ja_net = 2×1
     1.09653981853544e-07
    -1.89926267822574e-07
```

```
% Magnitude of net acceleration of asteroid wrt Jupiter
a_ja_net_mag              = norm(a_ja_net)
```

```
a_ja_net_mag =
     2.19307963707088e-07
```

Problem 3b)

```
r_earth     = 6378.1363;        % Radius of Earth [km]
altitude    = 8560;             % [km]

% Position vector from Earth CG to spacecraft (polar coordinates)
r_earth_sc  = [r_earth + altitude;0;0];

% Inertial velocity of spacecraft relative to earth (polar coordinates)
v_earth_sc  = [-2.11;4.89;0];   % [km/s]
m_sc        = 300;              % Spacecraft mass [kg]

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

m_earth     = 398600.4415/G;    % Earth mass

% Total system angular momentum
C3          = (m_earth*m_sc)*cross(r_earth_sc,v_earth_sc)...
              /(m_earth + m_sc) % [kg-km^2/s]
```

```
C3 = 3×1
                        0
                        0
            21914245.9521
```

```
% Specific angular momentum
h_vec       = cross(r_earth_sc,v_earth_sc) % [km^2/s]
```

```
h_vec = 3×1
                        0
                        0
             73047.486507
```

```
% Total system kinetic energy
T             = 1/2*(m_earth*m_sc)*dot(v_earth_sc,v_earth_sc)...
               /(m_earth + m_sc) % [kg-km^2/s^2]
```

```
T =
                  4254.63
```

```
% Gravitional potential
U              = G*m_earth*m_sc/norm(r_earth_sc);

% Total energy
C4             = T - U           % [kg-km^2/s^2]
```

```
C4 =
         -3750.39352157545
```

```
% Magnitude of angular momentum
h              = norm(h_vec);

% Gravitional parmeter
mu             = G*(m_earth + m_sc);

% Specific energy
E              = norm(v_earth_sc)^2/2 - mu/norm(r_earth_sc)
```

```
E =
         -12.5013117385848
```

```
% Areal velocity
Adot             = h/2 % [km^2/s]
```

```
Adot =
             36523.7432535
```

Problem 3d)

```
% Semi-latus rectum
p                = h^2/mu  % [km]
```

```
p =
          13386.6768057515
```

```
% Eccentricity vector
e_vec             = cross(v_earth_sc,h_vec)/mu -...
```

```
                     r_earth_sc/norm(r_earth_sc);

% Eccentricity
e                  = norm(e_vec)
```

```
e = 
       0.400383443095008
```

```
% Semi-major axis
sma                 = p/(1 - e^2) % [km]
```

```
sma = 
        15942.3446849075
```

```
% Orbital Period
period               = 2*pi*sqrt(sma^3/mu)/3600 % [hours]
```

```
period = 
        5.56463613853122
```

```
% Flight path angle
gamma                = acosd(v_earth_sc(2)/norm(v_earth_sc))
```

```
gamma = 
        23.3398520112336
```

```
% True anomaly
theta_star           = acosd((p/norm(r_earth_sc) - 1)/e) % [deg]
```

```
theta_star = 
         105.03439032896
```

```
% Rotation matrix from Inertial p & e frame to polar frame
DCM_C_I              = [cosd(theta_star), sind(theta_star), 0;...
                        -sind(theta_star), cosd(theta_star), 0;...
                        0, 0, 1];

% Position vector in semi-latus rectum and eccentricity unit vectors
r_earth_sc_ep         = DCM_C_I'*r_earth_sc
```

```
r_earth_sc_ep = 3×1
       -3874.93419372084
        14426.8084173774
                       0
```

```
% Velocity vector in semi-latus rectum and eccentricity unit vectors
v_earth_sc_ep          = DCM_C_I'*v_earth_sc
```

```
v_earth_sc_ep = 3×1
       -4.17528537426884
       -3.30623532789436
                       0
```

Problem 3e)

```
% Circular velocity
Vc                      = sqrt(mu/norm(r_earth_sc_ep))
```

```
Vc =
         5.16559887511456
```

```
% Magnitude of relative velocity
v_mag                    = norm(v_earth_sc_ep)
```

```
v_mag =
         5.32580510345619
```