Problem 1

```
interr = 'latex';
% interr = 'none';
set(groot,'defaulttextinterpreter',interr);
set(groot, 'defaultAxesTickLabelInterpreter',interr);
set(groot, 'defaultLegendInterpreter',interr);
```

Preliminary Calculations

```
Re = 6378.1; % Earth radius, km
mu = 398600.4415; % Earth mu, km^3/s^2

a0 = 4.5 * Re;
th0_deg = 125; th0 = deg2rad(th0_deg);
if th0 > pi
    th0 = th0 - 2*pi
    th0_deg = rad2deg(th0)
end

dw_deg = +30; dw = deg2rad(dw_deg)
```

```
dw = 0.5236
```

```
e0 = 0.75;
```

Part a)

```
p0 = a0*(1-e0^2)
```

```
p0 = 1.2557e+04
```

```
rmag = p0/(1+e0*cos(th0))
```

```
rmag = 2.2037e+04
```

```
r = [1 0]' * rmag
```

```
r = 2×1
10^4 ×
    2.2037
         0
```

```
v0mag = sqrt(mu*(2/rmag - 1/a0))
```

```
v0mag = 4.7210
```

```
h0 = sqrt(mu*p0)
```

```
h0 = 7.0747e+04
```

```
th0dot = h0/rmag^2
```

```
th0dot = 1.4569e-04
```

```
gamma = acos(rmag*th0dot/v0mag); gamma = gamma * bpsk((sign(gamma) == sign(th0))), gamm
```

```
gamma = 0.8230
gamma_deg = 47.1543
```

```
v0 = v0mag * [sin(gamma), cos(gamma)]'
```

```
v0 = 2×1
    3.4614
    3.2104
```

Part b)

```
rp0 = a0*(1-e0)
```

```
rp0 = 7.1754e+03
```

```
rpN = 2*Re
```

```
rpN = 1.2756e+04
```

```
thN = th0 - dw, thN_deg = rad2deg(thN)
```

```
thN = 1.6581
thN_deg = 95.0000
```

```
eN = (rmag/rpN - 1)/(1-rmag/rpN*cos(thN))
```

```
eN = 0.6323
```

```
pN = rmag*(1+eN*cos(thN))
```

```
pN = 2.0822e+04
```

```
aN = pN / (1-eN^2)
```

```
aN = 3.4694e+04
```

```
vNmag = sqrt(mu*(2/rmag - 1/aN)), min_dv = vNmag - v0mag
```

```
vNmag = 4.9686
min_dv = 0.2476
```

```
[gammaN,hN] = getfpa(mu,pN,rmag,vNmag,thN), gammaN_deg = rad2deg(gammaN)
```

```
gammaN = 0.5880
hN = 9.1103e+04
gammaN_deg = 33.6896
```

```
vN = vNmag*[sin(gammaN), cos(gammaN)]'
```

```
vN = 2×1
    2.7561
    4.1342
```

```
dv = vN - v0
```

```
dv = 2×1
   -0.7054
```

```
    0.9237
```

```
dgamma = gammaN - gamma, dgamma_deg = rad2deg(dgamma)
```

```
dgamma = -0.2350
dgamma_deg = -13.4647
```

```
dvmag = norm(dv) % dvmag = sqrt(vNmag^2 + v0mag^2 - 2*vNmag*v0mag*cos(dgamma))
```

```
dvmag = 1.1622
```

```
beta = asin(sin(dgamma)/dvmag*vNmag), beta = [beta pi-beta]
```

```
beta = -1.4752
beta = 1×2
   -1.4752    4.6167
```

```
beta_deg = rad2deg(beta(2))
```

```
beta_deg = 264.5202
```

```
alpha = -acos(dot(dv,v0)/(dvmag*v0mag))
```

```
alpha = -1.4752
```

```
alpha_deg = rad2deg(alpha)
```

```
alpha_deg = -84.5202
```

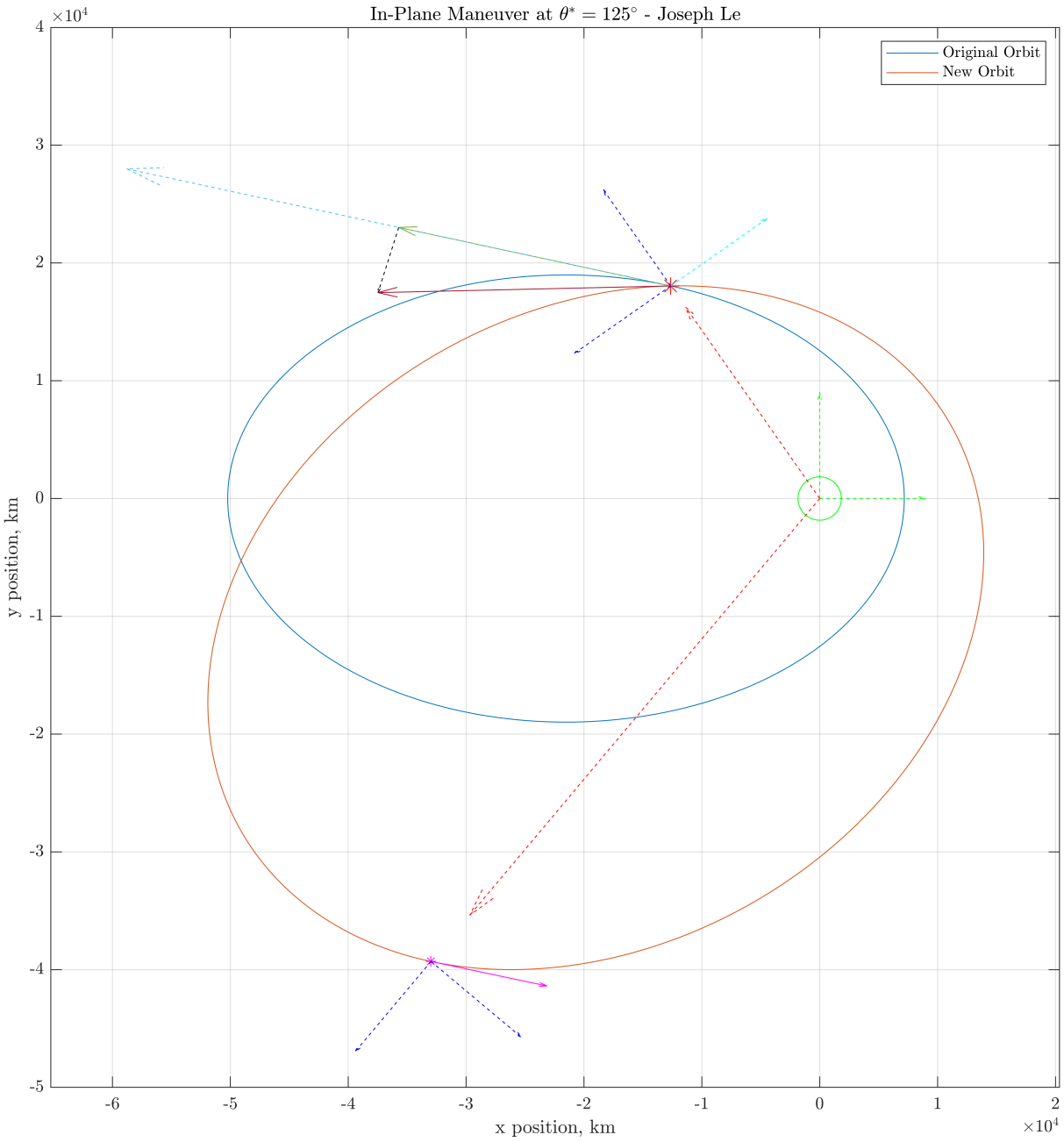
```
% Plotting
thplot = linspace(0,2*pi,2^10);
rplot = p0./(1+e0*cos(thplot));
rx = rplot.*cos(thplot); ry = rplot.*sin(thplot);
ogorbit = plot(rx,ry);
iCr = [cos(th0) -sin(th0); sin(th0) cos(th0)];
vNplot = iCr * vN;
v0plot = iCr * v0;
dvplot = iCr * dv;
hold on
rNplot = pN./(1+eN*cos(thplot));
rNx = rNplot.*cos(thplot+dw); rNy = rNplot.*sin(thplot+dw);
neworbit = plot(rNx,rNy);
plot(0,0,'go','markersize',25)
plot(rmag*cos(th0),rmag*sin(th0),'r*','markersize',10)
quiver(rmag*cos(th0),rmag*sin(th0),v0plot(1),v0plot(2),5e3) % v2
quiver(rmag*cos(th0),rmag*sin(th0),v0plot(1),v0plot(2),10e3,'--') % v2 line

quiver(rmag*cos(th0),rmag*sin(th0),vNplot(1),vNplot(2),5e3) % vN
quiver(rmag*cos(th0)+v0plot(1)*5e3,rmag*sin(th0)+v0plot(2)*5e3,dvplot(1),dvplot(2),5e3,
quiver(rmag*cos(th0),rmag*sin(th0),cos(th0),sin(th0),1e4,'b--')% r hat
quiver(rmag*cos(th0),rmag*sin(th0),-sin(th0),cos(th0),1e4,'b--')% th hat
quiver(1e4,0,'g--')% x hat
quiver(0,1e4,'g--')% y hat
quiver(rmag*cos(th0),rmag*sin(th0),sin(th0),-cos(th0),1e4,'c--')% l.h.
quiver(rmag*cos(th0),rmag*sin(th0),'r--') % r
```

```
th2_deg = 200
th2 = 3.4907
E2 = 3.8530
E2_deg = 220.7625
EN = 0.9558
EN_deg = 54.7628
n = 9.7699e-05
period = 6.4312e+04
dt1 = 4.4968e+03
dt2 = 4.3664e+04
dt = 3.9167e+04
dt_hr = 10.8797
f = -2.1020
g = 1.1988e+04
rI = 2×1
10^4 ×
   -1.2640
    1.8051
vNI = 2×1
   -4.9673
   -0.1136
r2 = 2×1
10^4 ×
   -3.2981
   -3.9306
r2mag = 5.1310e+04
r2magcheck = 5.1310e+04
fdot = -2.5161e-05
gdot = -0.3322
v2 = 2×1
    1.9684
   -0.4164
v2mag = 2.0119
v2magcheck = 2.0119
```

```
plot(r2(1),r2(2),'m*')
quiver(r2(1),r2(2),'r--') % new pos on new orbit
quiver(r2(1),r2(2),v2(1),v2(2),5e3,'m') % new vel on new orbit
th2 = deg2rad(200);
quiver(r2mag*cos(th2+dw),r2mag*sin(th2+dw),cos(th2+dw),sin(th2+dw),1e4,'b--')% r hat
quiver(r2mag*cos(th2+dw),r2mag*sin(th2+dw),-sin(th2+dw),cos(th2+dw),1e4,'b--')% th hat

set(gcf,'position',[0,0,1000,1000])
title('In-Plane Maneuver at $\theta^{*} = 125^{\circ}$ - Joseph Le')
xlabel('x position, km')
ylabel('y position, km')
xlim(10^4*[-6 2])
ylim(10^4*[-5 4])
grid on
axis equal
legend('Original Orbit','New Orbit')
```



Part d)

```
th2_deg = 200, th2 = deg2rad(th2_deg)
```

```
th2_deg = 200
th2 = 3.4907
```

```
E2 = 2*pi+eccenAnom(th2,eN), E2_deg = rad2deg(E2)
```

```
E2 = 3.8530
E2_deg = 220.7625
```

```
EN = eccenAnom(thN,eN), EN_deg = rad2deg(EN)
```

```
EN = 0.9558
EN_deg = 54.7628
```

```
n = sqrt(mu/aN^3)
```

```
n = 9.7699e-05
```

```
period = 2*pi/n
```

```
period = 6.4312e+04
```

```
dt1 = (EN-eN*sin(EN))/n
```

```
dt1 = 4.4968e+03
```

```
dt2 = (E2-eN*sin(E2))/n
```

```
dt2 = 4.3664e+04
```

```
dt = dt2-dt1, dt_hr = dt/3600
```

```
dt = 3.9167e+04
dt_hr = 10.8797
```

```
f = 1 - aN/rmag * (1 - cos(E2-EN))
```

```
f = -2.1020
```

```
g = dt + (sin(E2-EN)-(E2-EN))/n
```

```
g = 1.1988e+04
```

```
rI = iCr * r
```

```
rI = 2×1
10^4 ×
   -1.2640
    1.8051
```

```
vNI = iCr * vN
```

```
vNI = 2×1
   -4.9673
   -0.1136
```

```
r2 = f * rI + g * vNI
```

```
r2 = 2×1
10^4 ×
   -3.2981
   -3.9306
```

```
r2mag = norm(r2), r2magcheck = pN/(1+eN*cos(th2))
```

```
r2mag = 5.1310e+04
```

```
r2magcheck = 5.1310e+04
```

```
fdot = -n*aN^2/r2mag/rmag * sin(E2-EN)
```

```
fdot = -2.5161e-05
```

```
gdot = 1-aN/r2mag * (1-cos(E2-EN))
```

```
gdot = -0.3322
```

```
v2 = fdot * rI + gdot * vNI
```

```
v2 = 2×1
    1.9684
   -0.4164
```

```
v2mag = norm(v2), v2magcheck = sqrt(mu*(2/r2mag - 1/aN))
```

```
v2mag = 2.0119
v2magcheck = 2.0119
```

Function 1: BPSK

```
function numbpsk = bpsk(num)
    if num == 1
        numbpsk = 1;
    else
        numbpsk = -1;
    end
end
```

Function 2: Get FPA

```
function [gamma,h] = getfpa(mu,p,rmag,vmag,theta)
    h = sqrt(mu*p);
    gamma = acos(h/rmag/vmag);
    gamma = gamma * bpsk((sign(gamma) == sign(theta)));
end
```

Function 3: Plot Ellipse

```
% function plotmaneuver(r0,rN,v0,vN,th0,thN,p0,pN,e0,eN)
% figure
% thplot = linspace(0,2*pi,2^10);
% rplot = p./(1+e*cos(thplot));
% rx = rplot.*cos(thplot); ry = rplot.*sin(thplot);
% plot(rx,ry)
% hold on
%
% rNx = r2mag.*cos(thplot); rNy = r2mag.*sin(thplot);
% plot(rNx,rNy)
% axis equal
% xlim(1.2*[-rN rN])
% ylim(1.2*[-rN rN])
% grid on
```

```
% title('Circularizing Maneuver at r = 6.6R_{e} (Descending)')
% xlabel('X position, km')
% ylabel('Y Position, km')
% plot(0,0,'go','markersize',20)
% iCr = [cos(th0) -sin(th0); sin(th0) cos(th0)]
% vNplot = iCr * vN;
% v2plot = iCr * v2;
% plot(r2mag*cos(th0),r2mag*sin(th0),'r*','markersize',10)
% quiver(r2mag*cos(th0),r2mag*sin(th0),cos(th0),sin(th0),1e4,'b--')% r hat
% quiver(r2mag*cos(th0),r2mag*sin(th0),-sin(th0),cos(th0),1e4,'b--')% th hat
% quiver(r2mag*cos(th0),r2mag*sin(th0),v2plot(1),v2plot(2),5e3) % v2
% quiver(r2mag*cos(th0),r2mag*sin(th0),vNplot(1),vNplot(2),7e3) % vN
% set(gcf,'position',[0,0,1000,1000])
% legend('Original Orbit','New Orbit','Earth','Spacecraft','location','northeastoutside
%
% end
```

Function 4: Eccentric Anomaly

```
function E = eccenAnom(th,e)
    E = 2*atan(sqrt((1-e)/(1+e))*tan(th/2));
end
```