Problem 3

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

e = 0.65
```

```
e = 0.6500
```

```
a = 4.4*Re
```

```
a = 2.8064e+04
```

```
ths0_deg = -30, ths0 = deg2rad(ths0_deg)
```

```
ths0_deg = -30
ths0 = -0.5236
```

Preliminary Calculations (Characterize Original Orbit)

```
p = a*(1-e^2)
```

```
p = 1.6207e+04
```

```
r0mag = p/(1+e*cos(ths0))
```

```
r0mag = 1.0370e+04
```

```
h = sqrt(mu*p)
```

```
h = 8.0374e+04
```

```
r0= r0mag*[1 0]'
```

```
r0 = 2×1
10^4 ×
    1.0370
         0
```

```
v = [mu*e*sin(ths0)/h, h/r0mag]'
```

```
v = 2×1
   -1.6118
    7.7510
```

```
v0mag = norm(v)
```

```
v0mag = 7.9168
```

```
gamma0 = asin(v(1)/v0mag)
```

```
gamma0 = -0.2050
```

```
gamma0_deg = rad2deg(gamma0)
```

```
gamma0_deg = -11.7469
```

Part a)

```
E0 = 2*atan(sqrt((1-e)/(1+e))*tan(ths0/2)), E0_deg = rad2deg(E0)
```

```
E0 = -0.2456
E0_deg = -14.0704
```

```
ths1 = pi, ths1_deg = rad2deg(ths1)
```

```
ths1 = 3.1416
ths1_deg = 180
```

```
E1 = 2*atan(sqrt((1-e)/(1+e))*tan(ths1/2)), E1_deg = rad2deg(E1)
```

```
E1 = 3.1416
E1_deg = 180
```

```
dt0 = sqrt(a^3/mu) * (E0 - e*sin(E0))
```

```
dt0 = -651.9397
```

```
dt1 = sqrt(a^3/mu) * (E1 - e*sin(E1))
```

```
dt1 = 2.3394e+04
```

```
waittime = dt1 - dt0
```

```
waittime = 2.4046e+04
```

```
waittime_hr = waittime/3600
```

```
waittime_hr = 6.6793
```

```
ra = p/(1+e*cos(pi)); r1 = ra*[1 0], r1mag = norm(r1)
```

```
r1 = 1×2
10^4 ×
    4.6305         0
r1mag = 4.6305e+04
```

```
rN = ra
```

```
rN = 4.6305e+04
```

```
v1mag = sqrt(mu*(2/r1mag - 1/a))
```

```
v1mag = 1.7358
```

```
v1 = v1mag*[0 1]'
```

```
v1 = 2×1
         0
    1.7358
```

```
vNmag = sqrt(mu/rN)
```

```
vNmag = 2.9340
```

```
pN = rN;
aN = rN;
```

```
gamma = 0;
gammaN = acos(sqrt(mu*pN)/(rN*vNmag))
```

```
gammaN = 0
```

```
dvmag = sqrt(vNmag^2 + v1mag^2 - 2*vNmag*v1mag*cos(gammaN - gamma))
```

```
dvmag = 1.1982
```

```
vN = vNmag * [0 1]'
```

```
vN = 2×1
         0
    2.9340
```

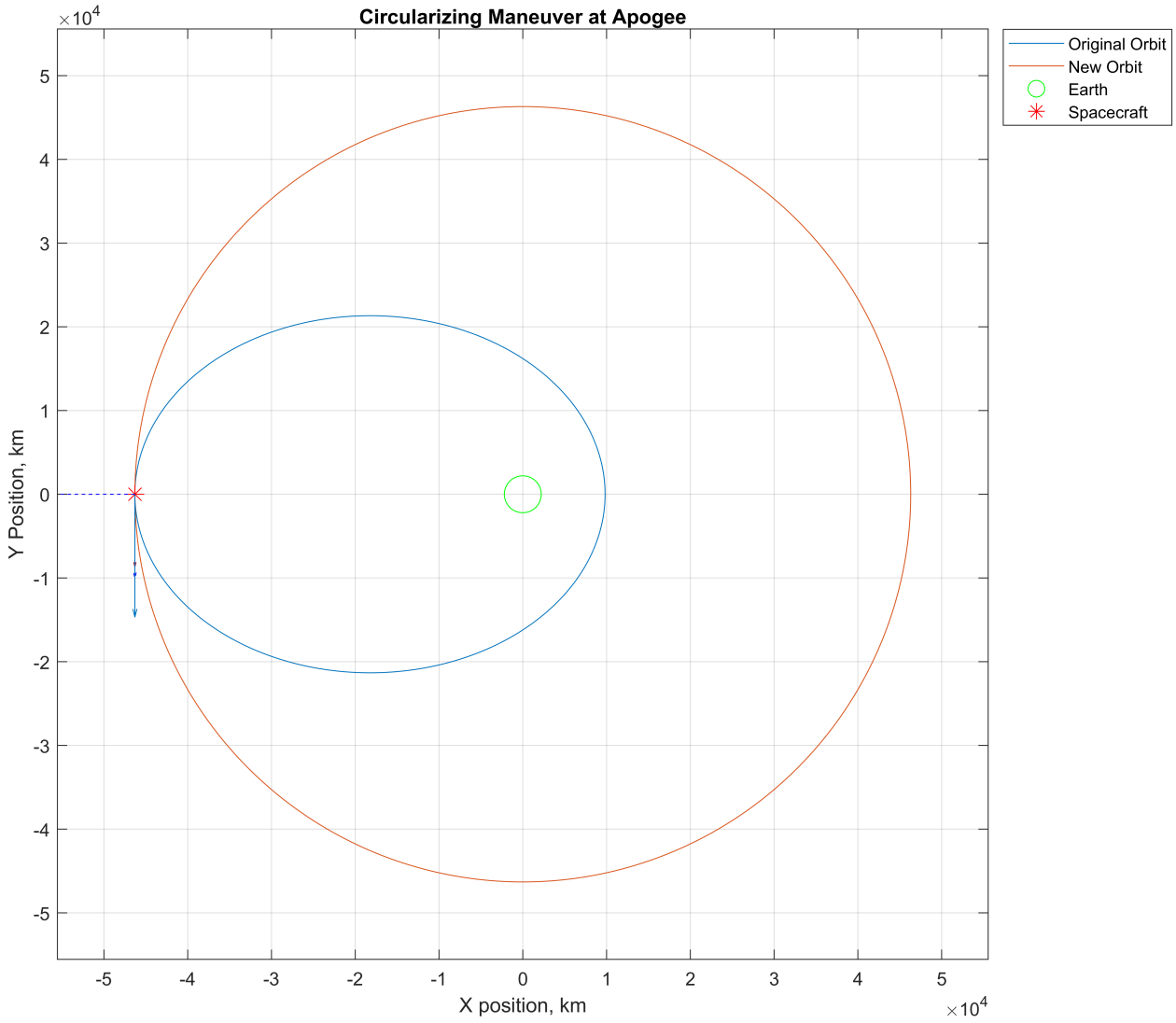
```
%% plotting

% plot original orbit

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 = rN.*cos(thplot); rNy = rN.*sin(thplot);
plot(rNx,rNy)
axis equal
xlim(1.2*[-rN rN])
ylim(1.2*[-rN rN])
grid on
title('Circularizing Maneuver at Apogee')
xlabel('X position, km')
ylabel('Y Position, km')
plot(0,0,'go','markersize',20)
plot(-rN,0,'r*','markersize',10)
iCr = [cos(ths1) -sin(ths1); sin(ths1) cos(ths1)]
```

```
iCr = 2×2
   -1.0000   -0.0000
    0.0000   -1.0000
```

```
vNplot = iCr * vN;
v1plot = iCr * v1;
quiver(-rN,0,cos(ths1),sin(ths1),1e4,'b--')% r hat
quiver(-rN,0,-sin(ths1),cos(ths1),1e4,'b--')% th hat
quiver(-rN,0,v1plot(1),v1plot(2),5e3) % v1
quiver(-rN,0,vNplot(1),vNplot(2),5e3) % vN
set(gcf,'position',[0,0,1000,1000])
legend('Original Orbit','New Orbit','Earth','Spacecraft','location','northeastoutside')
```



Part b)

```
r2mag = 6.6*Re
```

```
r2mag = 4.2095e+04
```

```
ths2 = -acos(1/e * (p/r2mag - 1))
```

```
ths2 = -2.8119
```

```
ths2_deg = rad2deg(ths2)
```

```
ths2_deg = -161.1121
```

```
v2 = [(mu*e/sqrt(mu*p)*sin(ths2)), mu/sqrt(mu*p)*(1+e*cos(ths2))]'
```

```
v2 = 2×1
   -1.0435
    1.9093
```

```
v2mag = norm(v2)
```

```
v2mag = 2.1759
```

```
gamma2 = asin(v2(1)/v2mag); gamma2 = [pi-gamma2 gamma2]; gamma2 = gamma2(2)
```

```
gamma2 = -0.5002
```

```
gamma2_deg = rad2deg(gamma2)
```

```
gamma2_deg = -28.6582
```

```
E2 = 2*atan(sqrt((1-e)/(1+e))*tan(ths2/2))+2*pi, E2_deg = rad2deg(E2)
```

```
E2 = 3.8348
E2_deg = 219.7151
```

```
dt2 = sqrt(a^3/mu) * (E2 - e*sin(E2))
```

```
dt2 = 3.1648e+04
```

```
dt2_hr = dt2/3600
```

```
dt2_hr = 8.7911
```

```
waittime2 = dt2-dt0, waittime2_hr = waittime2/3600
```

```
waittime2 = 3.2300e+04
waittime2_hr = 8.9722
```

```
vNmag = sqrt(mu/r2mag)
```

```
vNmag = 3.0772
```

```
gammaN = 0;
dvmag = sqrt(vNmag^2 + v2mag^2 - 2*vNmag*v2mag*cos(gammaN - gamma2))
```

```
dvmag = 1.5661
```

```
dv = vN - v2
```

```
dv = 2×1
    1.0435
    1.0246
```

```
vN = vNmag * [0 1]'
```

```
vN = 2×1
         0
    3.0772
```

```
alpha = asin(vNmag * sin(gammaN - gamma2)/dvmag)
```

```
alpha = 1.2294
```

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

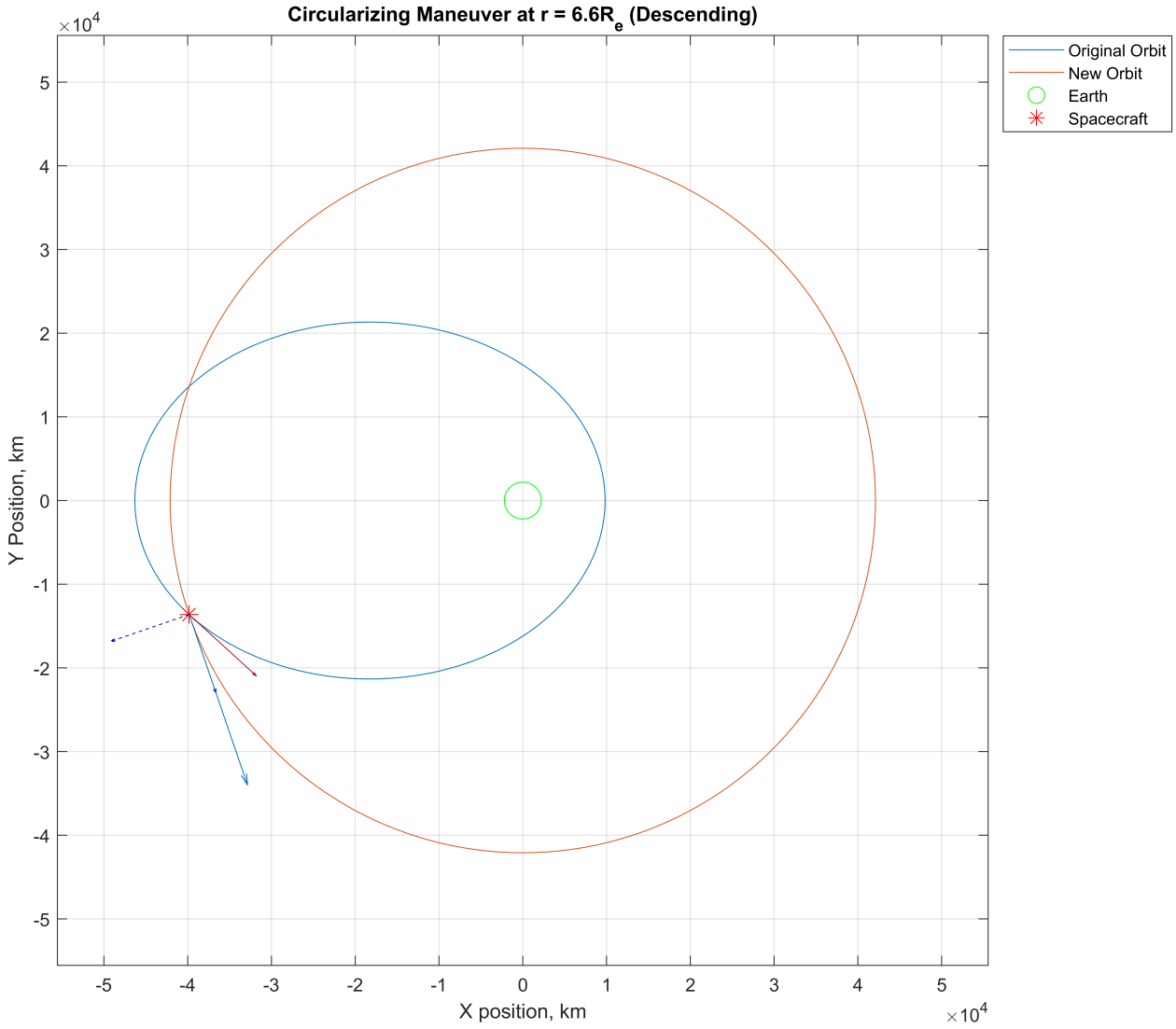
```
alpha_deg = 70.4405
```

```
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(ths2) -sin(ths2); sin(ths2) cos(ths2)]
```

```
iCr = 2×2
   -0.9462    0.3237
   -0.3237   -0.9462
```

```
vNplot = iCr * vN;
v2plot = iCr * v2;
plot(r2mag*cos(ths2),r2mag*sin(ths2),'r*','markersize',10)
quiver(r2mag*cos(ths2),r2mag*sin(ths2),cos(ths2),sin(ths2),1e4,'b--')% r hat
quiver(r2mag*cos(ths2),r2mag*sin(ths2),-sin(ths2),cos(ths2),1e4,'b--')% th hat
quiver(r2mag*cos(ths2),r2mag*sin(ths2),v2plot(1),v2plot(2),5e3) % v2
quiver(r2mag*cos(ths2),r2mag*sin(ths2),vNplot(1),vNplot(2),7e3) % vN
set(gcf,'position',[0,0,1000,1000])
legend('Original Orbit','New Orbit','Earth','Spacecraft','location','northeastoutside')
```


Circularizing Maneuver at r = 6.6R_e (Descending)
×10^4
Y Position, km
X position, km
×10^4
Original Orbit
New Orbit
Earth
Spacecraft