Problem 2

```
M0_deg = 45;
M0 = deg2rad(M0_deg)
```

```
M0 = 0.7854
```

```
rp = 15300;
ra = 61000;
mu = 398600.4415;

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

Part a)

```
a = (rp+ra)/2
```

```
a = 38150
```

```
energy = -mu/(2*a)
```

```
energy = -5.2241
```

```
e = 1- rp/a
```

```
e = 0.5990
```

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

```
p = 2.4464e+04
```

```
period = 2*pi*sqrt(a^3/mu), periodhr = period/3600
```

```
period = 7.4157e+04
periodhr = 20.5992
```

```
E0 = M0;
for m = 1:100
    temp = 2/m*bessel(m,e)*sin(m*M0);
    E0 = E0 + temp;
end
E0
```

```
E0 = 1.3136
```

```
for n = 1:10
    E0 = E0 - (E0 - e*sin(E0) - M0)/(1 - e*cos(E0));
end
E0
```

```
E0 = 1.3726
```

```
M_check = E0 - e*sin(E0)
```

```
M_check = 0.7854
```

```
th0 = 2*atan(sqrt((1+e)/(1-e))*tan(E0/2))
```

```
th0 = 2.0441
```

```
th0_deg = rad2deg(th0)
```

```
th0_deg = 117.1182
```

```
r0_mag = p / (1+e*cos(th0))
```

```
r0_mag = 3.3651e+04
```

```
v0_mag = sqrt(mu*(2/r0_mag-1/a))
```

```
v0_mag = 3.6389
```

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

```
n = 1.1802e+04
```

```
dt0 = M0*n
```

```
dt0 = 9.2696e+03
```

```
dt0_hr = dt0/3600
```

```
dt0_hr = 2.5749
```

```
th0dot = sqrt(mu*p)/r0_mag^2
```

```
th0dot = 8.7202e-05
```

```
gamma0 = acos(r0_mag*th0dot/v0_mag)
```

```
gamma0 = 0.6327
```

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

```
gamma0_deg = 36.2532
```

Part b)

```
r0 = r0_mag * [cos(th0) sin(th0)]
```

```
r0 = 1×2
10^4 ×
   -1.5339    2.9952
```

```
r0_polar = r0_mag * [1 0]
```

```
r0_polar = 1×2
10^4 ×
    3.3651         0
```

```
v0_polar = v0_mag * [sin(gamma0) cos(gamma0)]
```

```
v0_polar = 1×2
    2.1519    2.9345
```

```
ICR = [cos(th0) -sin(th0); sin(th0) cos(th0)]
```

```
ICR = 2×2
   -0.4558   -0.8901
    0.8901   -0.4558
```

```
v0 = (ICR* v0_polar')'
```

```
v0 = 1×2
   -3.5928    0.5777
```

Part c)

```
dt = 400 * 60
```

```
dt = 24000
```

```
M = sqrt(mu/a^3)*dt + M0
```

```
M = 2.8189
```

```
M_deg = rad2deg(M)
```

```
M_deg = 161.5094
```

```
E = M;
for m = 1:100
    temp = 2/m*bessel(m,e)*sin(m*M);
    E = E + temp;
end
E
```

```
E = 2.9266
```

```
for n = 1:10
    E = E - (E - e*sin(E) - M)/(1 - e*cos(E));
end
E
```

```
E = 2.9392
```

```
M_check = E - e*sin(E)
```

```
M_check = 2.8189
```

```
th = 2*atan(sqrt((1+e)/(1-e))*tan(E/2))
```

```
th = 3.0400
```

```
th_deg = rad2deg(th)
```

```
th_deg = 174.1787
```

```
dE = E - E0
```

```
dE = 1.5666
```

```
f = 1 - a/r0_mag * (1-cos(dE))
```

```
f = -0.1289
```

```
g = dt - sqrt(a^3/mu) * (dE - sin(dE))
```

```
g = 1.7312e+04
```

```
r_mag = p / (1+e*cos(th)), v_mag = sqrt(mu*(2/r_mag-1/a))
```

```
r_mag = 6.0534e+04
v_mag = 1.6496
```

```
fdot = -sqrt(mu/a^3)*a^2/(r_mag*r0_mag) * sin(dE)
```

```
fdot = -6.0536e-05
```

```
gdot = 1 - a/r_mag * (1 - cos(dE))
```

```
gdot = 0.3724
```

Part d)

```
r_r0v0 = [f/r0_mag g/v0_mag]
```

```
r_r0v0 = 1×2
10^3 ×
   -0.0000    4.7576
```

```
v_r0v0 = [fdot/r0_mag gdot/v0_mag]
```

```
v_r0v0 = 1×2
   -0.0000    0.1023
```

```
f_dth = 1 - r_mag/p * (1 - cos(th - th0))
```

```
f_dth = -0.1289
```

```
g_dth = r_mag * r0_mag / sqrt(mu*p) * sin(th-th0)
```

```
g_dth = 1.7312e+04
```

```
r_I = f*r0 + g*v0
```

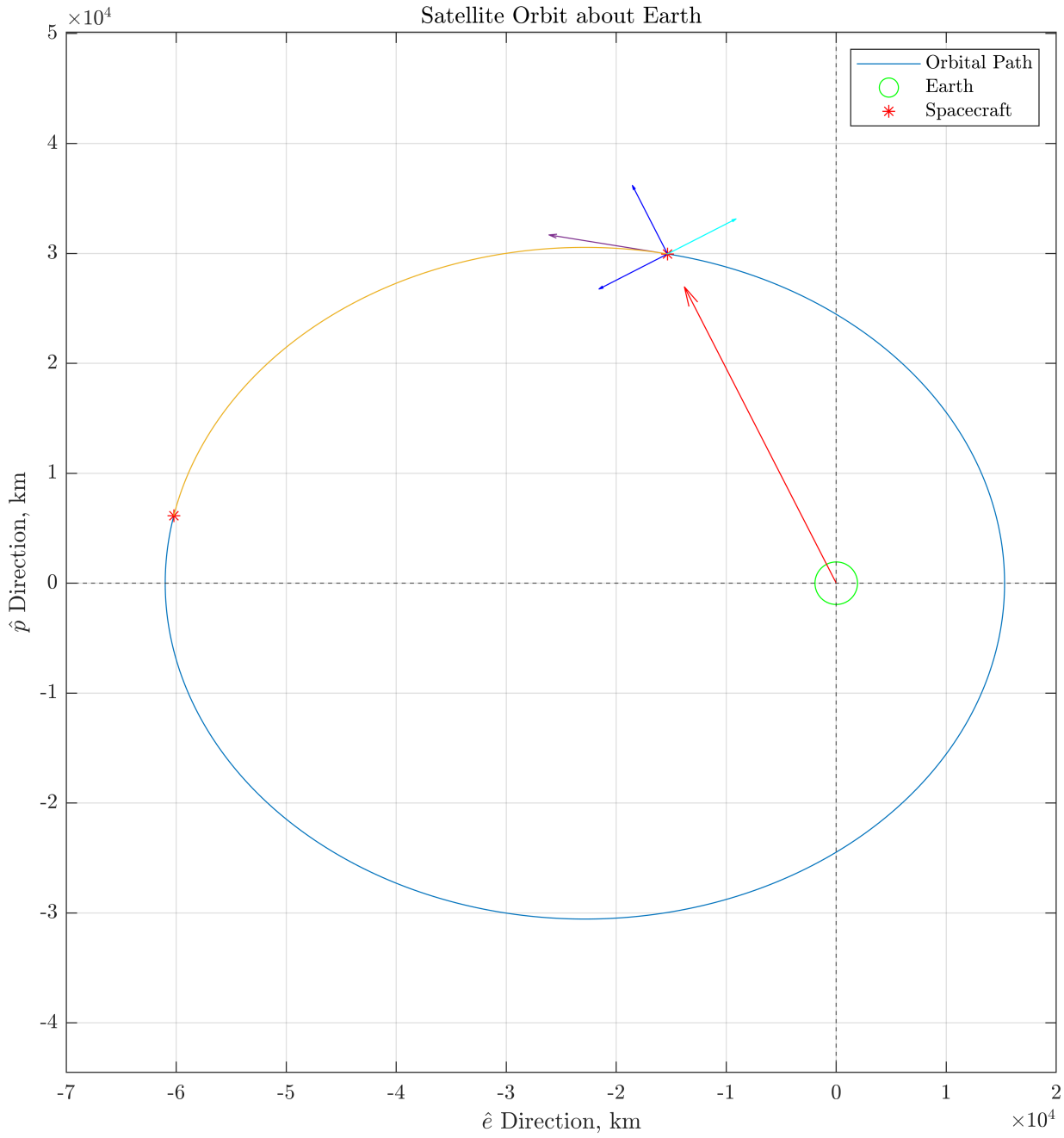
```
r_I = 1×2
10^4 ×
   -6.0222    0.6140
```

```
v_I = fdot*r0 + gdot*v0
```

```
v_I = 1×2
   -0.4094   -1.5980
```

Part e)

```
th_plot = linspace(0,2*pi,2^10);
r_plot = p./(1+e*cos(th_plot)); rx = r_plot.*cos(th_plot); ry = r_plot.*sin(th_plot);
plot(rx,ry)
hold on
plot(0,0,'go','markersize',20)
plot(r0(1),r0(2),'r*')
plot(r_I(1),r_I(2),'r*')
grid on
quiver(r0(1),r0(2),cos(th0),sin(th0),7e3,'b')% r hat
quiver(r0(1),r0(2),-sin(th0),cos(th0),7e3,'b')% th hat
quiver(r0(1),r0(2),sin(th0),-cos(th0),7e3,'c')% local horizon
quiver(r0(1),r0(2),v0(1),v0(2),3e3,'color','#7E2F8E') % v0 vector
quiver(r0(1),r0(2),'r') % r0 vector
th_plot = linspace(th0,th,2^10);
r_plot = p./(1+e*cos(th_plot)); rx = r_plot.*cos(th_plot); ry = r_plot.*sin(th_plot);
plot(rx,ry)
xline(0,'--'),yline(0,'--')
set(gcf,'position',[0,0,800,800])
xlim([-7 2]*1e4)
ylim([-4 4]*1e4)
axis equal
xlabel('$\hat{e}$ Direction, km')
ylabel('$\hat{p}$ Direction, km')
legend('Orbital Path','Earth','Spacecraft','')
title('Satellite Orbit about Earth')
```



Function 1: Bessel function

```
function jm = bessel(m,e)
jm = 0;
    for n = 0:20
        jm = jm + (-1)^n * (m*e/2)^(n+m) / (factorial(n)*factorial(m+n));
    end
end
```