Problem 3

```
Rv = 6051.9;
mu = 324858.59882646;

a = 8*Rv
```

```
a = 4.8415e+04
```

```
e = 0.7
```

```
e = 0.7000
```

```
inc_deg = 30, inc = deg2rad(inc_deg)
```

```
inc_deg = 30
inc = 0.5236
```

```
om_deg = 60, om = deg2rad(om_deg)
```

```
om_deg = 60
om = 1.0472
```

```
w_deg = 90, w = deg2rad(w_deg)
```

```
w_deg = 90
w = 1.5708
```

Part a)

```
% Original Orbit Characteristics
ths_deg = 235, ths = deg2rad(ths_deg), th = w + ths, th_deg = rad2deg(th)
```

```
ths_deg = 235
ths = 4.1015
th = 5.6723
th_deg = 325
```

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

```
p = 2.4692e+04
```

```
iCr = findDCM(om,inc,th)
```

```
iCr = 3×3
    0.8398   -0.3276    0.4330
    0.4610    0.8514   -0.2500
   -0.2868    0.4096    0.8660
```

```
rmag = p/(1+e*cos(ths))
```

```
rmag = 4.1256e+04
```

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

```
r_r = 3×1
10^4 ×
```

```
    4.1256
         0
         0
```

```
r = iCr * r_r
```

```
r = 3×1
10^4 ×
    3.4645
    1.9021
   -1.1832
```

```
vmag = sqrt(mu*(2/rmag - 1/a))
```

```
vmag = 3.0064
```

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

```
hmag = 8.9562e+04
```

```
gamma = -acos(hmag/(rmag*vmag)), gamma_deg = rad2deg(gamma)
```

```
gamma = -0.7640
gamma_deg = -43.7735
```

```
v_r = vmag*[sin(gamma), cos(gamma), 0]'
```

```
v_r = 3×1
   -2.0799
    2.1709
         0
```

```
v = iCr * v_r
```

```
v = 3×1
   -2.4577
    0.8895
    1.4856
```

```
h = cross(r,v)
```

```
h = 3×1
10^4 ×
    3.8781
   -2.2390
    7.7563
```

```
% New Orbit Characteristics
e1 = 0.5, w1_deg = w_deg - 30, w1 = deg2rad(w1_deg), dw_deg = -30, dw = deg2rad(dw_deg)
```

```
e1 = 0.5000
w1_deg = 60
w1 = 1.0472
dw_deg = -30
dw = -0.5236
```

```
inc1 = inc, inc1_deg = inc_deg, om1 = om, om1_deg = om_deg
```

```
inc1 = 0.5236
```

```
inc1_deg = 30
om1 = 1.0472
om1_deg = 60
```

```
ths1 = ths - dw, ths1_deg = rad2deg(ths1)
```

```
ths1 = 4.6251
ths1_deg = 265
```

```
th1 = w1 + ths1, th1_deg = rad2deg(th1)
```

```
th1 = 5.6723
th1_deg = 325
```

```
r1mag = rmag, r1 = r, r1_r = r_r
```

```
r1mag = 4.1256e+04
r1 = 3×1
10^4 ×
    3.4645
    1.9021
   -1.1832
r1_r = 3×1
10^4 ×
    4.1256
         0
         0
```

```
p1 = r1mag * (1+e1*cos(ths1))
```

```
p1 = 3.9458e+04
```

```
a1 = p1/(1-e1^2)
```

```
a1 = 5.2611e+04
```

```
v1mag = sqrt(mu*(2/r1mag - 1/a1))
```

```
v1mag = 3.0941
```

```
h1mag = sqrt(mu*p1)
```

```
h1mag = 1.1322e+05
```

```
gamma1 = -acos(h1mag/(r1mag*v1mag)), gamma1_deg = rad2deg(gamma1)
```

```
gamma1 = -0.4801
gamma1_deg = -27.5102
```

```
iCr1 = findDCM(om1,inc1,th1)
```

```
iCr1 = 3×3
    0.8398   -0.3276    0.4330
    0.4610    0.8514   -0.2500
   -0.2868    0.4096    0.8660
```

```
v1_r = v1mag*[sin(gamma1), cos(gamma1), 0]'
```

```
v1_r = 3×1
   -1.4292
    2.7443
         0
```

```
v1 = iCr1 * v1_r
```

```
v1 = 3×1
   -2.0991
    1.6777
    1.5339
```

```
% Delta V Characteristics
dv1 = v1 - v
```

```
dv1 = 3×1
    0.3586
    0.7882
    0.0483
```

```
dv1mag = norm(dv1)
```

```
dv1mag = 0.8673
```

```
dv1_r = v1_r - v_r
```

```
dv1_r = 3×1
    0.6507
    0.5734
         0
```

```
vhat = v/vmag
```

```
vhat = 3×1
   -0.8175
    0.2959
    0.4941
```

```
nhat = h/hmag
```

```
nhat = 3×1
    0.4330
   -0.2500
    0.8660
```

```
bhat = cross(vhat,nhat)
```

```
bhat = 3×1
    0.3798
    0.9219
    0.0763
```

```
iCv = [vhat nhat bhat]
```

```
iCv = 3×3
   -0.8175    0.4330    0.3798
    0.2959   -0.2500    0.9219
    0.4941    0.8660    0.0763
```

```
dv1_vnb = iCv.' * dv1
```

```
dv1_vnb = 3×1
   -0.0361
    0.0000
    0.8665
```

```
beta1 = asin(dv1_vnb(2)), beta1_deg = rad2deg(beta1)
```

```
beta1 = 2.2204e-16
beta1_deg = 1.2722e-14
```

```
alpha1 = acos(dv1_vnb(1)/dv1mag), alpha1_deg = rad2deg(alpha1)
```

```
alpha1 = 1.6124
alpha1_deg = 92.3850
```

```
alpha1_check = asin(dv1_vnb(3)/dv1mag); alpha1_check = [alpha1_check pi-alpha1_check]
```

```
alpha1_check = 1×2
    1.5292    1.6124
```

```
phi1 = alpha1 + gamma, phi1_deg = rad2deg(phi1)
```

```
phi1 = 0.8484
phi1_deg = 48.6115
```

```
dgamma1 = gamma1 - gamma, dgamma1_deg = rad2deg(dgamma1)
```

```
dgamma1 = 0.2838
dgamma1_deg = 16.2633
```

```
% check using dv1_r
beta1 = asin(dv1_r(3)), beta1_deg = rad2deg(beta1)
```

```
beta1 = 0
beta1_deg = 0
```

```
phi1 = asin(dv1_r(1)/dv1mag); phi1 = [phi1 pi-phi1]
```

```
phi1 = 1×2
    0.8484    2.2932
```

```
phi1_check = acos(dv1_r(2)/dv1mag), phi1 = phi1(1), phi1_deg = rad2deg(phi1)
```

```
phi1_check = 0.8484
phi1 = 0.8484
phi1_deg = 48.6115
```

```
alpha1 = phi1 - gamma, alpha1_deg = rad2deg(alpha1)
```

```
alpha1 = 1.6124
alpha1_deg = 92.3850
```

```
r1a = p1/(1+e1*cos(pi))
```

```
r1a = 7.8917e+04
```

```
r1p = p1/(1+e1*cos(0))
```

```
r1p = 2.6306e+04
```

```
period1 = 2*pi*sqrt(a1^3/mu), period1_hr = period1/3600, period1_days = period1_hr/24
```

```
period1 = 1.3303e+05
period1_hr = 36.9529
period1_days = 1.5397
```

```
E1 = eccenAnom(ths1,e1), E1_deg = rad2deg(E1)
```

```
E1 = -1.1245
E1_deg = -64.4274
```

Part b)

```
dv2mag = 1, phi2_deg = 40, phi2 = deg2rad(phi2_deg)
```

```
dv2mag = 1
phi2_deg = 40
phi2 = 0.6981
```

```
beta2_deg = -30, beta2 = deg2rad(beta2_deg)
```

```
beta2_deg = -30
beta2 = -0.5236
```

```
% OG Orbit Characteristics
ths_deg = 150, ths = deg2rad(ths_deg)
```

```
ths_deg = 150
ths = 2.6180
```

```
th = w + ths, th_deg = rad2deg(th)
```

```
th = 4.1888
th_deg = 240.0000
```

```
iCr = findDCM(om,inc,th)
```

```
iCr = 3×3
    0.3995    0.8080    0.4330
   -0.8080    0.5335   -0.2500
   -0.4330   -0.2500    0.8660
```

```
rmag = p/(1+e*cos(ths))
```

```
rmag = 6.2704e+04
```

```
r_r = rmag * [1;0;0]
```

```
r_r = 3×1
10^4 ×
    6.2704
         0
         0
```

```
r = iCr * r_r
```

```
r = 3×1
10^4 ×
    2.5051
   -5.0666
   -2.7152
```

```
vmag = sqrt(mu*(2/rmag - 1/a))
```

```
vmag = 1.9110
```

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

```
hmag = 8.9562e+04
```

```
gamma = acos(hmag/(rmag*vmag)), gamma_deg = rad2deg(gamma)
```

```
gamma = 0.7266
gamma_deg = 41.6312
```

```
v_r = vmag*[sin(gamma), cos(gamma), 0]'
```

```
v_r = 3×1
    1.2695
    1.4283
         0
```

```
v = iCr * v_r
```

```
v = 3×1
    1.6613
   -0.2638
   -0.9068
```

```
h = cross(r,v)
```

```
h = 3×1
10^4 ×
    3.8781
   -2.2390
    7.7563
```

```
dv2_r = dv2mag*[cos(beta2)*sin(phi2), cos(beta2)*cos(phi2), sin(beta2)]'
```

```
dv2_r = 3×1
    0.5567
    0.6634
   -0.5000
```

```
dv2 = iCr * dv2_r
```

```
dv2 = 3×1
    0.5419
    0.0291
   -0.8399
```

```
alpha2 = phi2-gamma
```

```
alpha2 = -0.0285
```

```
dv2_vnb = [cos(beta2)*cos(alpha2);sin(beta2);cos(beta2)*sin(alpha2)]
```

```
dv2_vnb = 3×1
    0.8657
   -0.5000
   -0.0247
```

```
% Post Maneuver
v2 = dv2 + v
```

```
v2 = 3×1
    2.2032
   -0.2347
   -1.7467
```

```
v2_r = dv2_r + v_r, v2mag = norm(v2)
```

```
v2_r = 3×1
    1.8262
    2.0917
   -0.5000
v2mag = 2.8214
```

```
r2 = r, r2mag = rmag
```

```
r2 = 3×1
10^4 ×
    2.5051
   -5.0666
   -2.7152
r2mag = 6.2704e+04
```

```
a2 = mu/2/(mu/r2mag - v2mag^2/2)
```

```
a2 = 1.3528e+05
```

```
h2 = cross(r2,v2)
```

```
h2 = 3×1
10^5 ×
    0.8213
   -0.1606
    1.0575
```

```
h2mag = norm(h2)
```

```
h2mag = 1.3486e+05
```

```
p2 = h2mag^2/mu
```

```
p2 = 5.5981e+04
```

```
e2 = sqrt(1-p2/a2)
```

```
e2 = 0.7656
```

```
ths2 = acos(1/e2 * (p2/r2mag - 1)), ths2_deg = rad2deg(ths2)
```

```
ths2 = 1.7113
ths2_deg = 98.0496
```

```
r2hat = r2/r2mag
```

```
r2hat = 3×1
    0.3995
   -0.8080
   -0.4330
```

```
h2hat = h2/h2mag
```

```
h2hat = 3×1
    0.6090
   -0.1191
    0.7842
```

```
th2hat = cross(h2hat, r2hat)
```

```
th2hat = 3×1
    0.6852
    0.5770
   -0.4445
```

```
iCr2 = [r2hat, th2hat, h2hat]
```

```
iCr2 = 3×3
    0.3995    0.6852    0.6090
   -0.8080    0.5770   -0.1191
   -0.4330   -0.4445    0.7842
```

```
i2 = acos(h2hat(3)), i2_deg = rad2deg(i2)
```

```
i2 = 0.6694
i2_deg = 38.3556
```

```
om2 = asin(h2hat(1)/sin(i2)); om2 = [om2 pi-om2]
```

```
om2 = 1×2
    1.3776    1.7640
```

```
om2check = acos(-h2hat(2)/sin(i2)), om2 = om2(1), om2_deg = rad2deg(om2)
```

```
om2check = 1.3776
om2 = 1.3776
om2_deg = 78.9327
```

```
th2 = asin(r2hat(3)/sin(i2)); th2 = [th2 pi-th2]
```

```
th2 = 1×2
   -0.7723    3.9139
```

```
th2check = 2*pi- acos(th2hat(3)/sin(i2))
```

```
th2check = 3.9139
```

```
th2 = -(2*pi -th2(2)), th2_deg = rad2deg(th2)
```

```
th2 = -2.3693
th2_deg = -135.7493
```

```
w2 = th2 - ths2, w2_deg = rad2deg(w2)
```

```
w2 = -4.0806
w2_deg = -233.7989
```

```
r2a = p2/(1+e2*cos(pi))
```

```
r2a = 2.3886e+05
```

```
r2p = p2/(1+e2*cos(0))
```

```
r2p = 3.1706e+04
```

```
period2 = 2*pi*sqrt(a2^3/mu), period2_hr = period2/3600, period2_days = period2_hr/24
```

```
period2 = 5.4854e+05
period2_hr = 152.3712
period2_days = 6.3488
```

```
E2 = eccenAnom(ths2,e2), E2_deg = rad2deg(E2)
```

```
E2 = 0.7944
E2_deg = 45.5144
```

Function 1: Find Direction Cosine Matrix

```
function iCr = findDCM(om,inc,th)
    col1 = [cos(om)*cos(th) - sin(om)*cos(inc)*sin(th);
        sin(om)*cos(th)+cos(om)*cos(inc)*sin(th);
        sin(inc)*sin(th)];
%     col2 = [-cos(om)*sin(th)-sin(om)*cos(inc)*cos(th);
%         -sin(om)*sin(th)+cos(om)*cos(inc)*cos(th);
%         sin(inc)*cos(th)];
    col3 = [sin(om)*sin(inc);
        -cos(om)*sin(inc);
        cos(inc)];

    col2 = cross(col3,col1);
    iCr = [col1 col2 col3];
end
```

Function 4: Eccentric Anomaly

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