Problem 2

Constants:

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

Part a)

```
r = [2.12, 2.73, -0.60]'*Re % km
```

```
r = 3×1
10^4 ×
    1.3522
    1.7412
   -0.3827
```

```
v = [-3.40, 1.62, 2.90]' % km/s
```

```
v = 3×1
   -3.4000
    1.6200
    2.9000
```

```
% r = [1.6772 -1.6772 2.3719]'*Re
% v = [3.1574 2.4987 0.4658]'
rmag = sqrt(r(1)^2+r(2)^2+r(3)^2)
```

```
rmag = 2.2375e+04
```

```
vmag = sqrt(v(1)^2+v(2)^2+v(3)^2)
```

```
vmag = 4.7534
```

```
a = mu/2/(mu/rmag-vmag^2/2)
```

```
a = 3.0582e+04
```

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

```
h = 3×1
10^4 ×
    5.6695
   -2.6201
    8.1106
```

```
hmag = norm(h)
```

```
hmag = 1.0237e+05
```

```
p = hmag^2/mu
```

```
p = 2.6290e+04
```

```
e = sqrt(1-p/a)
```

```
e = 0.3746
```

```
hhat = h/hmag
```

```
hhat = 3×1
    0.5538
   -0.2560
    0.7923
```

```
i = acos(hhat(3))
```

```
i = 0.6562
```

```
i_deg = rad2deg(i)
```

```
i_deg = 37.5983
```

```
om = asin(hhat(1)/sin(i)); om = [pi-om om]
```

```
om = 1×2
    2.0037    1.1379
```

```
om_check = acos(-hhat(2)/sin(i))*[1 -1]
```

```
om_check = 1×2
    1.1379   -1.1379
```

```
om = om(2), omg_deg = rad2deg(om) %%%%%
```

```
om = 1.1379
omg_deg = 65.1963
```

```
rhat = r/rmag
```

```
rhat = 3×1
    0.6043
    0.7782
   -0.1710
```

```
thhat = cross(hhat,rhat)
```

```
thhat = 3×1
   -0.5728
    0.5735
    0.5857
```

```
th = asin(rhat(3)/sin(i)); th = [pi-th th]
```

```
th = 1×2
    3.4257   -0.2841
```

```
th_check = acos(thhat(3)/sin(i))*[1 -1]
```

```
th_check = 1×2
    0.2841   -0.2841
```

```
th = th(2), th_deg = rad2deg(th) %%%%%
```

```
th = -0.2841
```

```
th_deg = -16.2793
```

```
r_dot = dot(v,rhat)
```

```
r_dot = -1.2900
```

```
ths = sign(r_dot)*acos(1/e * (p/rmag-1))
```

```
ths = -1.0850
```

```
ths_deg = rad2deg(ths)
```

```
ths_deg = -62.1640
```

```
th_dot = hmag/rmag^2
```

```
th_dot = 2.0446e-04
```

```
gamma = asin(r_dot/vmag); gamma = gamma * (sign(r_dot) == sign(gamma))
```

```
gamma = -0.2748
```

```
gamma_deg = rad2deg(gamma) %%%%%
```

```
gamma_deg = -15.7463
```

```
w = th - ths, w_deg = rad2deg(w)
```

```
w = 0.8008
w_deg = 45.8847
```

```
% check orbit type
if e < 1
    E = 2*atan(sqrt((1-e)/(1+e))*tan(ths/2))
    E_deg = rad2deg(E)
    M = E - e*sin(E), M_deg = rad2deg(M)
    n = sqrt(mu/a^3)
    dt = M/n
    dt_hr = dt/3600
elseif e > 1
    H = atanh(sqrt((e-1)/(e+1))*tan(ths/2))
    N = e*sinh(H) - H, N_deg = rad2deg(N)
    n = sqrt(mu/abs(a^3))
    dt = N/n
    dt_hr = dt/3600
end
```

```
E = -0.7723
E_deg = -44.2522
M = -0.5109
M_deg = -29.2736
n = 1.1805e-04
dt = -4.3279e+03
dt_hr = -1.2022
```

```
rp = p/(1+e*cos(0)) % collision test
```

```
rp = 1.9125e+04
```

Part b)

```
clear
Re = 6378.1; % Earth radius, km
mu = 398600.4415; % Earth mu, km^3/s^2
r = [10.80 3.600, -2.940]'*Re
```

```
r = 3×1
10^4 ×
    6.8883
    2.2961
   -1.8752
```

```
v = [-5.705 -0.8151 1.997]'
```

```
v = 3×1
   -5.7050
   -0.8151
    1.9970
```

```
rmag = sqrt(r(1)^2+r(2)^2+r(3)^2)
```

```
rmag = 7.4992e+04
```

```
vmag = sqrt(v(1)^2+v(2)^2+v(3)^2)
```

```
vmag = 6.0991
```

```
a = mu/2/(mu/rmag-vmag^2/2)
```

```
a = -1.5003e+04
```

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

```
h = 3×1
10^4 ×
    3.0569
   -3.0582
    7.4846
```

```
hmag = norm(h)
```

```
hmag = 8.6439e+04
```

```
p = hmag^2/mu
```

```
p = 1.8745e+04
```

```
e = sqrt(1-p/a)
```

```
e = 1.4998
```

```
hhat = h/hmag
```

```
hhat = 3×1
    0.3536
   -0.3538
    0.8659
```

```
i = acos(hhat(3))
```

```
i = 0.5239
```

```
i_deg = rad2deg(i)
```

```
i_deg = 30.0160
```

```
om = asin(hhat(1)/sin(i)); om = [pi-om om]
```

```
om = 1×2
    2.3564    0.7852
```

```
om_check = acos(-hhat(2)/sin(i))*[1 -1]
```

```
om_check = 1×2
    0.7852   -0.7852
```

```
om = om(2), omg_deg = rad2deg(om) %%%%%
```

```
om = 0.7852
omg_deg = 44.9875
```

```
rhat = r/rmag
```

```
rhat = 3×1
    0.9185
    0.3062
   -0.2500
```

```
thhat = cross(hhat,rhat)
```

```
thhat = 3×1
   -0.1767
    0.8838
    0.4333
```

```
th = asin(rhat(3)/sin(i)); th = [pi-th th]
```

```
th = 1×2
    3.6650   -0.5234
```

```
th_check = acos(thhat(3)/sin(i))*[1 -1]
```

```
th_check = 1×2
    0.5234   -0.5234
```

```
th = th(2), th_deg = rad2deg(th) %%%%%
```

```
th = -0.5234
```

```
th_deg = -29.9905
```

```
r_dot = dot(v,rhat)
```

```
r_dot = -5.9892
```

```
ths = sign(r_dot)*acos(1/e * (p/rmag-1))
```

```
ths = -2.0945
```

```
ths_deg = rad2deg(ths)
```

```
ths_deg = -120.0058
```

```
th_dot = hmag/rmag^2
```

```
th_dot = 1.5370e-05
```

```
gamma = asin(r_dot/vmag); gamma = gamma * (sign(r_dot) == sign(gamma))
```

```
gamma = -1.3807
```

```
gamma_deg = rad2deg(gamma) %%%%%
```

```
gamma_deg = -79.1064
```

```
w = th - ths, w_deg = rad2deg(w)
```

```
w = 1.5711
w_deg = 90.0153
```

```
% check orbit type
if e < 1
    E = 2*atan(sqrt((1-e)/(1+e))*tan(ths/2))
    E_deg = rad2deg(E)
    M = E - e*sin(E), M_deg = rad2deg(M)
    n = sqrt(mu/a^3)
    dt = M/n
    dt_hr = dt/3600
elseif e > 1
    H = 2*atanh(sqrt((e-1)/(e+1))*tan(ths/2))
    H_deg = rad2deg(H)
    N = e*sinh(H) - H, N_deg = rad2deg(N)
    n = sqrt(mu/abs(a^3))
    dt = N/n
    dt_hr = dt/3600
end
```

```
H = -2.0633
H_deg = -118.2198
N = -3.7448
N_deg = -214.5595
n = 3.4358e-04
dt = -1.0899e+04
```

```
dt_hr = -3.0276
```

```
rp = p/(1+e*cos(0)) % collision test
```

```
rp = 7.4985e+03
```