

Zach Warren

ASTR 3800

Homework 4

Code:

```
import numpy as np
import math as math
import matplotlib.pyplot as plt
import scipy.integrate as integrate

f, plts = plt.subplots(3,2,figsize=(23,15))

def Dc(m,lam,w,z):
    w = 1+ w
    E = lambda y: 1/(np.sqrt((m*math.pow(y+1,3))+ (lam*math.pow(y+1,w))))
    Dc = [3*(integrate.quad(E, 0, x))[0] for x in z]
    return Dc

def DL(z,Dc):
    DL = [(1+z)*Dc for z,Dc in zip(z,Dc)]
    return DL

def DA(z,Dc):
    DA = [Dc/(1+z) for z,Dc in zip(z,Dc)]
    return DA

def VC(Dc):
    Vc = [(4.0/3)*math.pi*math.pow(x,3) for x in Dc]
    return Vc

def t1(m,lam,w,z):
    w = 1+ w
    E = lambda y: 1/((1+y)*(np.sqrt((m*math.pow(y+1,3))+ (lam*math.pow(y+1,w)))))
    t1 = [9.78*(integrate.quad(E, 0, x))[0] for x in z]
    return t1

z = np.linspace(0,3,100)

#part1
Dc1 = Dc(1,0,0,z)
DL1 = DL(z,Dc1)
DA1 = DA(z,Dc1)
Vc1 = VC(Dc1)
t11 = t1(1,0,0,z)

plts[0,0].plot(z,Dc1)
plts[0,1].plot(z,DL1)
plts[1,0].plot(z,DA1)
plts[1,1].plot(z,Vc1)
plts[2,0].plot(z,t11)

#part2
Dc2 = Dc(.25,.75,-1,z)
DL2 = DL(z,Dc2)
DA2 = DA(z,Dc2)
Vc2 = VC(Dc2)
t12 = t1(.25,.75,-1,z)

plts[0,0].plot(z,Dc2, 'r')
plts[0,1].plot(z,DL2, 'r')
plts[1,0].plot(z,DA2, 'r')
plts[1,1].plot(z,Vc2, 'r')
```

```

plt[2,0].plot(z,t12, 'r')

#part3
Dc3 = Dc(.25,.75,-.8,z)
DL3 = DL(z,Dc3)
DA3 = DA(z,Dc3)
Vc3 = VC(Dc3)
t13 = t1(.25,.75,-.8,z)

plt[0,0].plot(z,Dc3, 'c')
plt[0,1].plot(z,DL3, 'c')
plt[1,0].plot(z,DA3, 'c')
plt[1,1].plot(z,Vc3, 'c')
plt[2,0].plot(z,t13, 'c')

#part4
Dc4 = Dc(.25,.75,-1.2,z)
DL4 = DL(z,Dc4)
DA4 = DA(z,Dc4)
Vc4 = VC(Dc4)
t14 = t1(.25,.75,-.12,z)

plt[0,0].plot(z,Dc4, 'g')
plt[0,1].plot(z,DL4, 'g')
plt[1,0].plot(z,DA4, 'g')
plt[1,1].plot(z,Vc4, 'g')
plt[2,0].plot(z,t14, 'g')

#set up plots
plt[0,0].legend(['1','2','3','4'])
plt[0,0].set_title('Comoving Distance vs Redshift')
plt[0,0].set_xlabel('z')
plt[0,0].set_ylabel('Dc (h-1 Gpc)')

plt[0,1].legend(['1','2','3','4'])
plt[0,1].set_title('Luminosity Distance vs Redshift')
plt[0,1].set_xlabel('z')
plt[0,1].set_ylabel('DL (h-1 Gpc)')

plt[1,0].legend(['1','2','3','4'])
plt[1,0].set_title('Angular Diameter Distance vs Redshift')
plt[1,0].set_xlabel('z')
plt[1,0].set_ylabel('DA (h-1 Gpc)')

plt[1,1].legend(['1','2','3','4'])
plt[1,1].set_title('Comoving volume vs Redshift')
plt[1,1].set_xlabel('z')
plt[1,1].set_ylabel('Vc (h-3 Gpc3)')

plt[2,0].legend(['1','2','3','4'])
plt[2,0].set_title('Lookback time vs Redshift')
plt[2,0].set_xlabel('z')
plt[2,0].set_ylabel('t1 (Gyr)')

plt.show()

```

