ESA614: Computational Astrophysics

Assignment # 4

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Program: MS Astronomy and Astrophysics

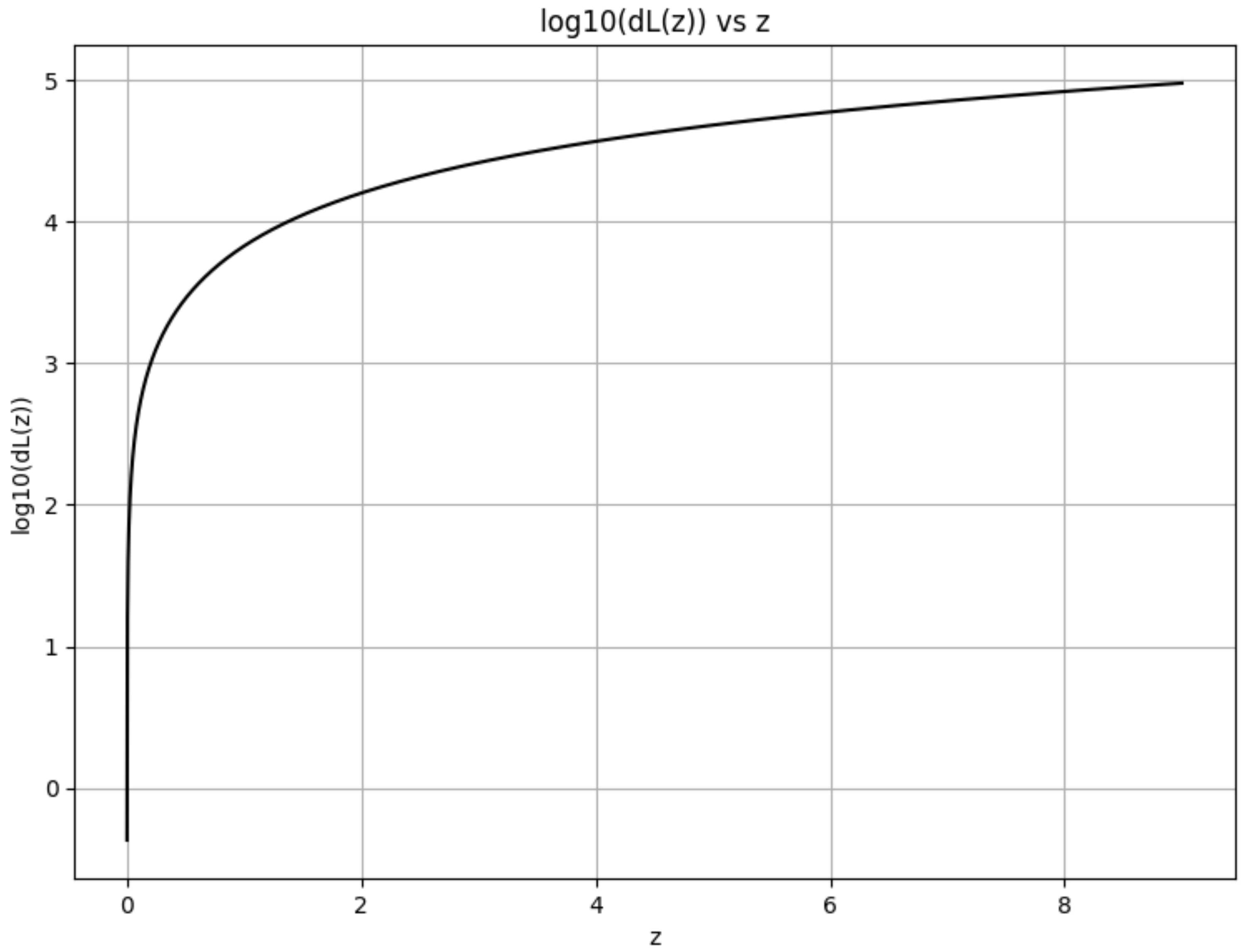
Luminosity distance redshift relation in the standard ΛCDM cosmological model is given by

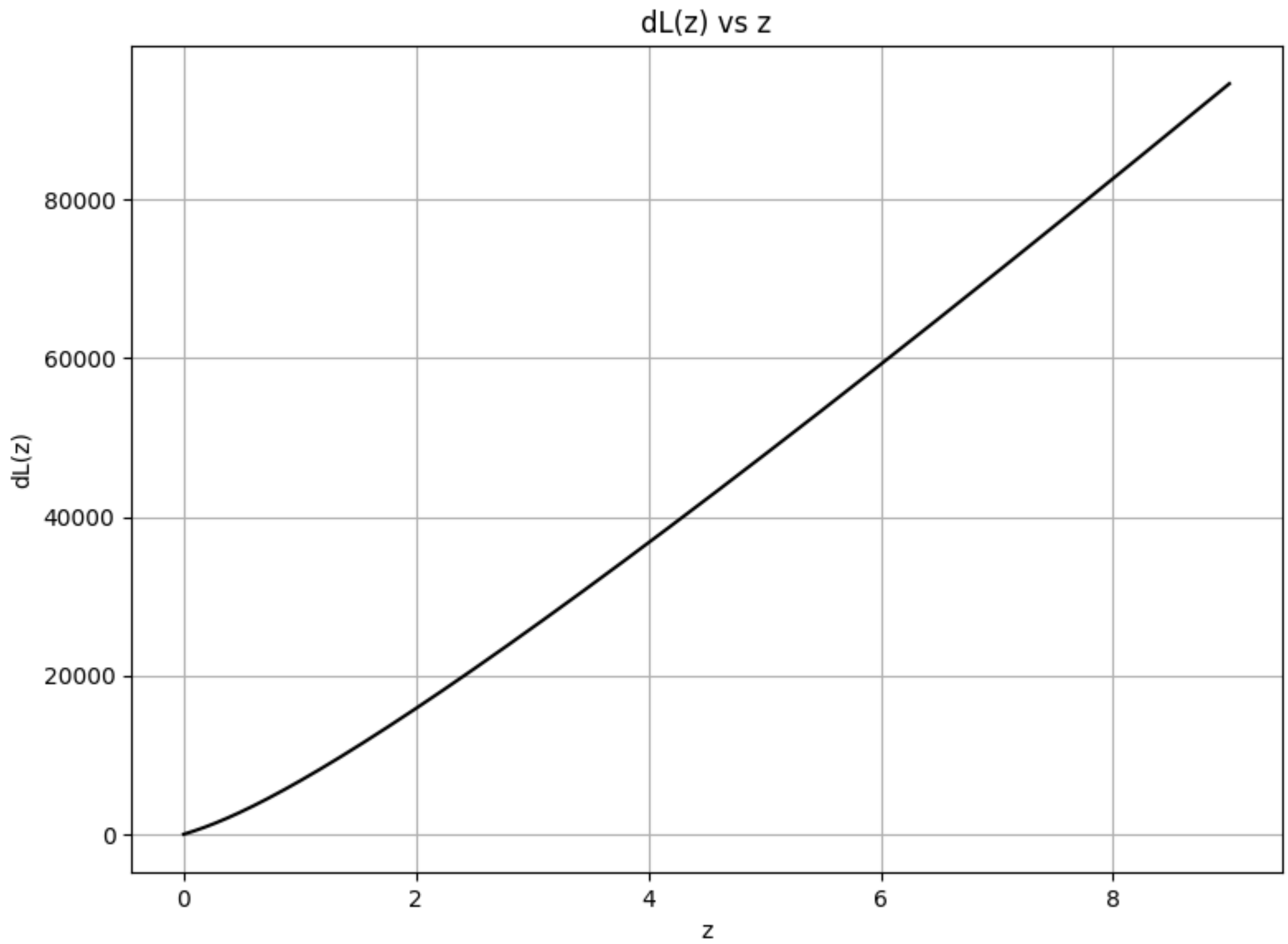
$$d_L = (1+z)\frac{c}{H_0}\int_0^z dz \frac{1}{\left[\Omega_m(1+z)^3 + \Omega_\Lambda\right]^{1/2}},$$

where z is the redshift, H_0 is the Hubble's constant, Ω_m is the density parameter for matter, Ω_Λ is the same for dark energy, and c is the speed of light.

Use the following cosmological parameters derived** using data from the Wilkinson Microwave Anisotropy Probe (WMAP††).
$H_0 = 69.7\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$,
$\Omega_m = 0.282$, and
$\Omega_\Lambda = 0.718$,
Plot $d_L(z)$ vs z for a range of $z \leq 0 \leq 9$. Use Trapezoid method, and code it by yourself.

In [1]:
```python
import math
import numpy as np
import matplotlib.pyplot as plt

plt.style.use('default')
fig = plt.figure(figsize = (9,6.5))

Ho = 69.7 #km s−1 Mpc−1,
Om = 0.282
Oa = 0.718
c = 3 * pow(10,5)
# Trapezoidal Integration
def trap(x,f_x):
    n = len(x)
    h = (x[-1]-x[0])/n
    I = (h/2)*(f_x[0]+f_x[-1]+(2*np.sum(f_x[1:-1])))
    return(I)
# Given function
def d_l(z):
    return((1/(np.sqrt((Om*pow(1+z,3))+Oa))))

I_append = []
z = np.linspace(0.0001,9,5000,endpoint=True)
for i in z:
    n_sample = 5000
    x = np.linspace(0,i,n_sample)
    f_x = d_l(x)
    #print("max(f_x) = ",np.nanmax(f_x))
    I = (1+i)*(c/Ho)*trap(x,f_x)
    I = np.array(I)
    I_append = np.append(I_append,I)
    #print("I = ",I)
    #plt.scatter(i,I,color='black',marker='.')

plt.plot(z,np.log10(I_append),color='black')
plt.xlabel("z")
plt.ylabel("log10(dL(z))")
plt.title("log10(dL(z)) vs z")
plt.grid()
plt.show()

fig = plt.figure(figsize = (9,6.5))
plt.plot(z,I_append,color='black')
plt.xlabel("z")
plt.ylabel("dL(z)")
plt.title("dL(z) vs z")
plt.grid()
plt.show()
```


log10(dL(z)) vs z
log10(dL(z))
z
0
1
2
3
4
5
0
2
4
6
8


dL(z) vs z
dL(z)
z
0
20000
40000
60000
80000
0
2
4
6
8

```
In [ ]:
```