

In [5]:

```
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np
import seaborn as sns
%matplotlib inline
plt.show()
alp=.168*pow(10,-6)
R=0.5
z=500.2
v_avg=.001
del_r=.01
del_z=.2
T_W=50
T_in=20
col=int(R/del_r)
row=int(z/del_z)
def K1(j):
    r=j*del_r
    V=2*v_avg*(1-(pow(r,2)/pow(R,2)))
    return (V/del_z)
def K2(j):
    r=j*del_r
    return (alp/(2*r*del_r))
def K3(j):
    return (alp/(2*pow(del_r,2)))
def K():
    return (alp*del_z/(2*v_avg*pow(del_r,2)))
bound=np.zeros((row,col+1))
bound[0,:col]=T_in

bound[:,col]=T_W
i=0
while i<(row-1):
    T=np.zeros((col,col+1))
    b=np.zeros(col)
    for j in range(col):
        if j==0:
            T[j,j]=1+2*K()
            T[j,j+1]=-2*K()
            b[j]=bound[i,j+1]*(2*K())+bound[i,j]*(1-2*K())
        else:
            T[j,j]=K1(j)+2*K3(j)
            T[j,j+1]=-K2(j)-K3(j)
            T[j,j-1]=K2(j)-K3(j)
            b[j]=bound[i,j+1]*(K2(j)+K3(j))+bound[i,j]*(K1(j)-2*K3(j))+bound[i,j-1]*(K2(j)-K3(j))
    B=b-T[:,col]*T_W
    X=np.linalg.solve(T[:,col],B)
    for l in range(col):
        bound[i+1,l]=X[l]
    i=i+1
left=np.zeros((row,col))
for i in range(col):
    left[:,i]=bound[:,col-i]
T=np.concatenate((left,bound),axis=1)
y1=np.array([- (col-i)*del_r for i in range(col)])
y2=np.array([i*del_r for i in range(col+1)])
y=np.concatenate((y1,y2))
index=[i*del_z for i in range(row)]

plt.figure(figsize=(15,20))
data=pd.DataFrame(T,columns=y,index=index)
sns.heatmap(data,cmap= 'CMRmap')
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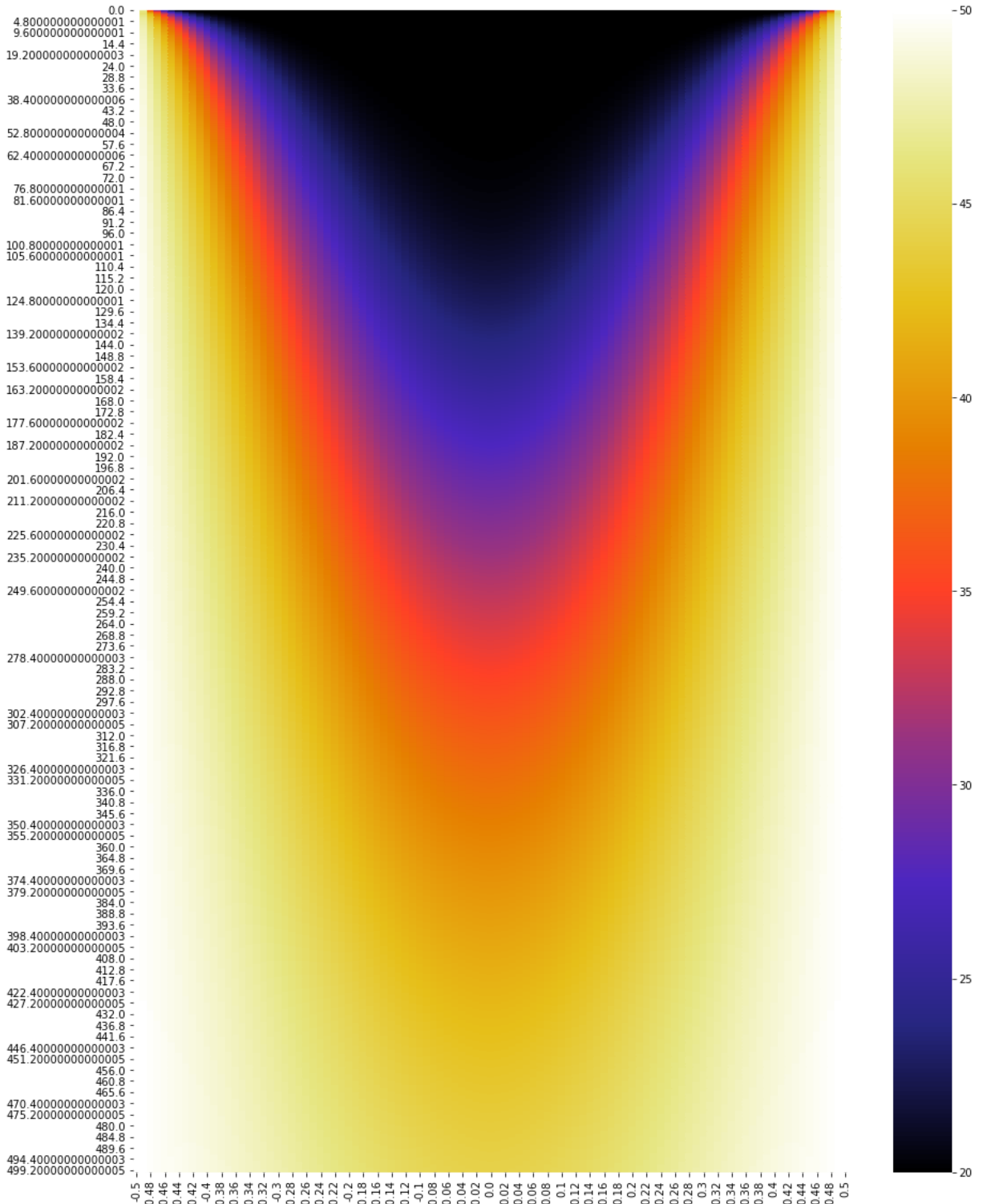
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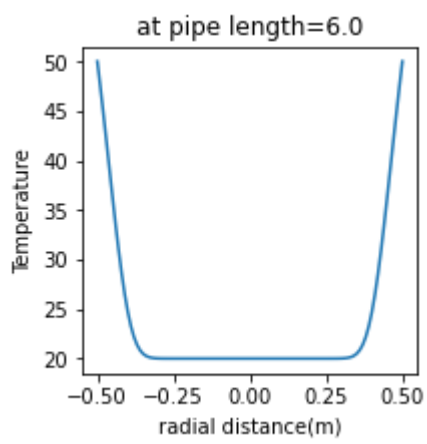
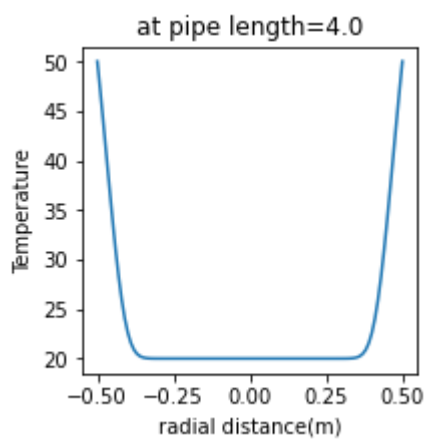
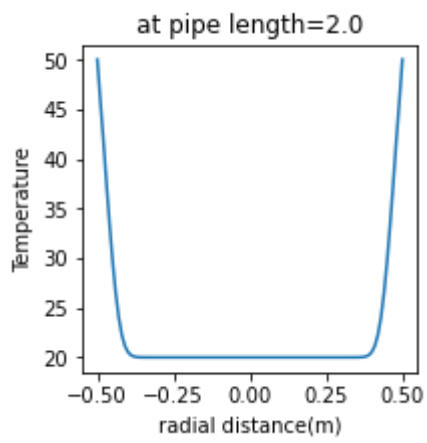
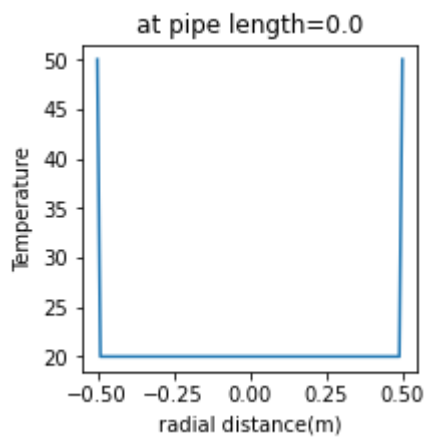
for i in range(int(row/10)):
    plt.figure(figsize=(3,3))
    plt.plot(y,T[i*10,:])
    plt.xlabel('radial distance(m)')
    plt.ylabel('Temperature')
    plt.title('at pipe length={} '.format(i*10*del_z))

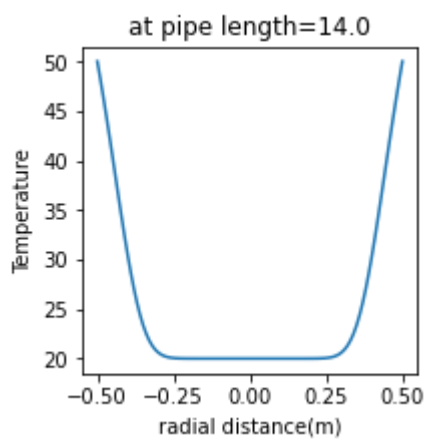
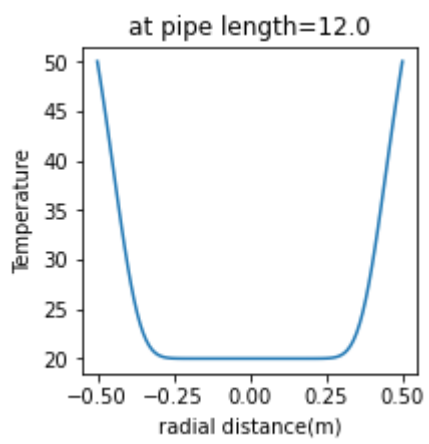
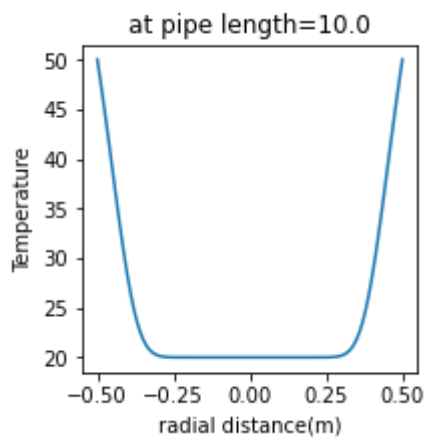
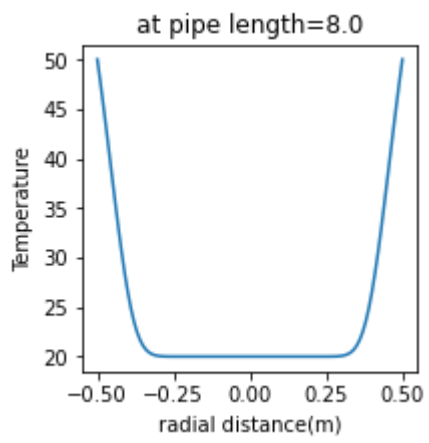
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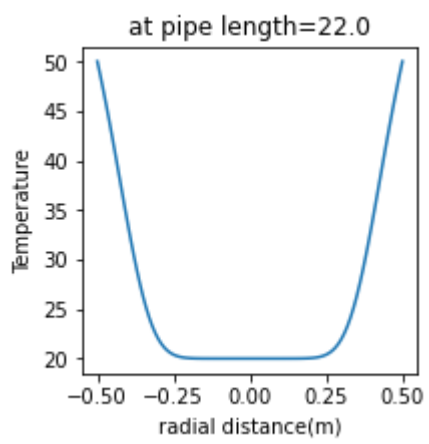
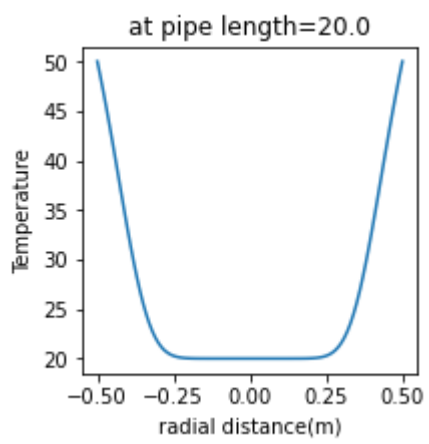
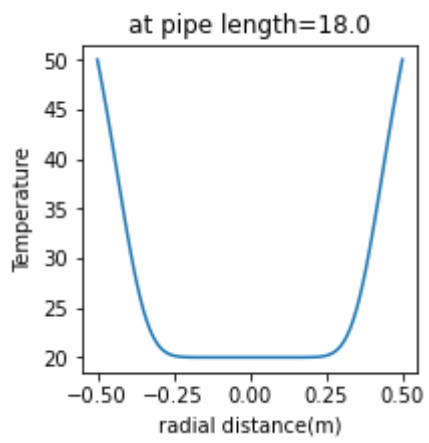
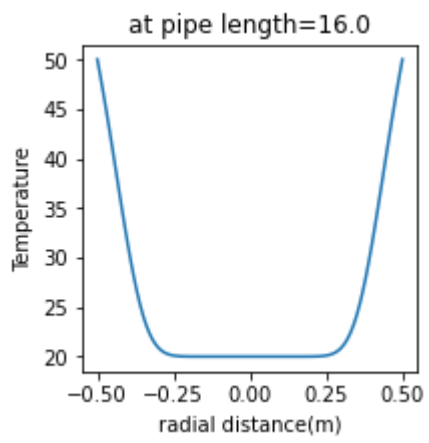
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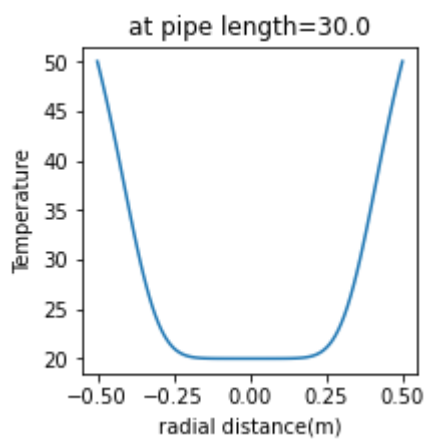
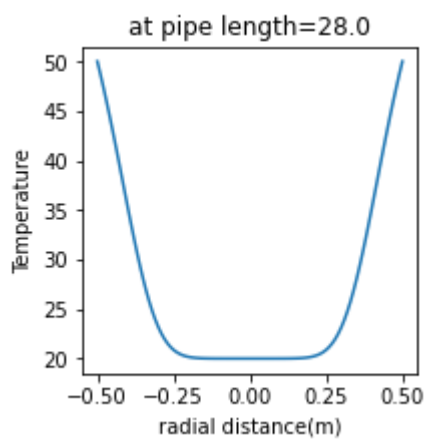
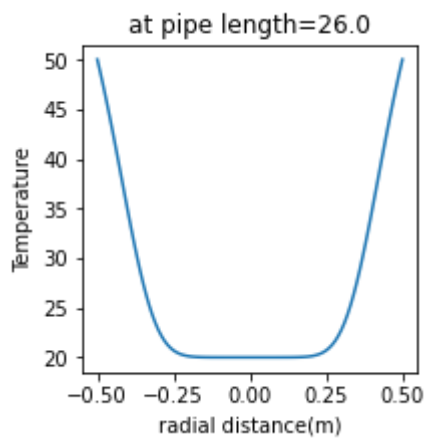
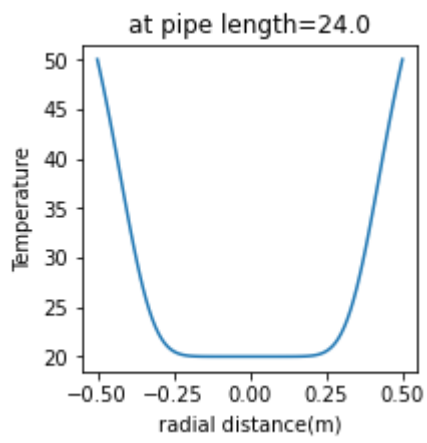
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plt.figure(figsize=(3,3))
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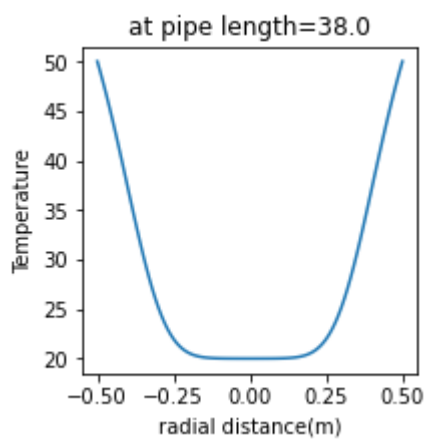
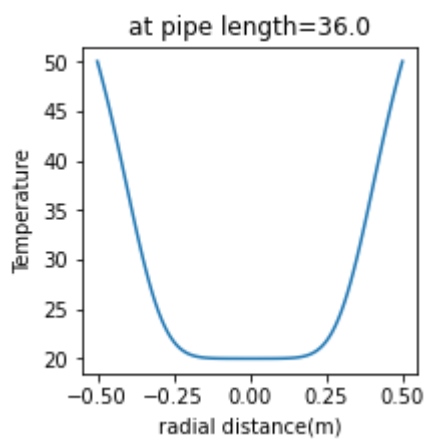
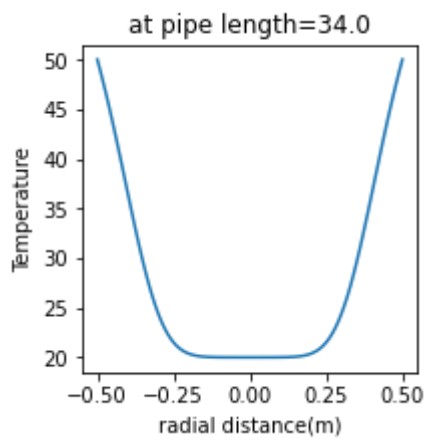
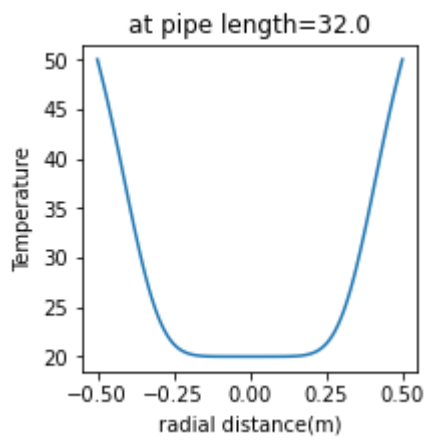


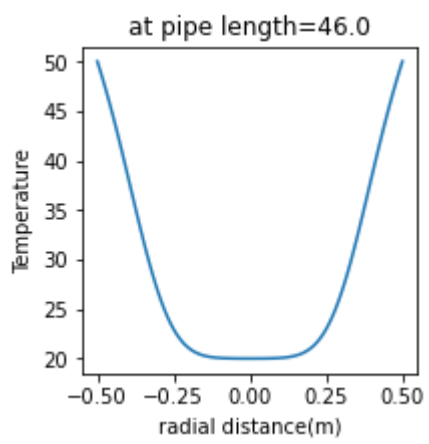
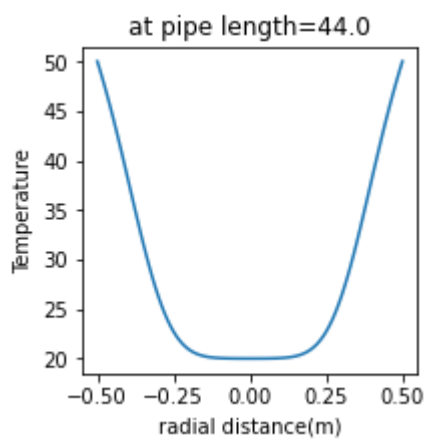
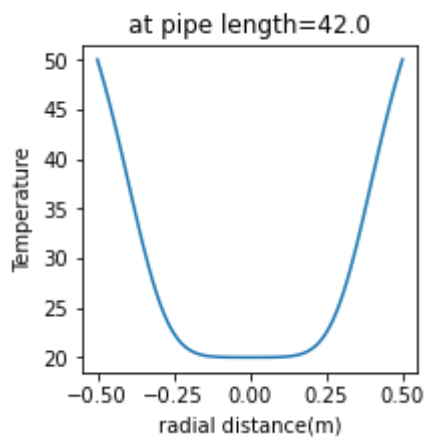
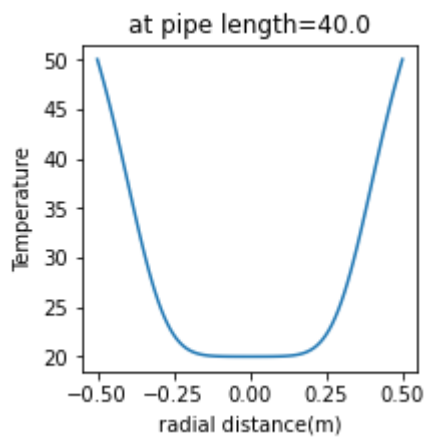


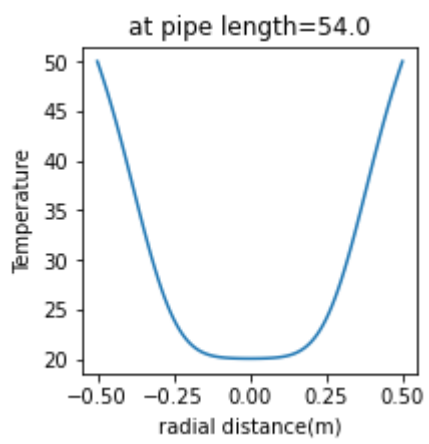
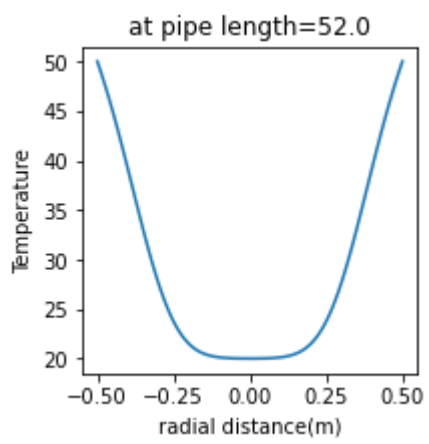
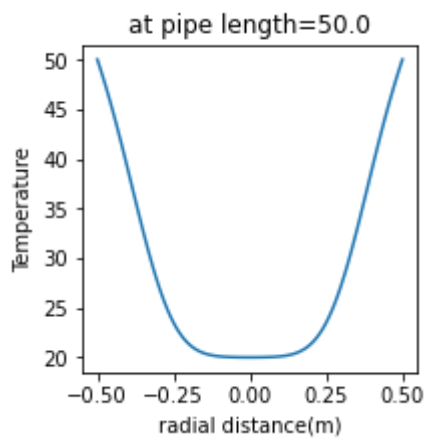
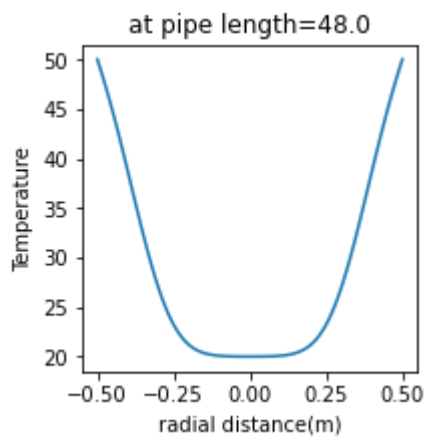


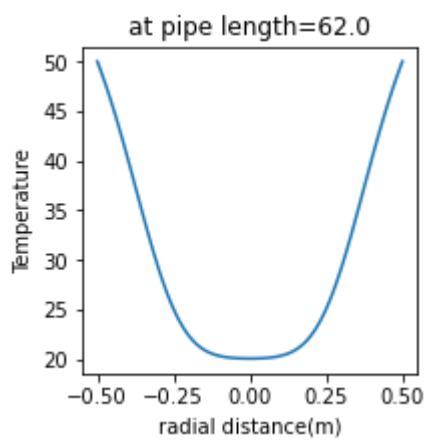
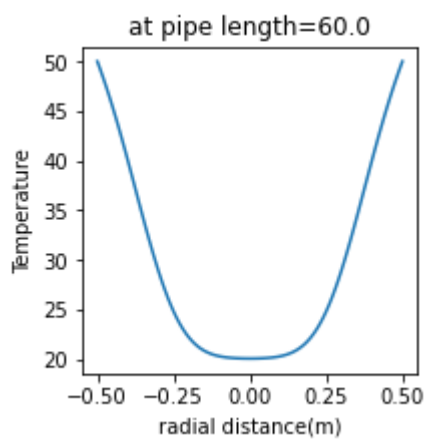
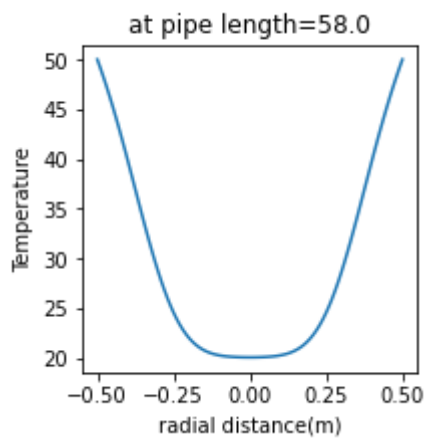
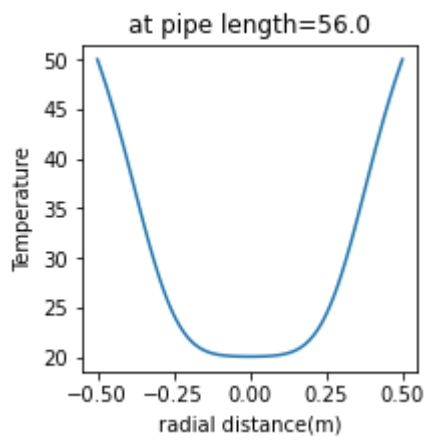


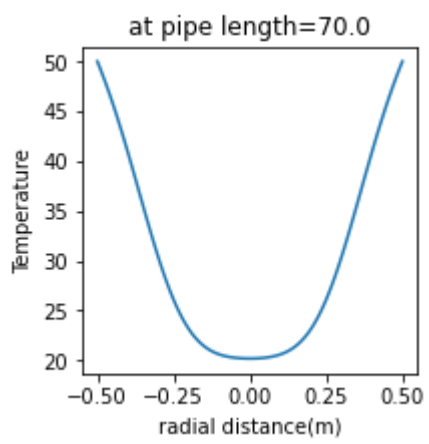
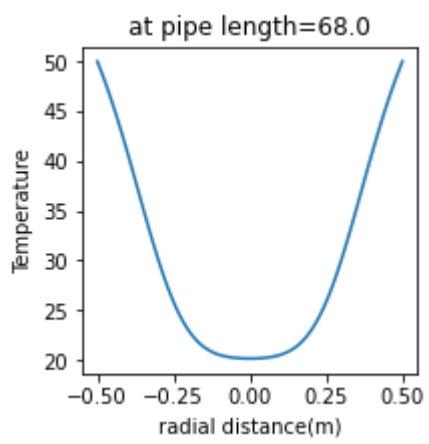
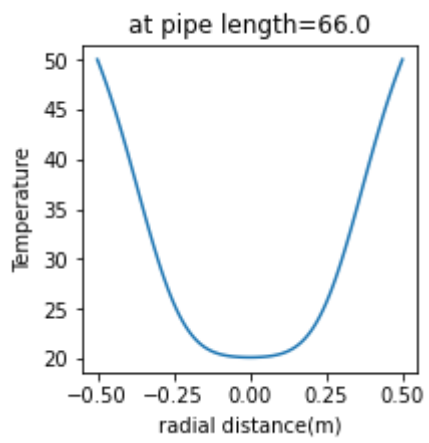
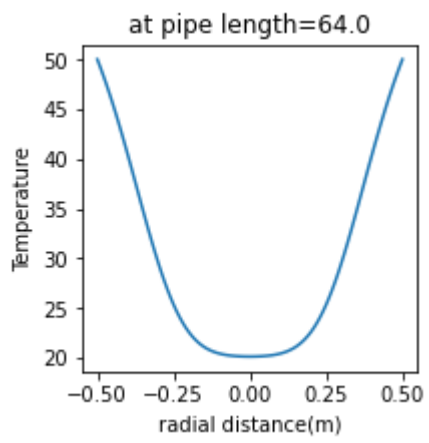


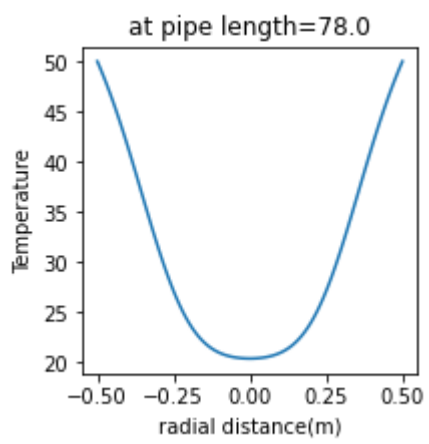
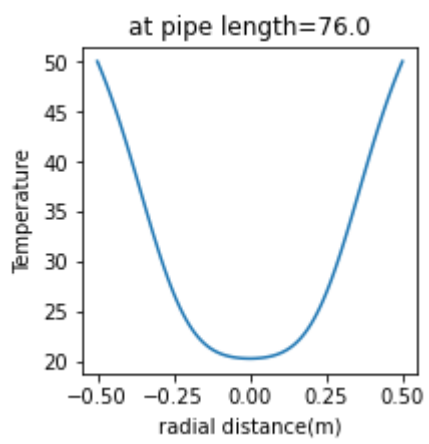
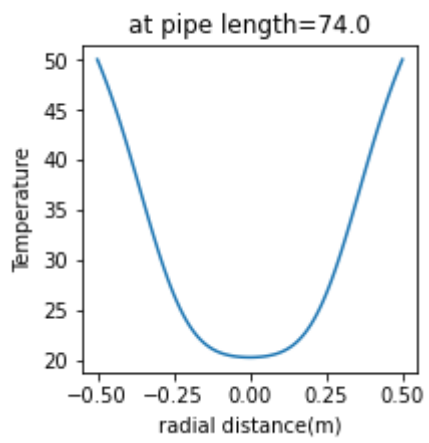
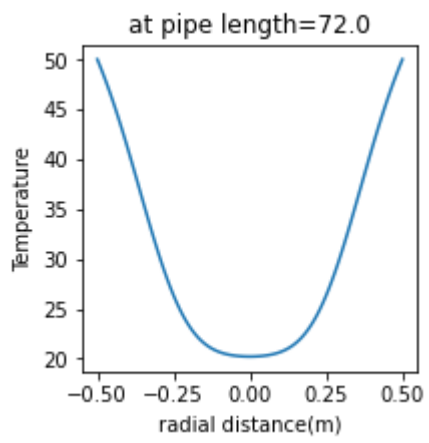


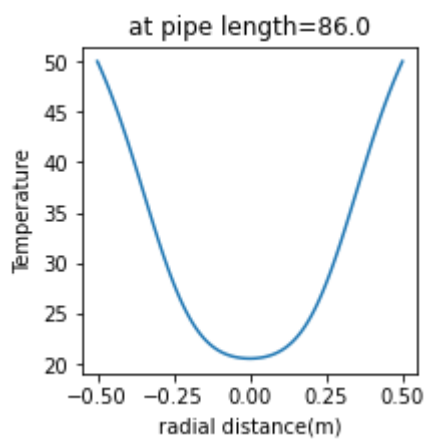
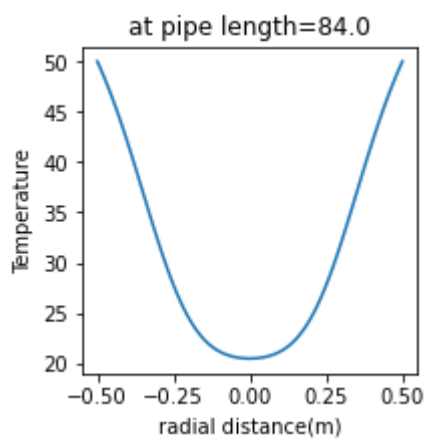
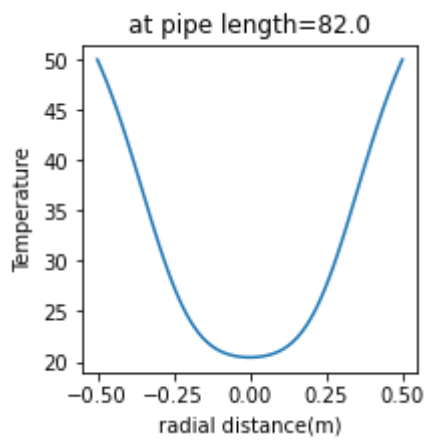
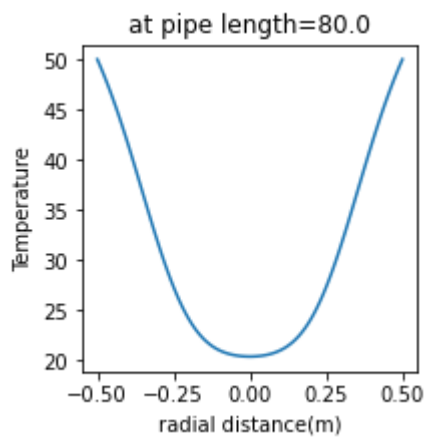


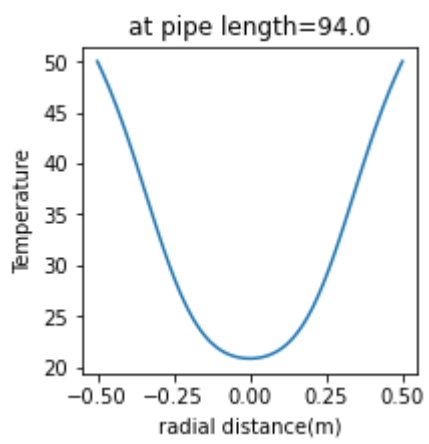
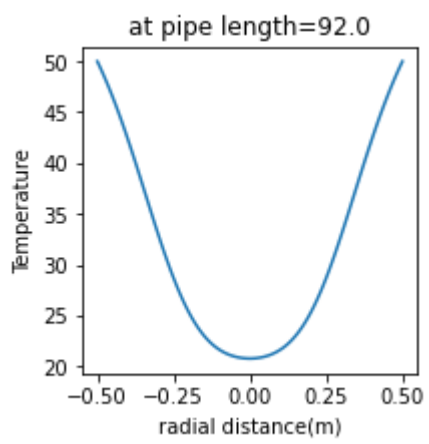
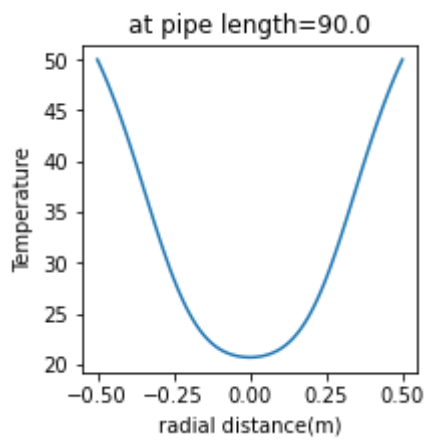
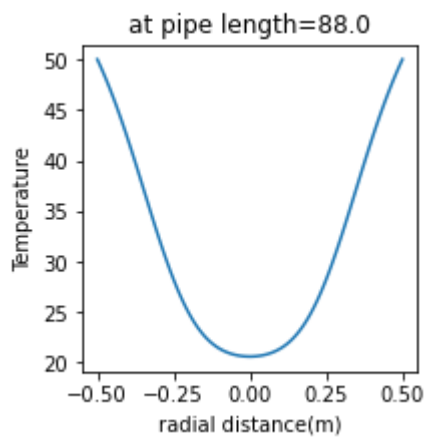


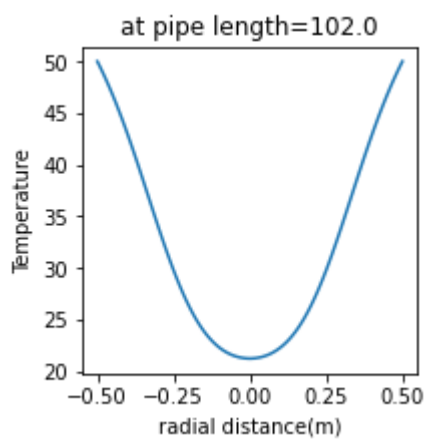
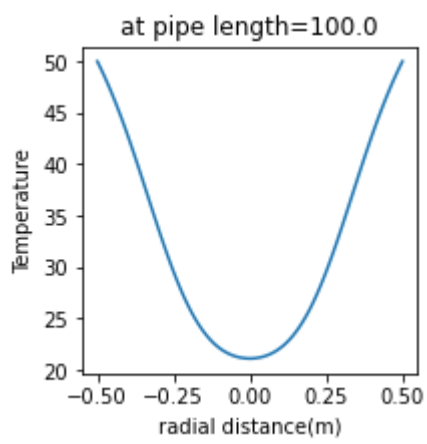
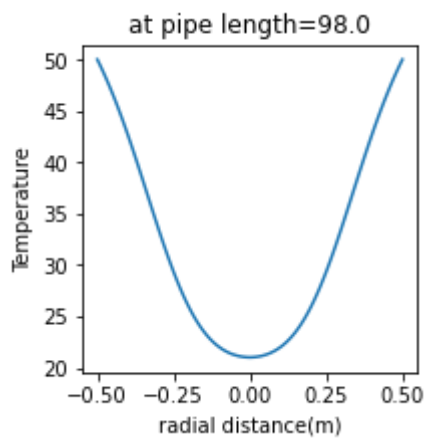
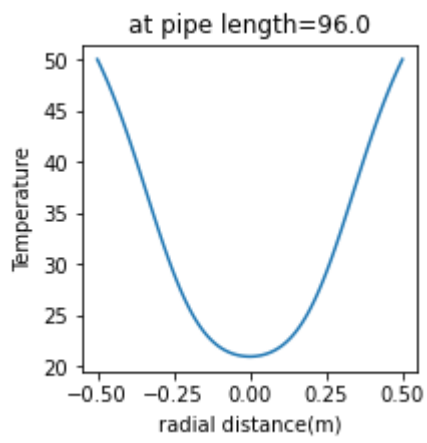


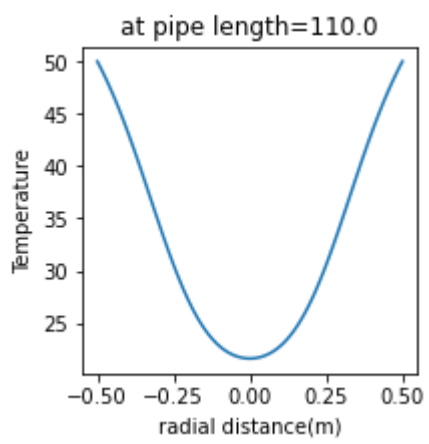
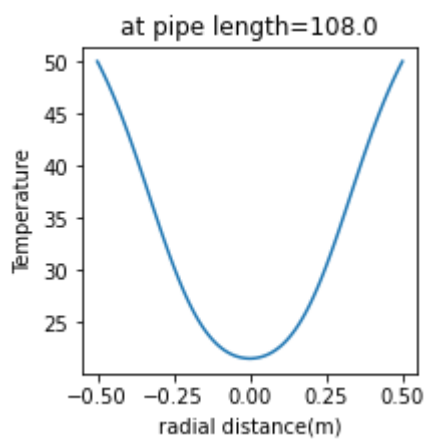
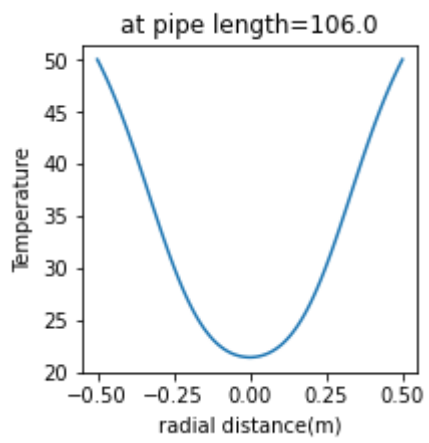
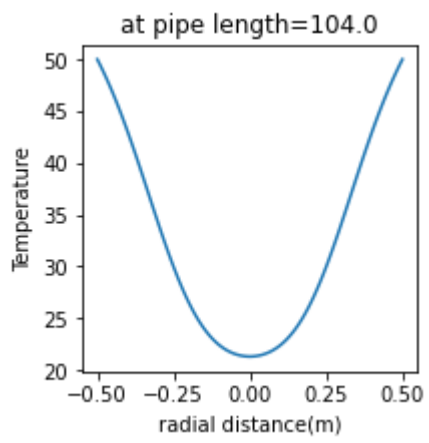


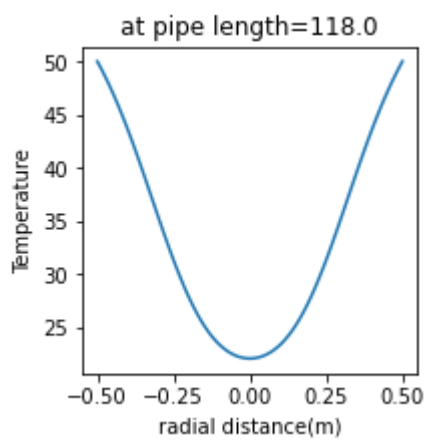
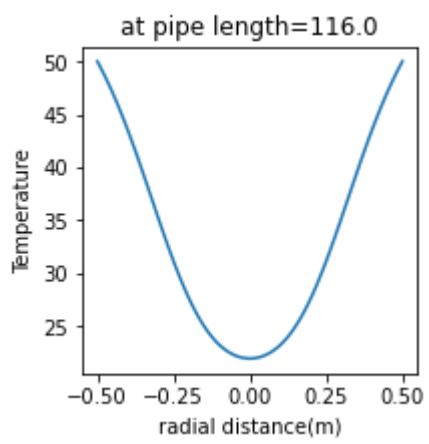
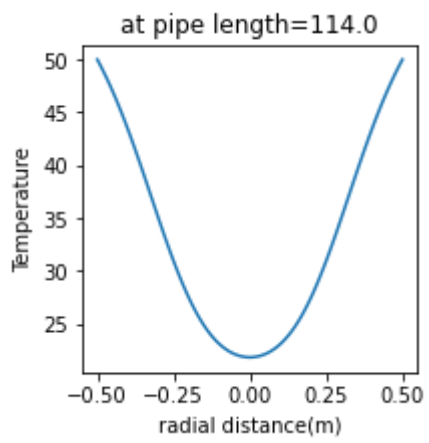
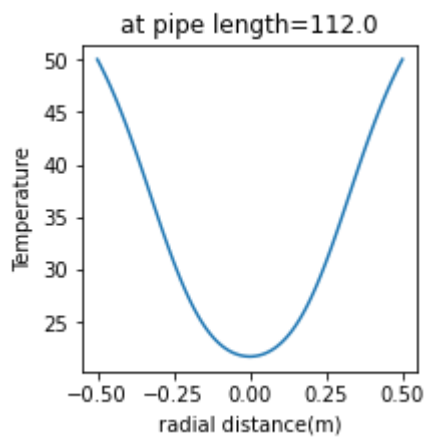


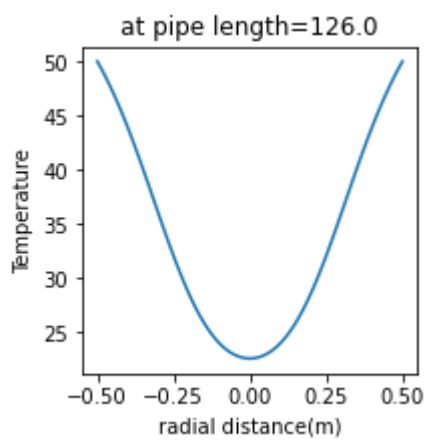
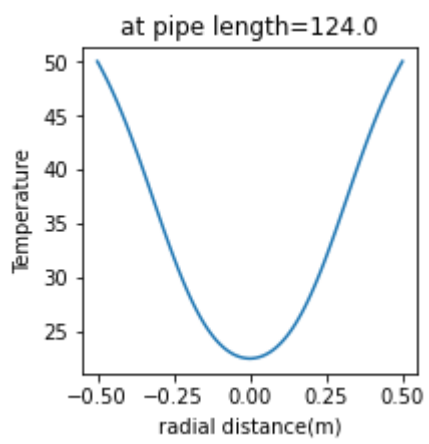
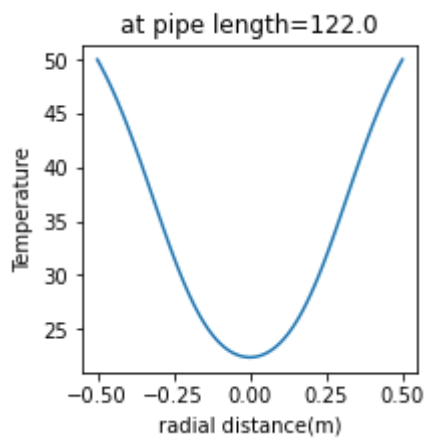
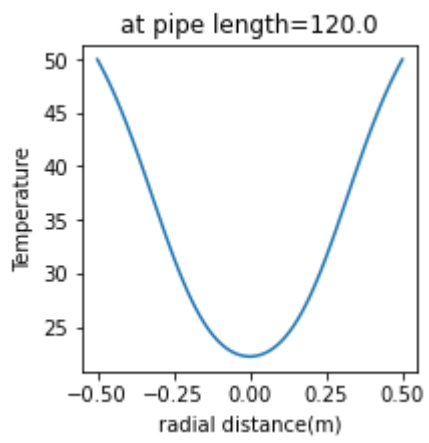


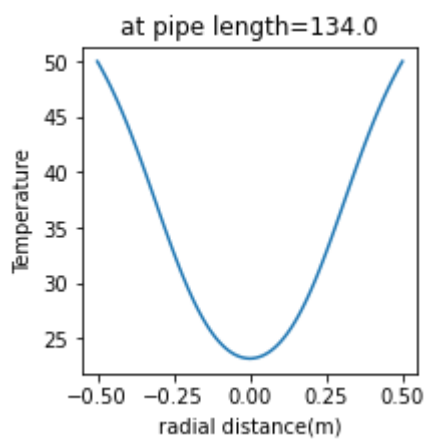
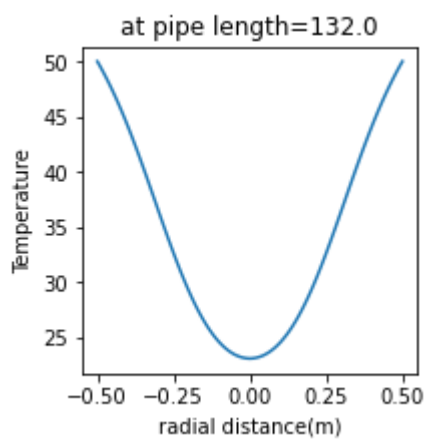
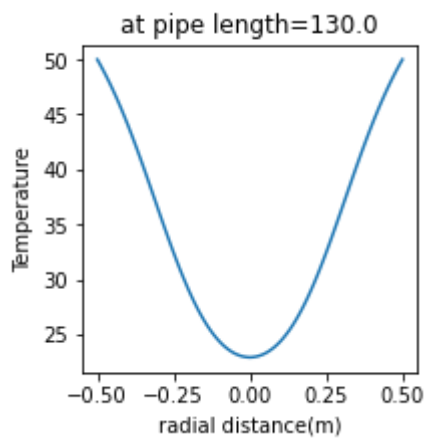
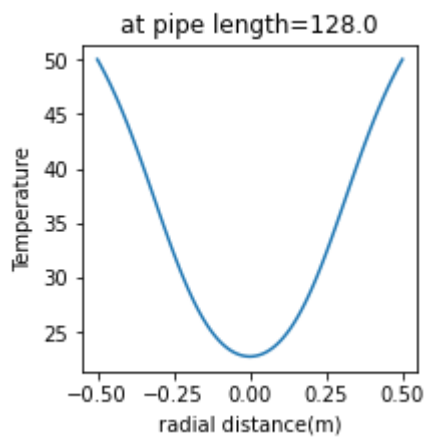


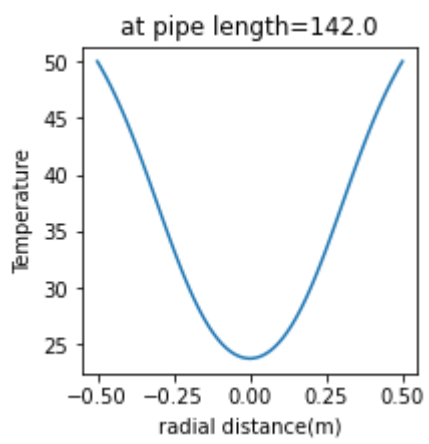
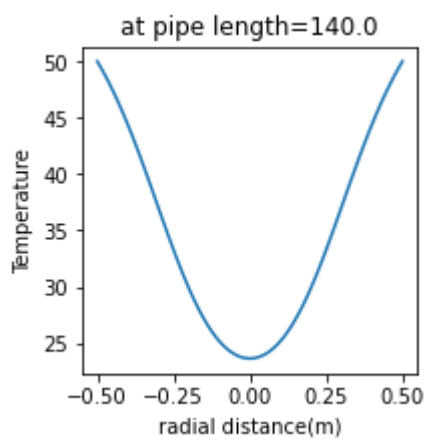
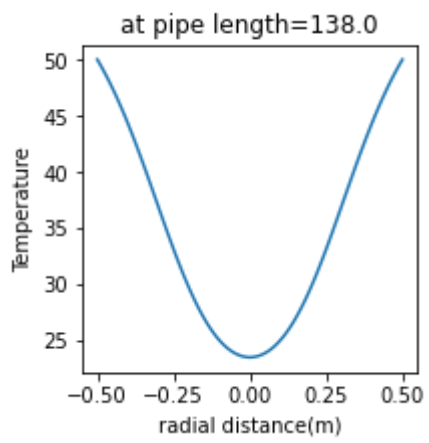
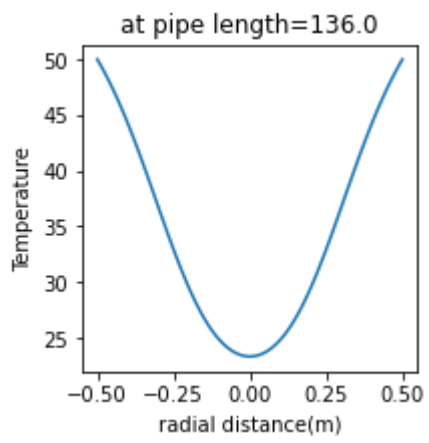


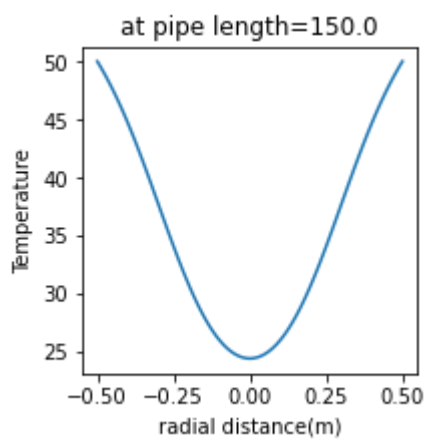
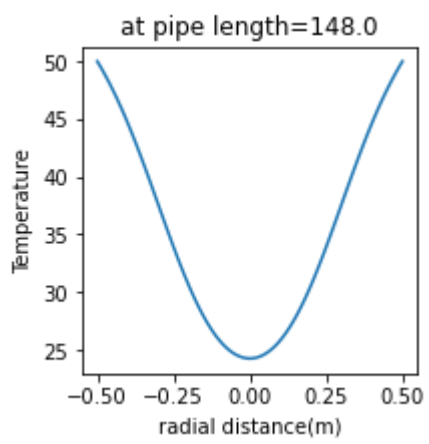
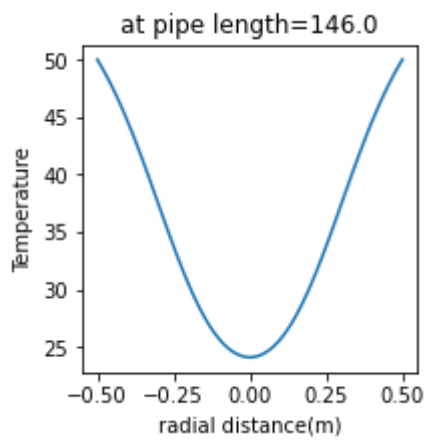
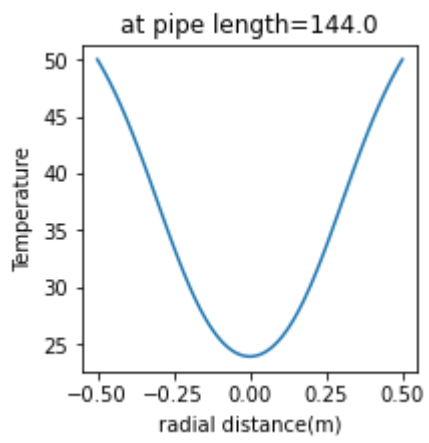


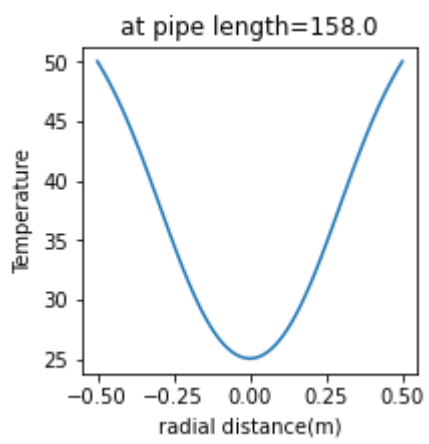
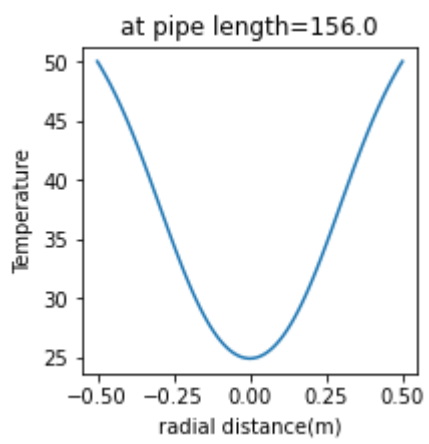
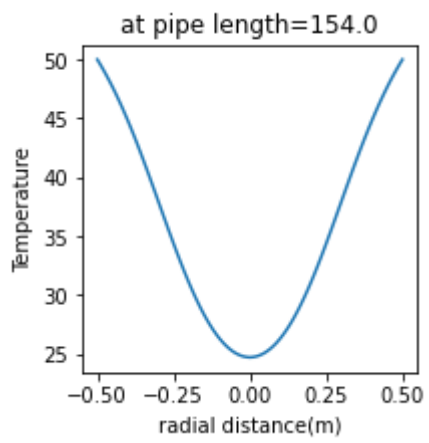
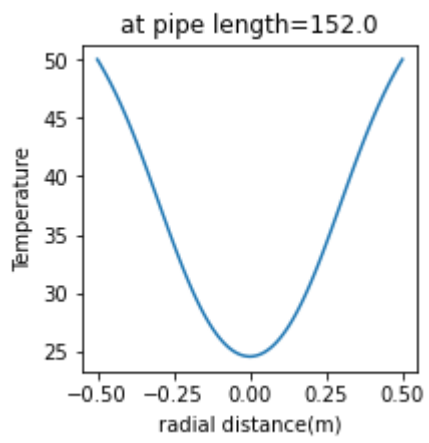


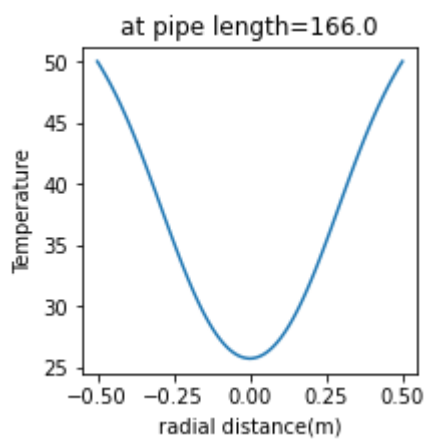
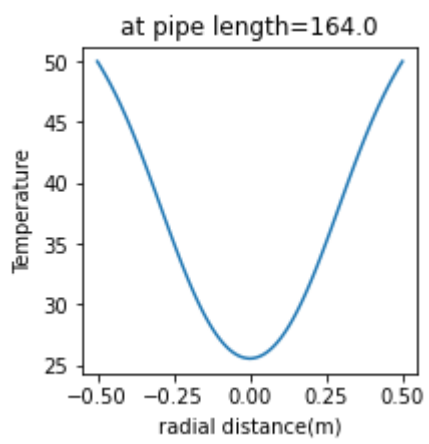
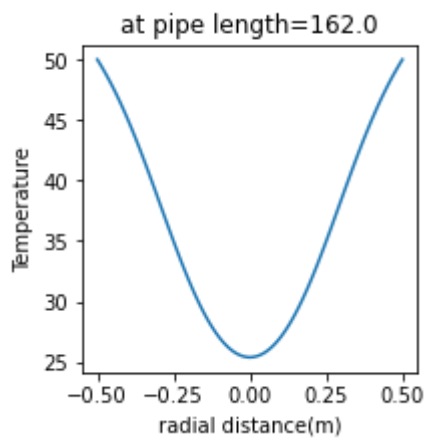
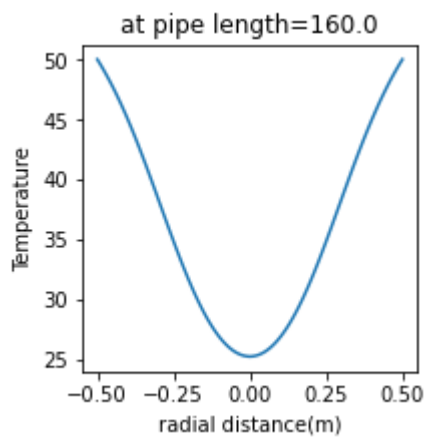


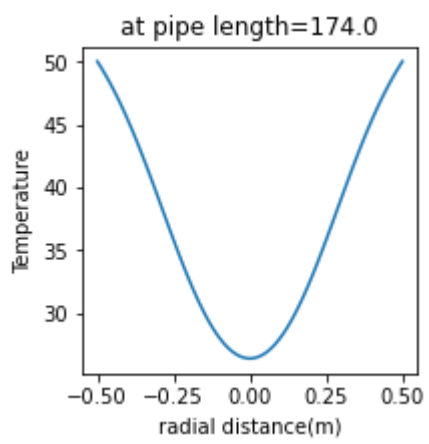
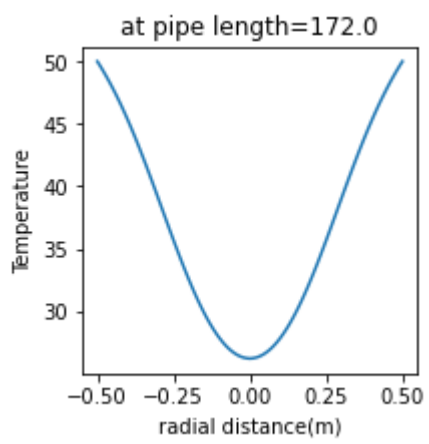
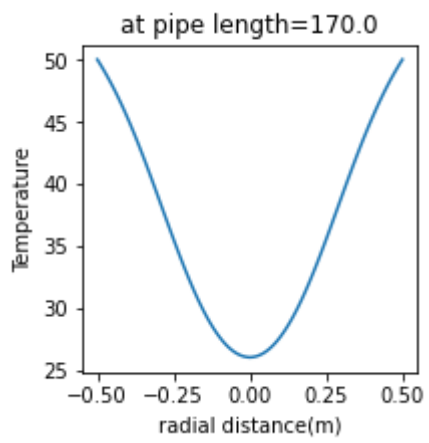
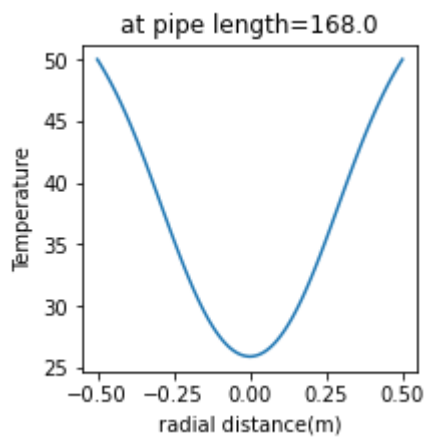


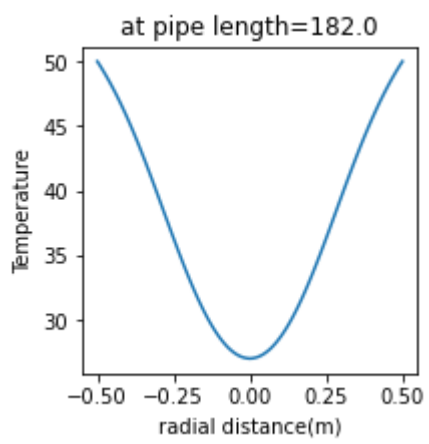
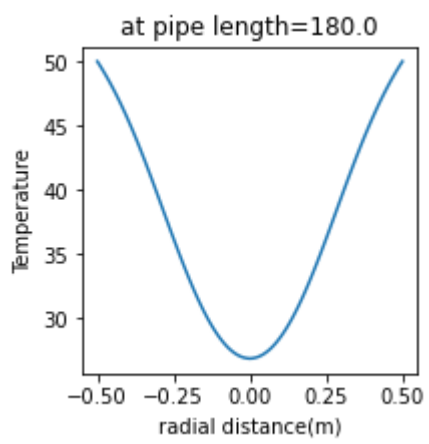
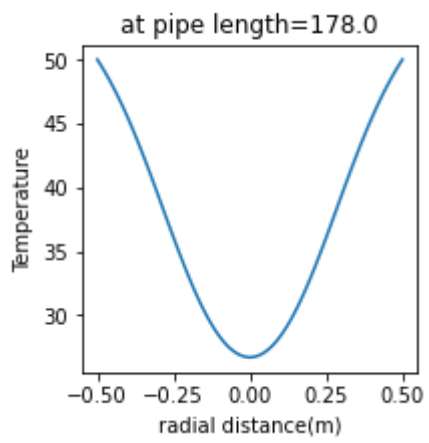
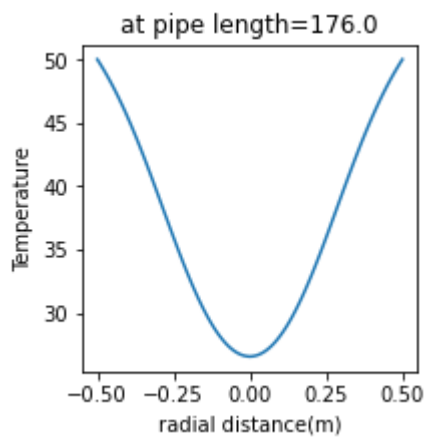


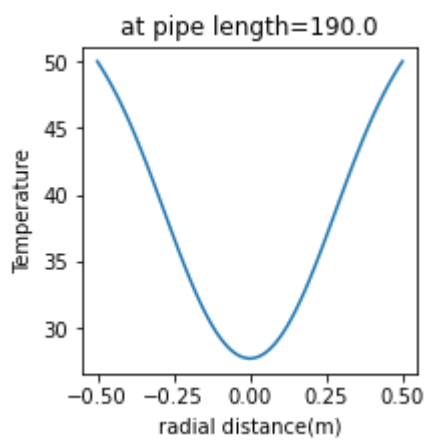
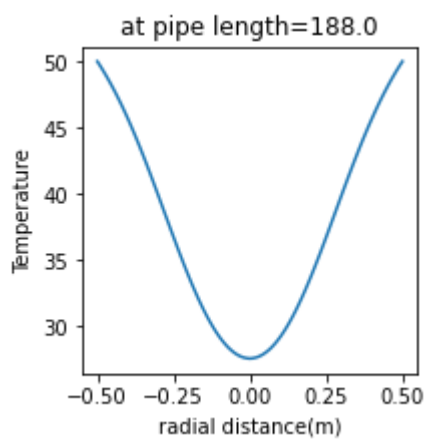
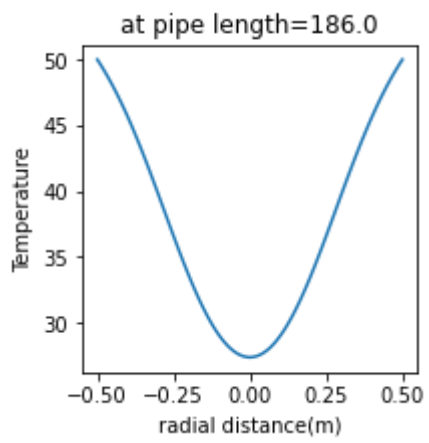
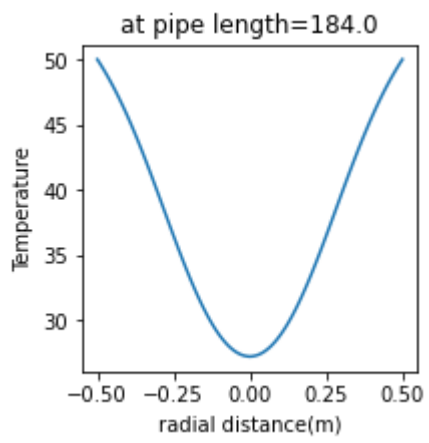


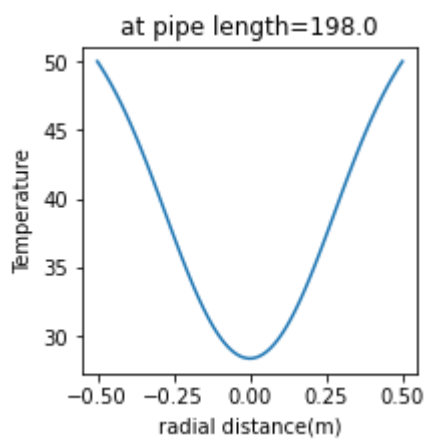
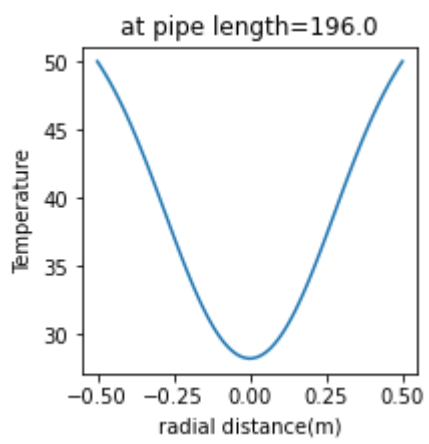
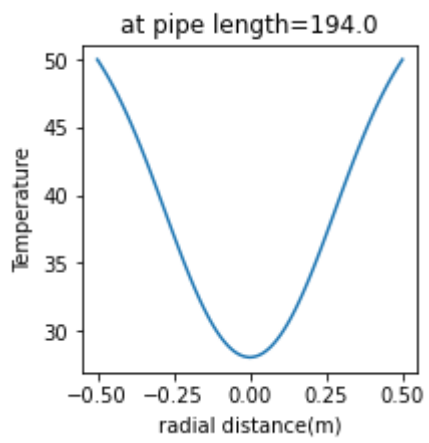
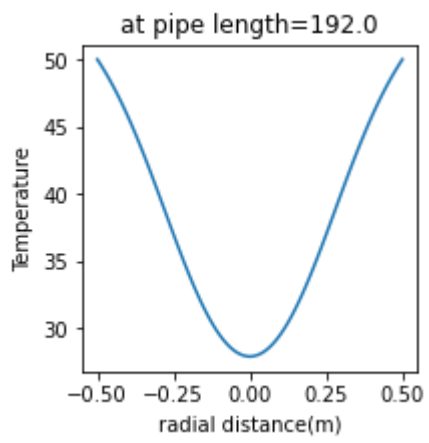


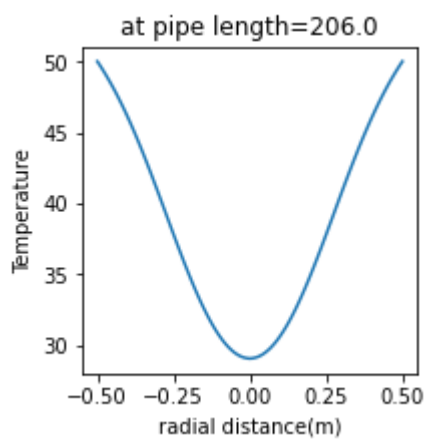
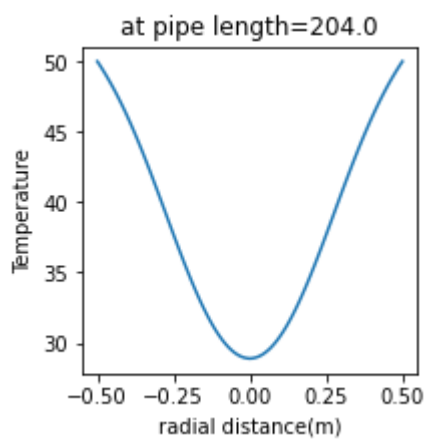
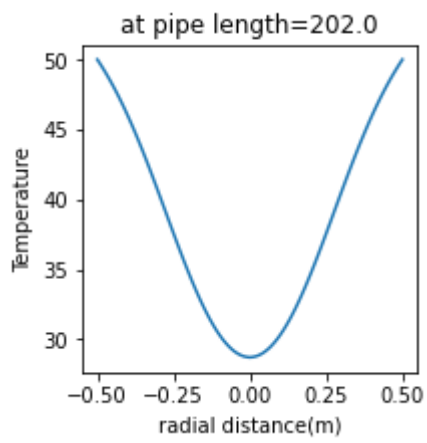
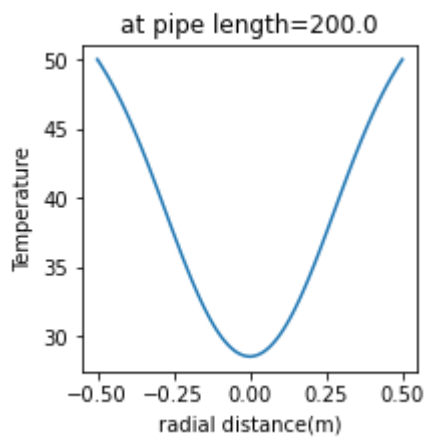


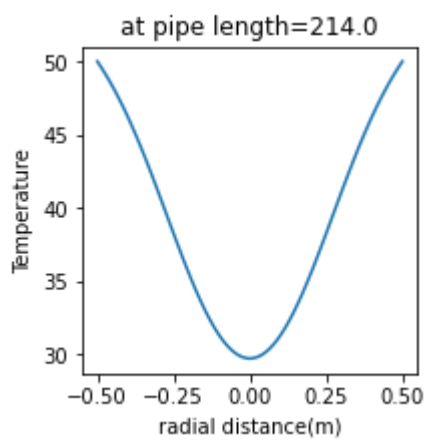
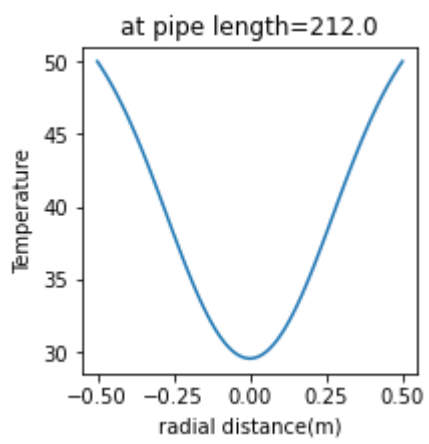
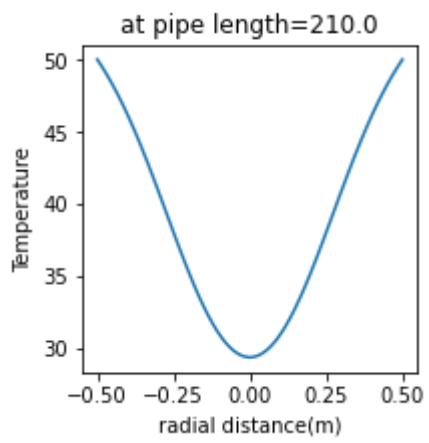
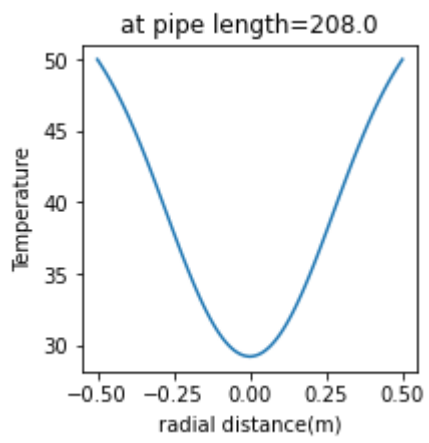


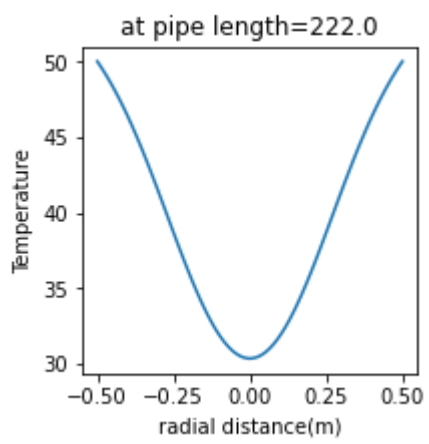
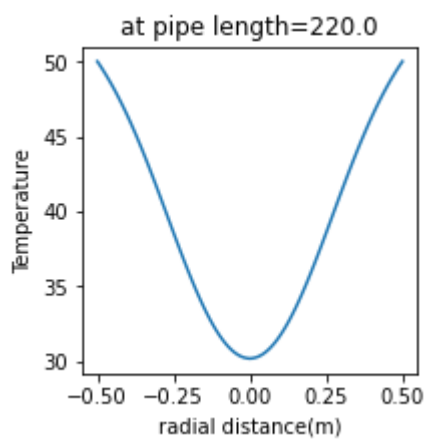
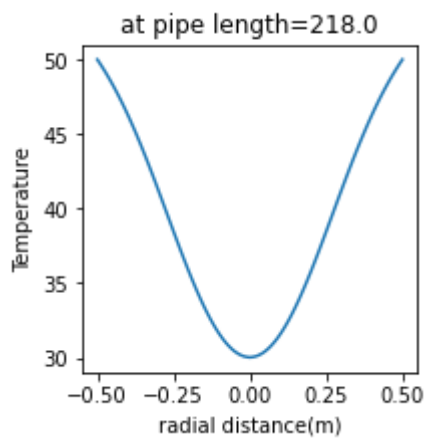
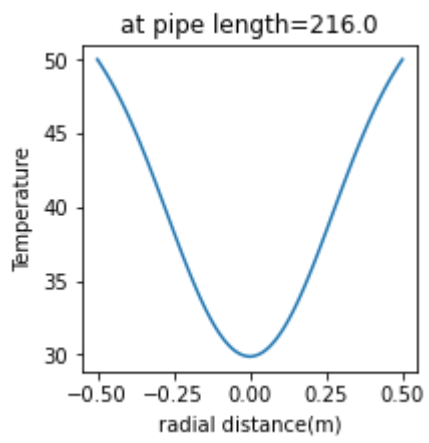


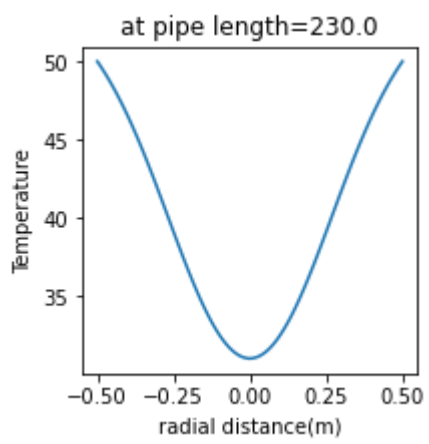
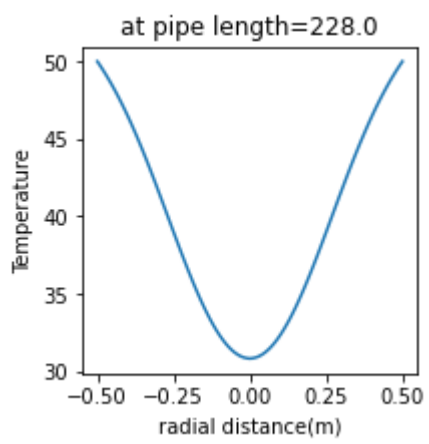
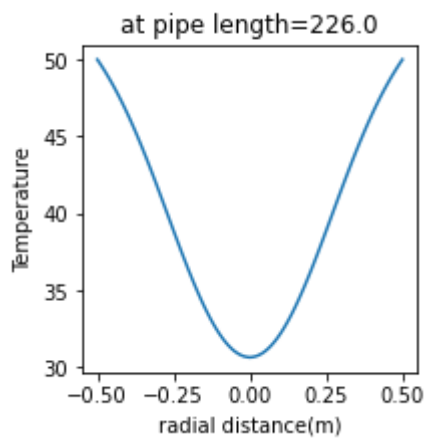
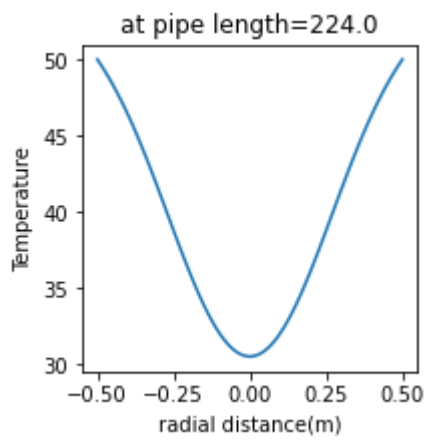


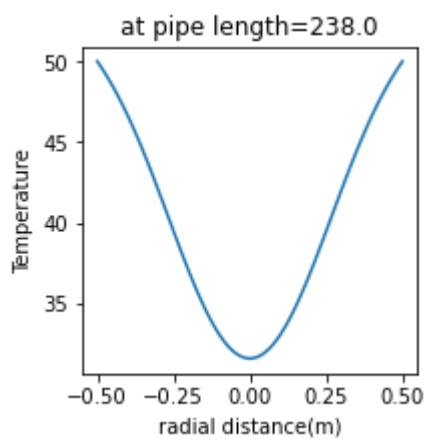
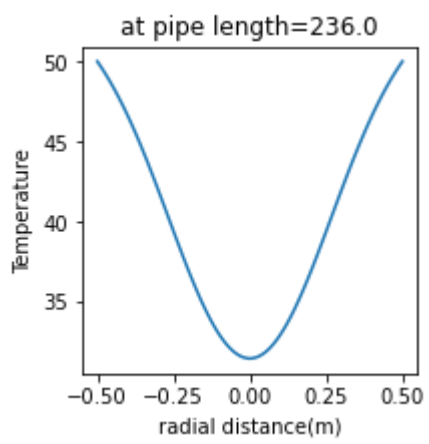
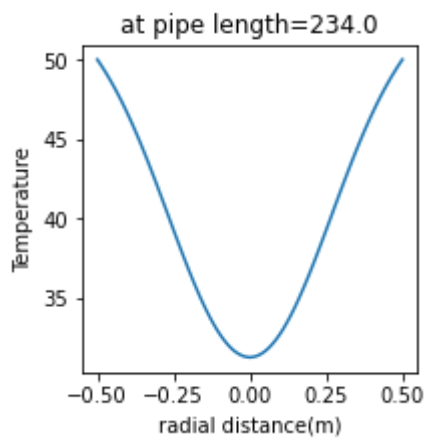
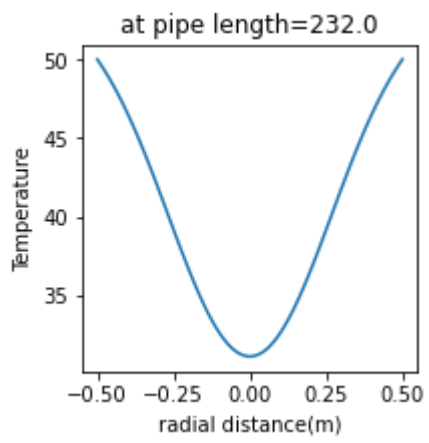


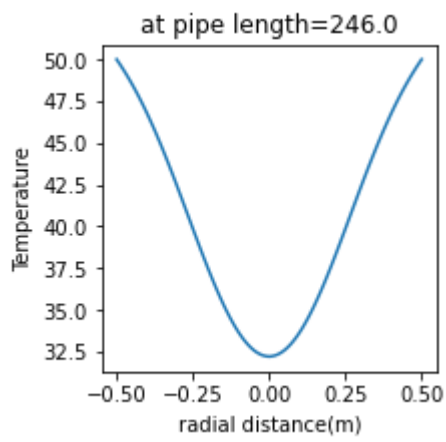
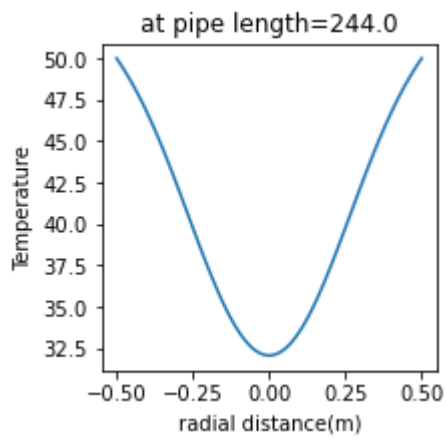
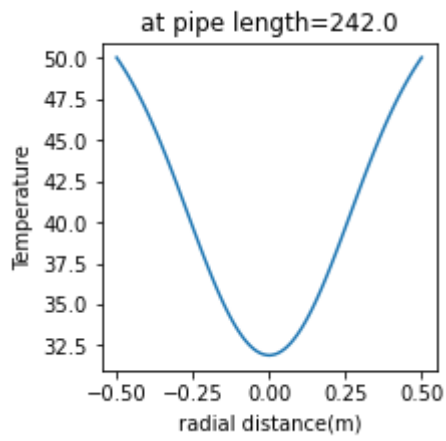
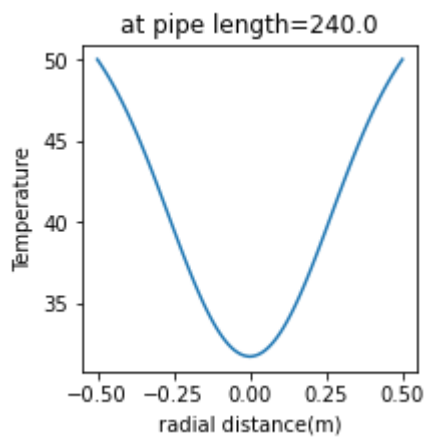


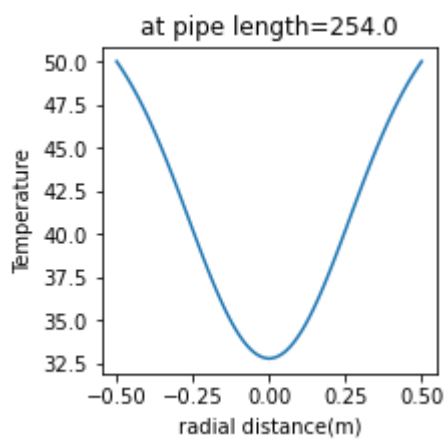
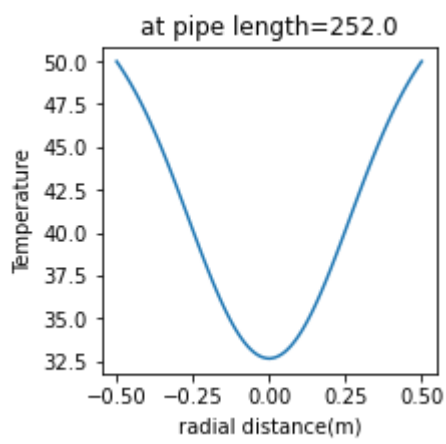
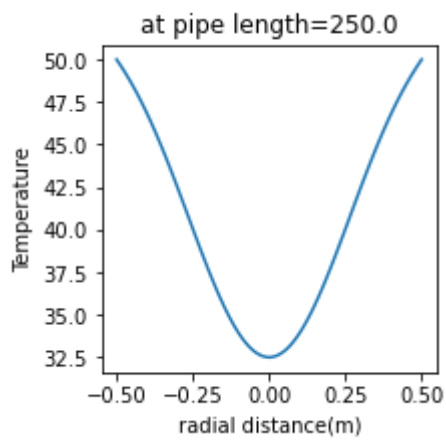
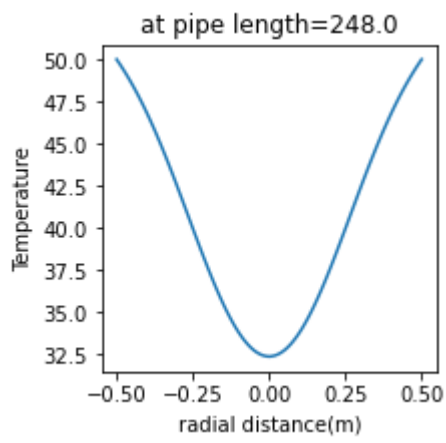


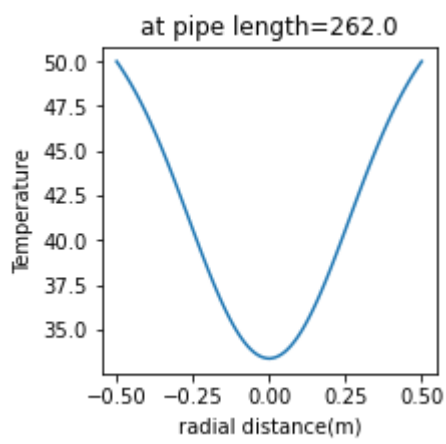
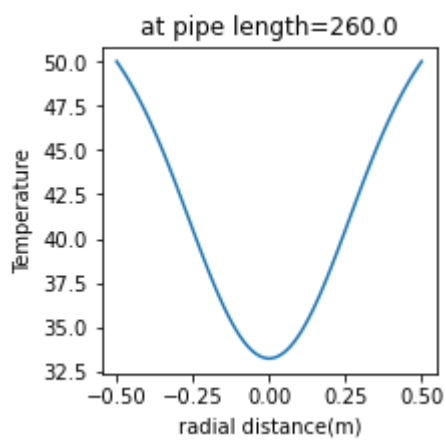
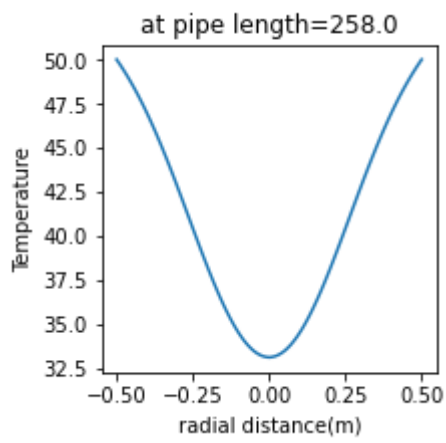
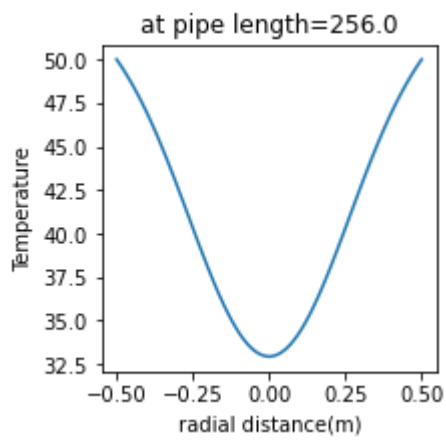


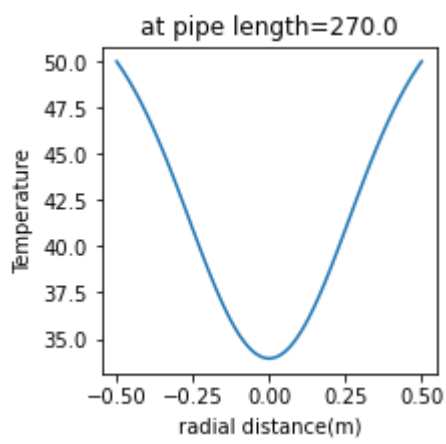
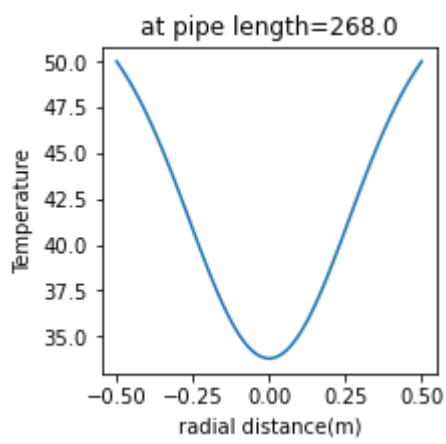
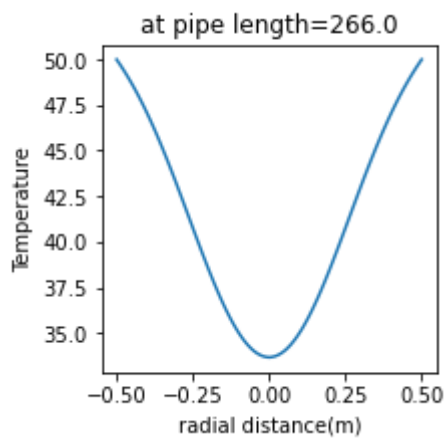
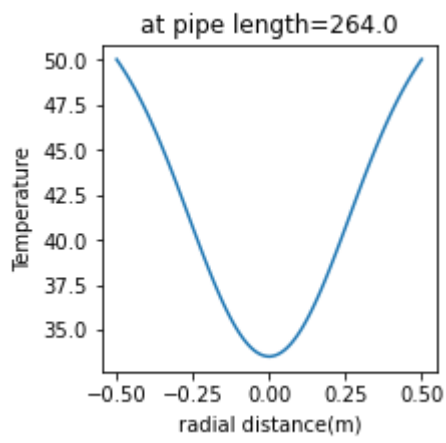


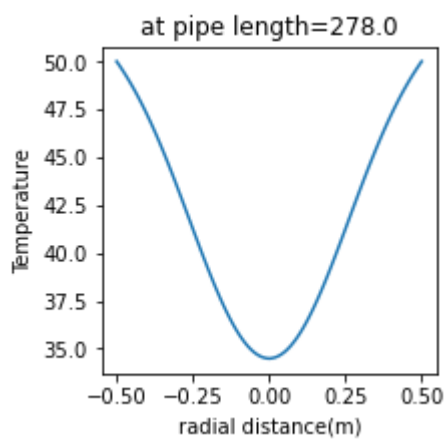
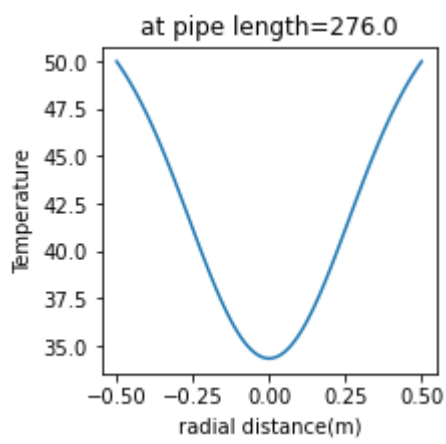
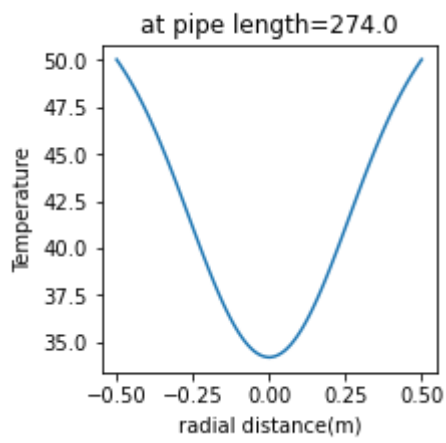
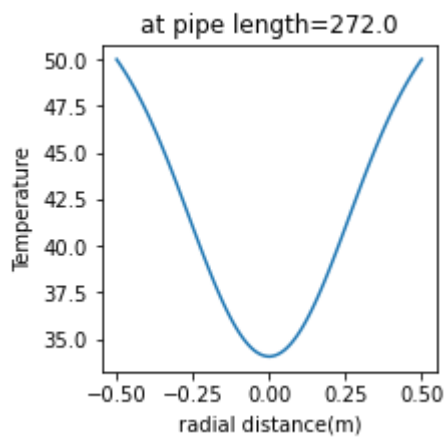


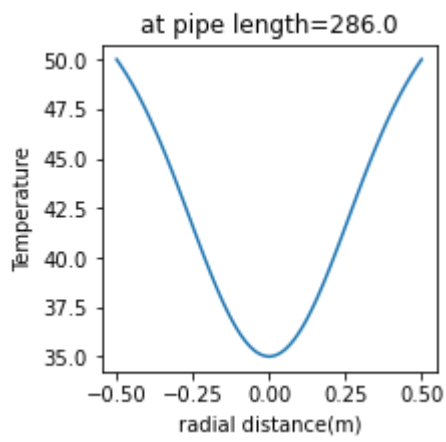
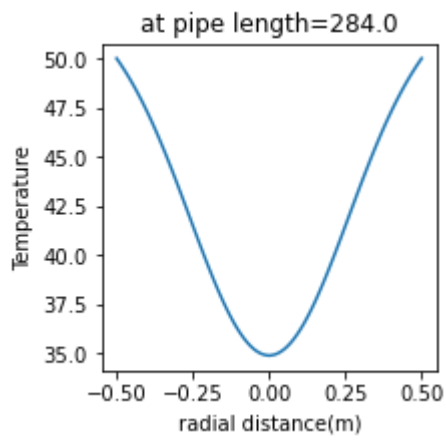
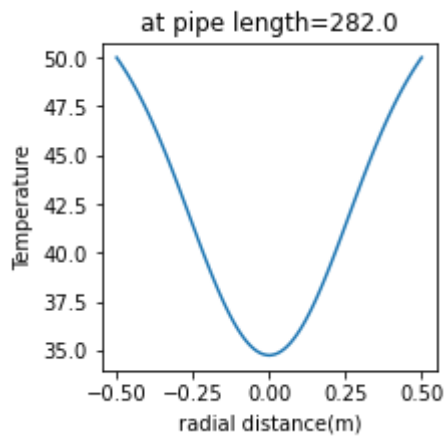
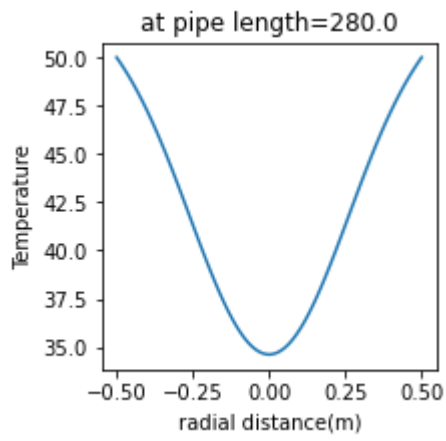


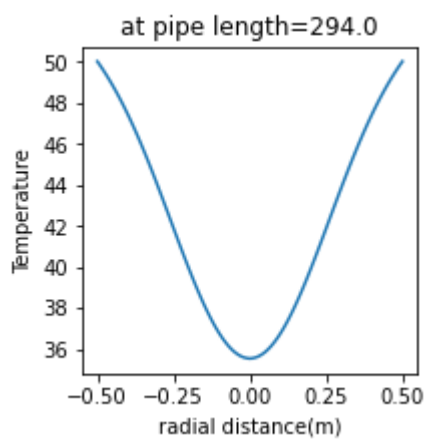
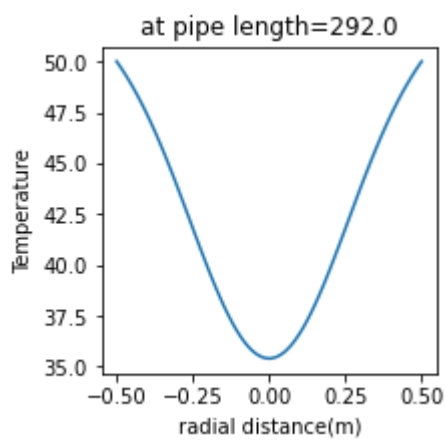
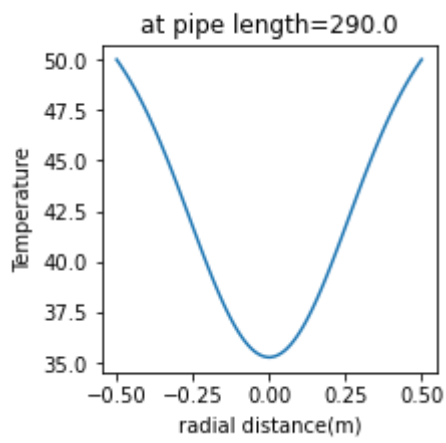
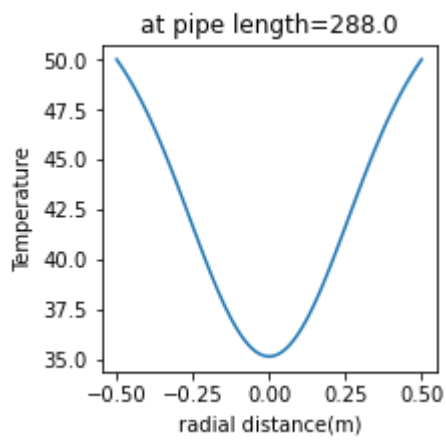


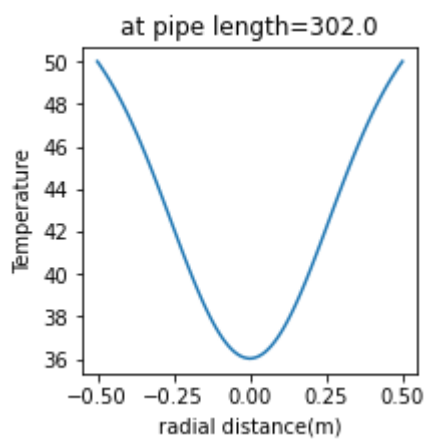
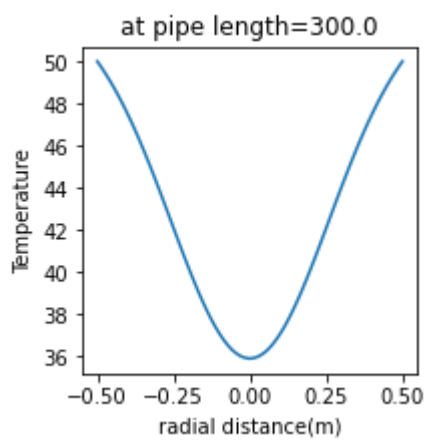
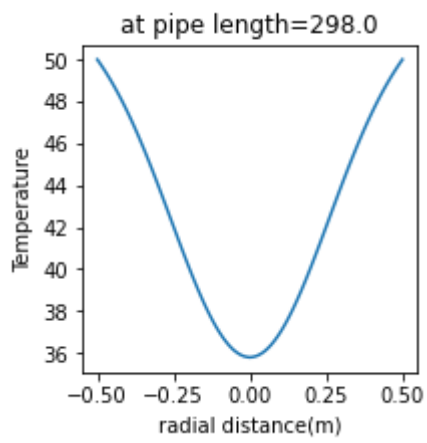
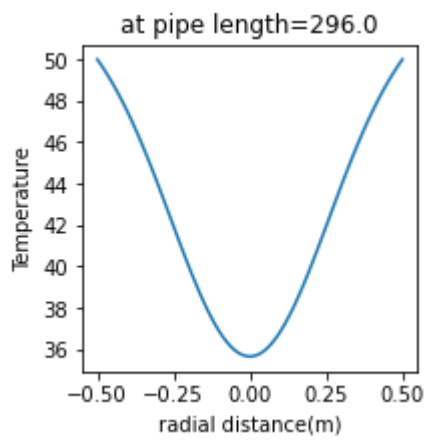


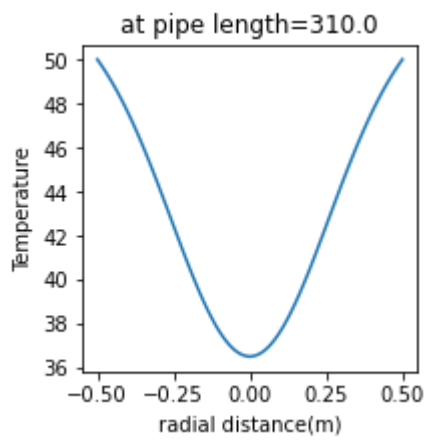
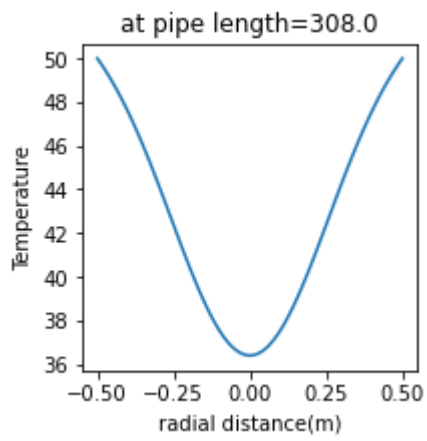
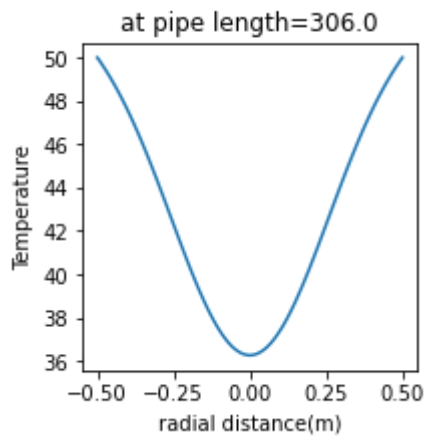
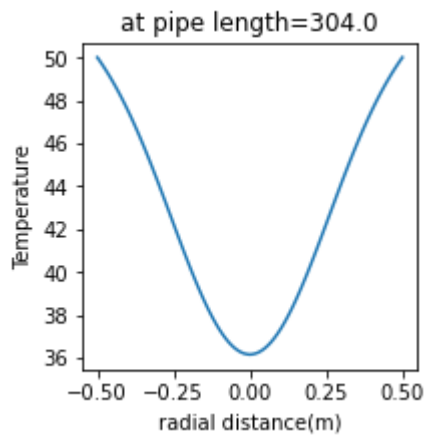


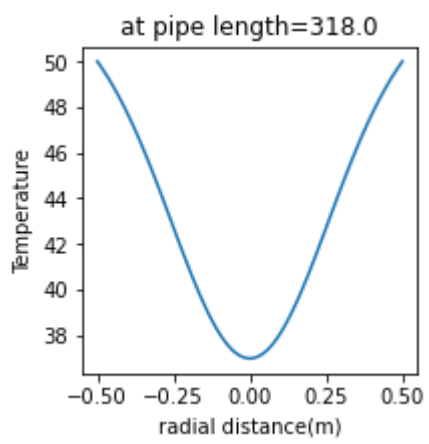
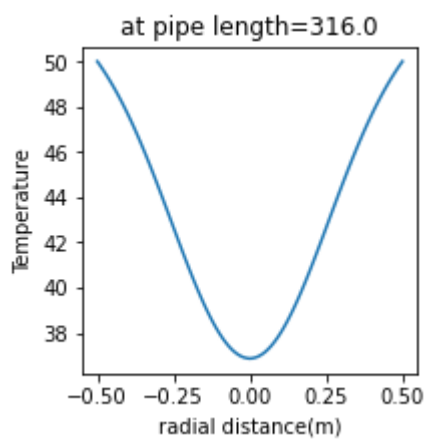
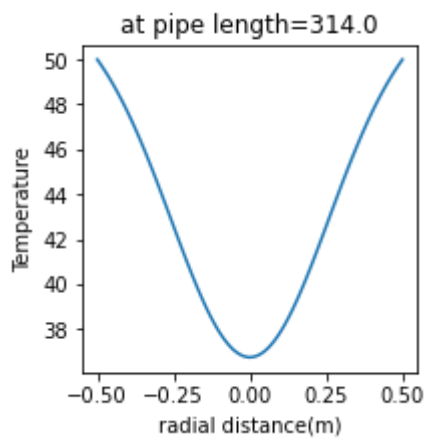
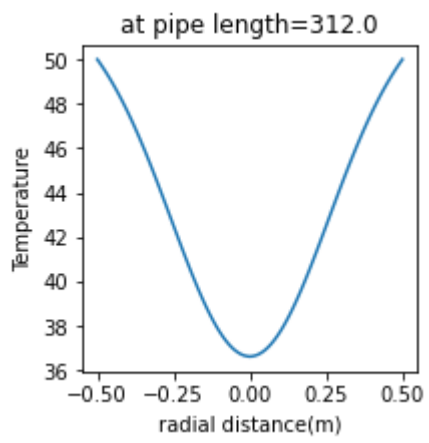


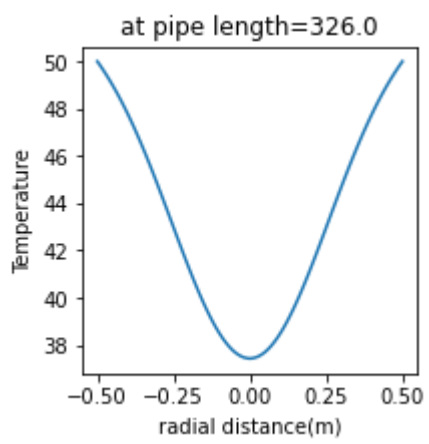
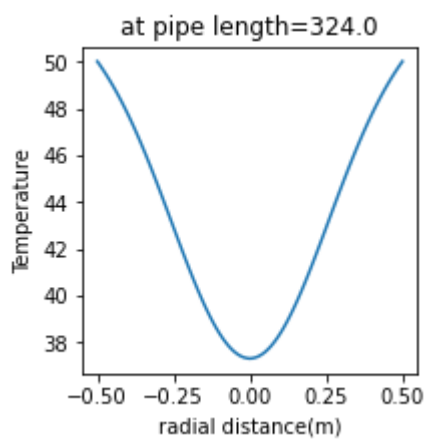
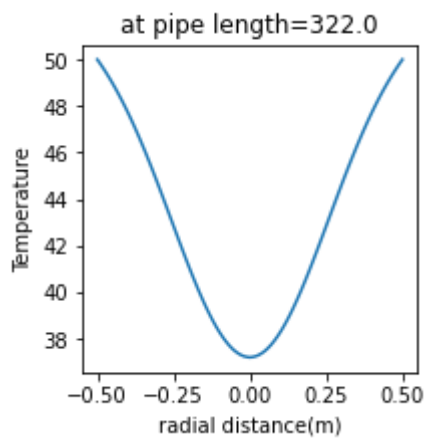
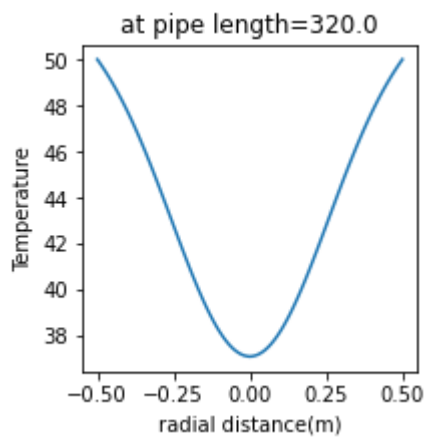


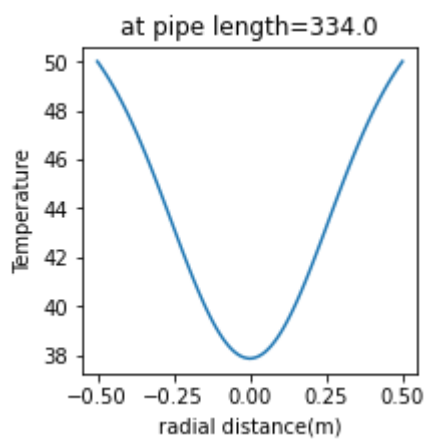
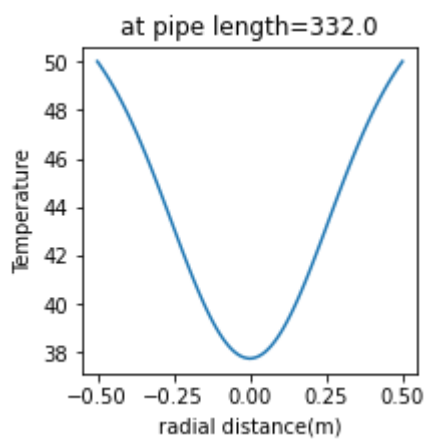
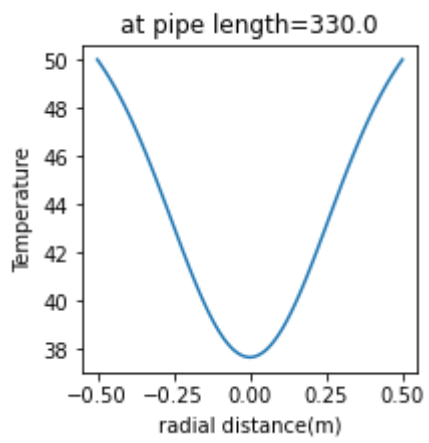
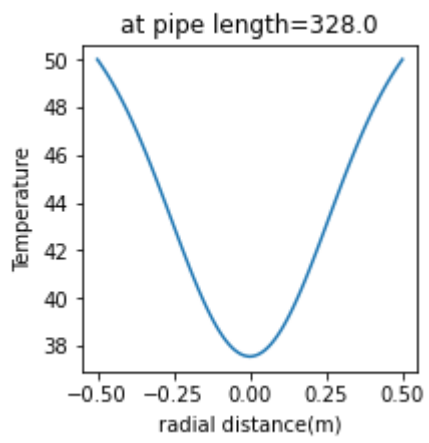


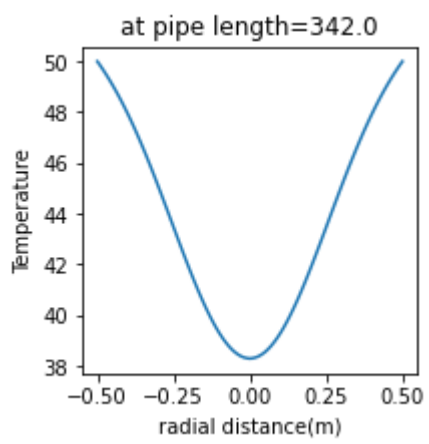
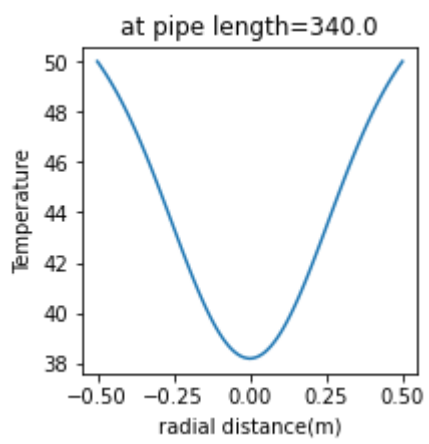
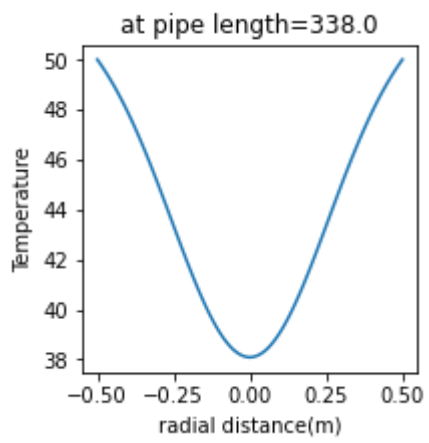
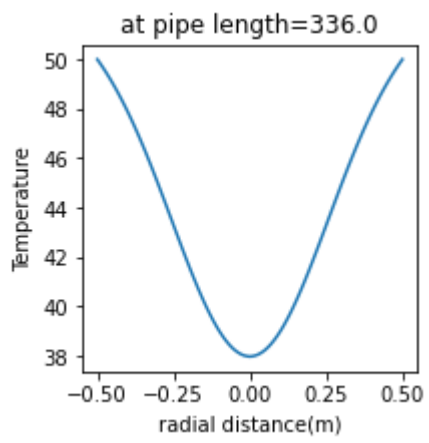


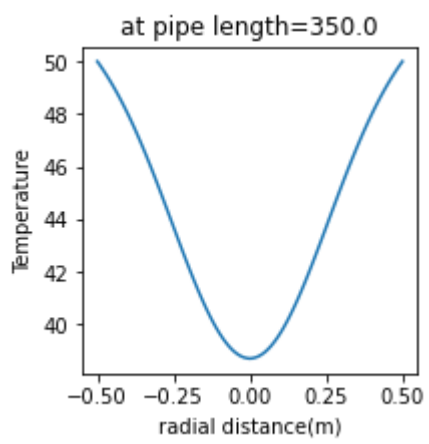
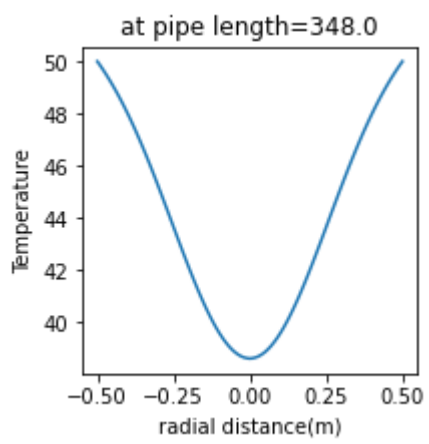
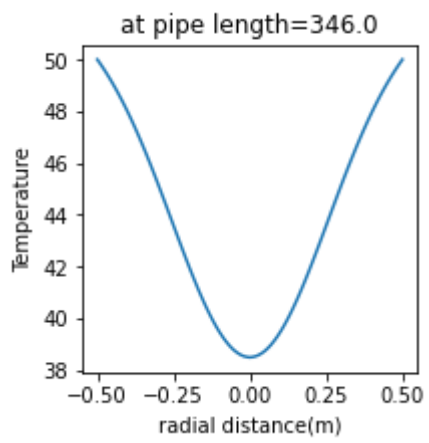
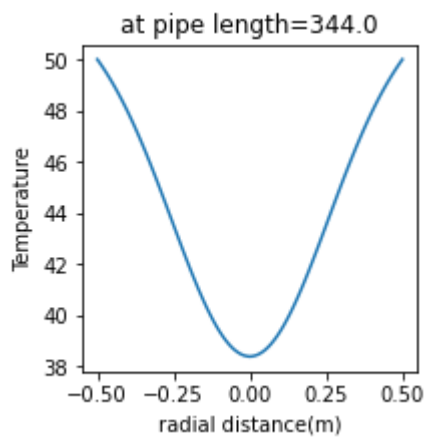


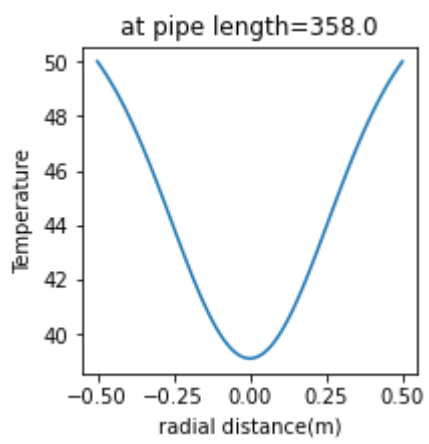
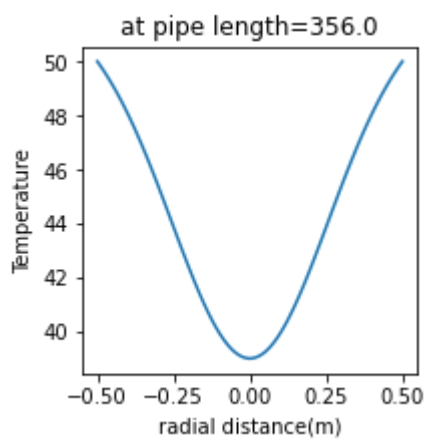
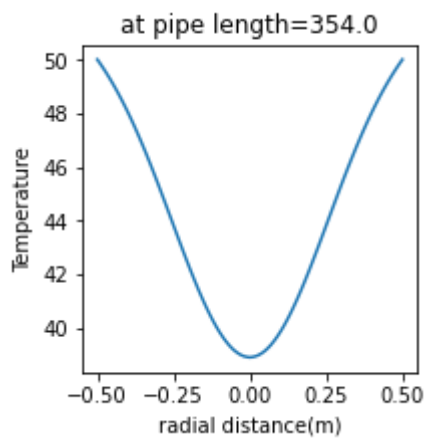
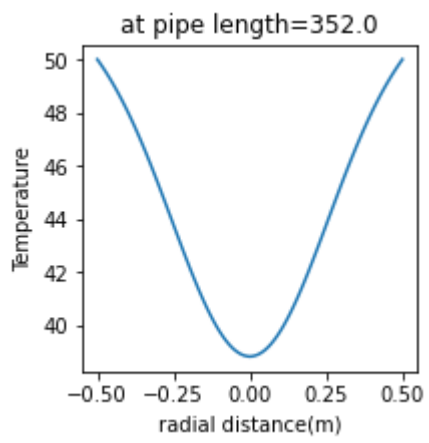


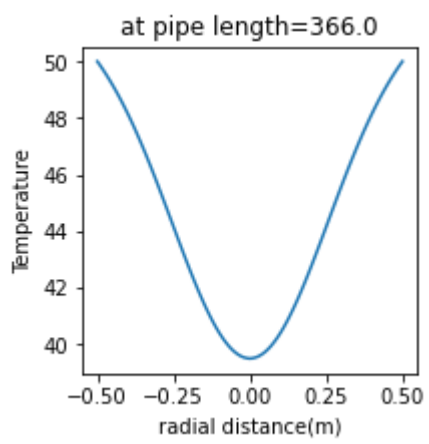
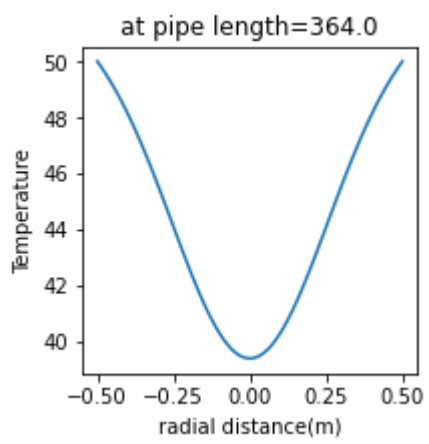
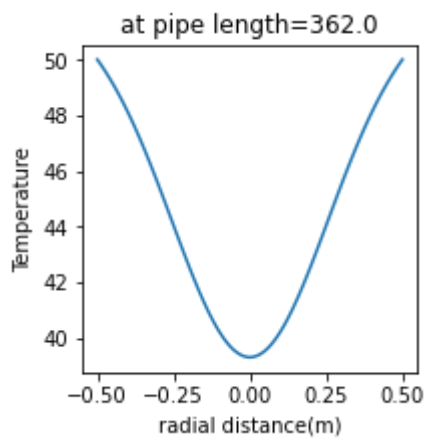
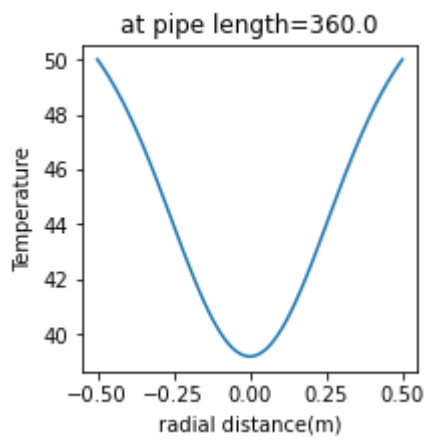


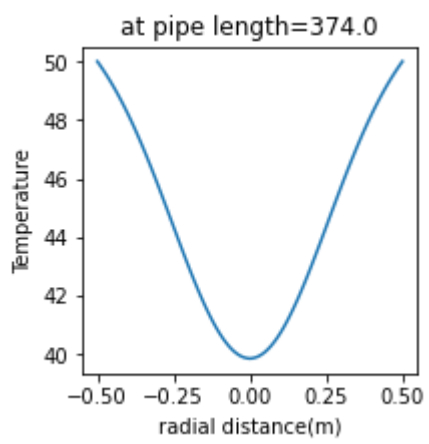
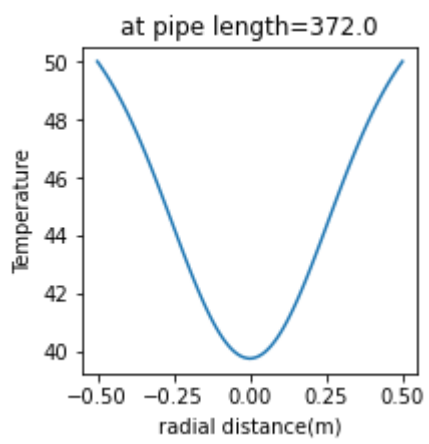
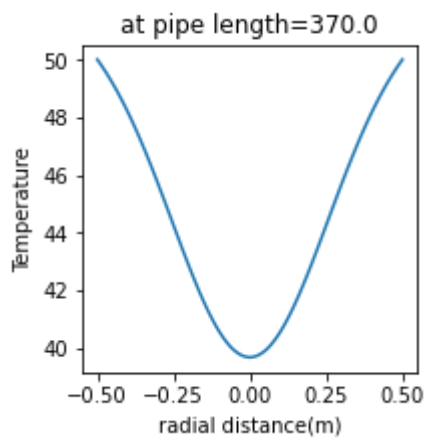
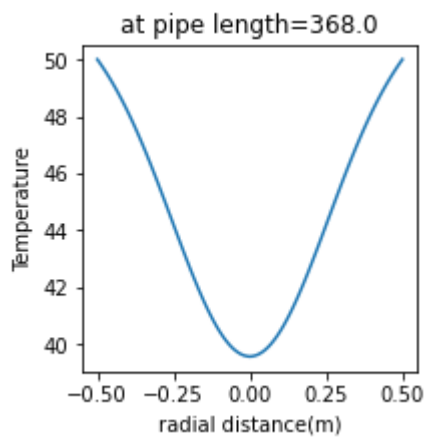


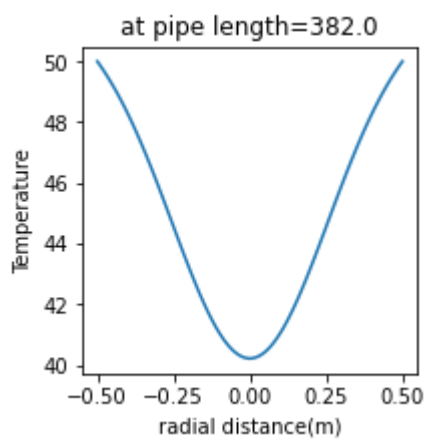
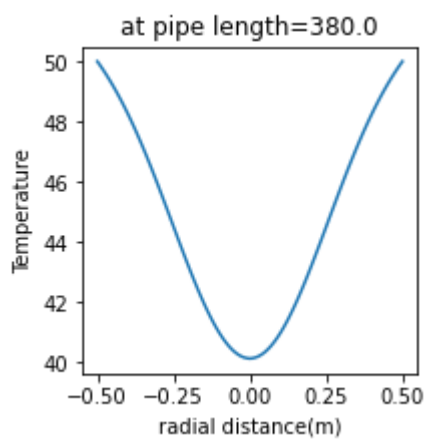
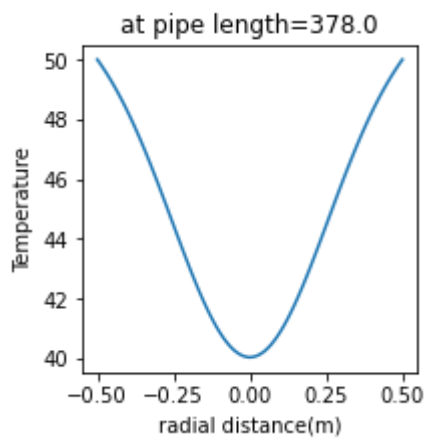
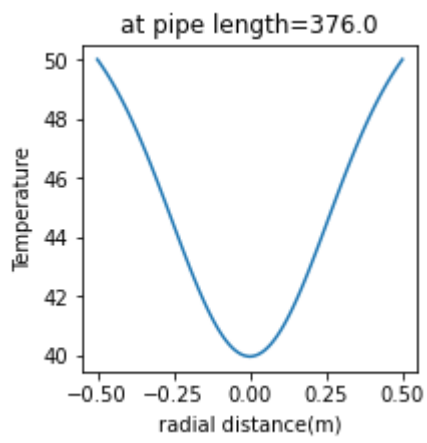


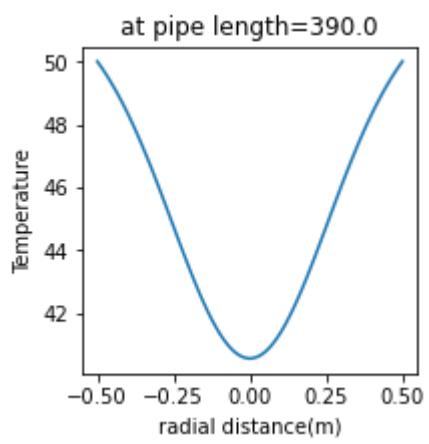
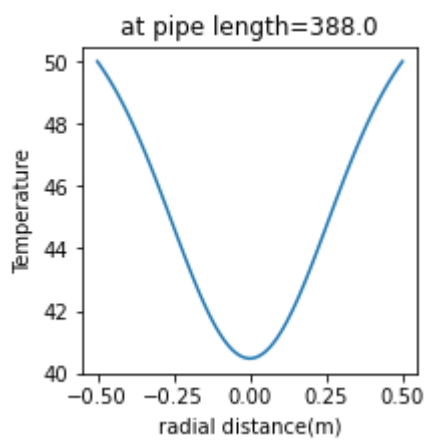
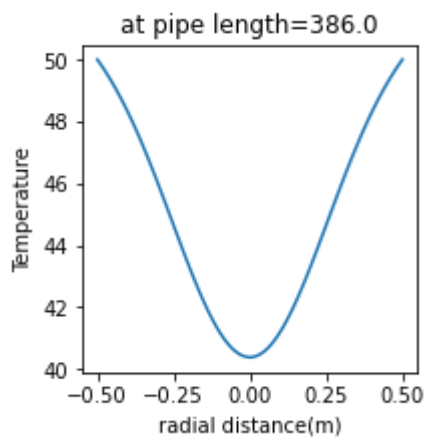
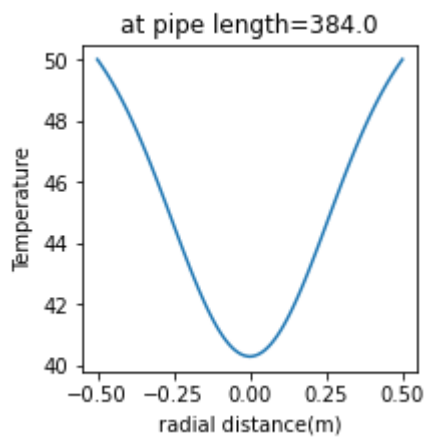


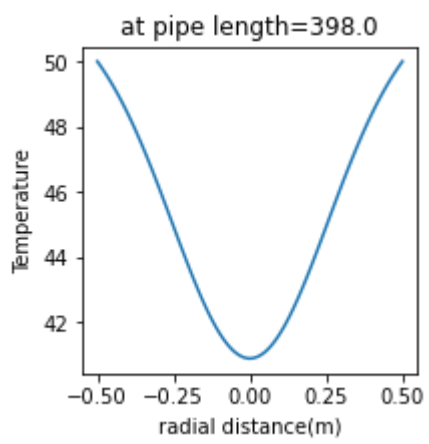
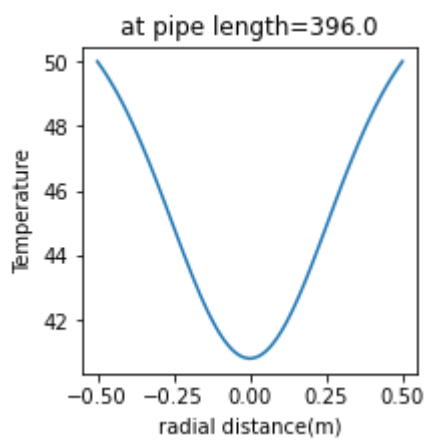
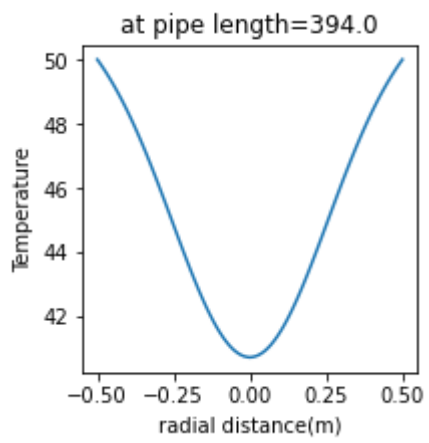
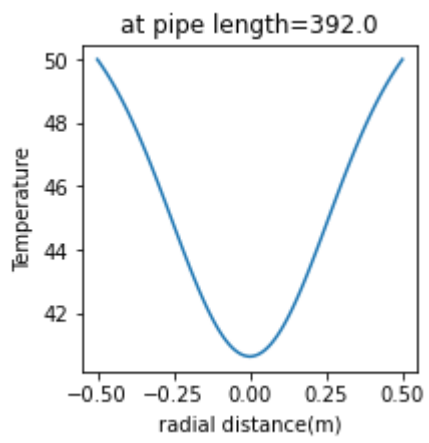


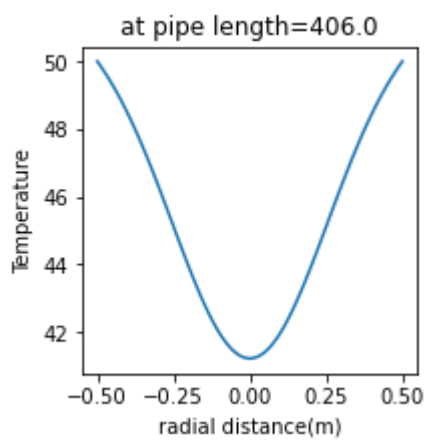
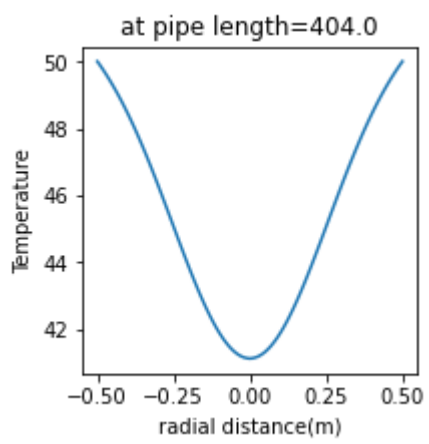
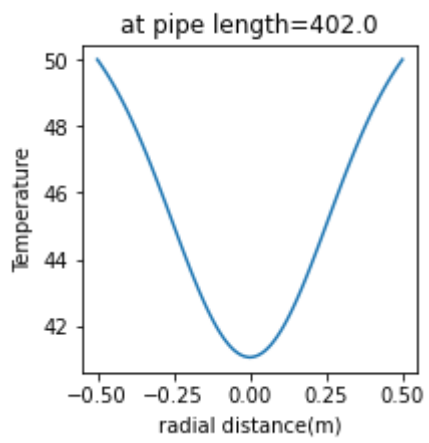
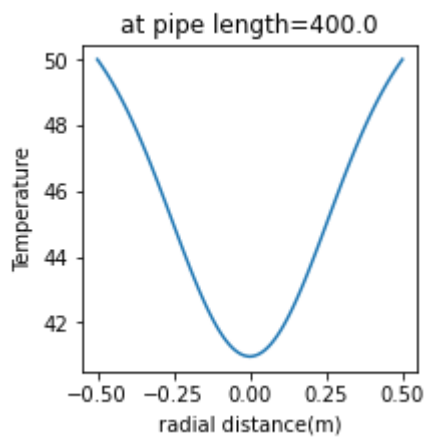


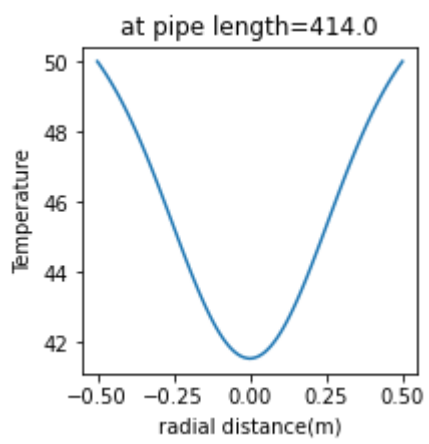
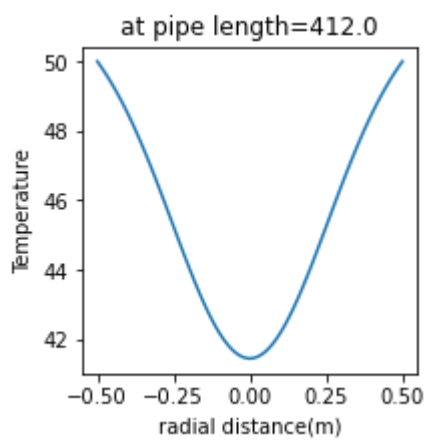
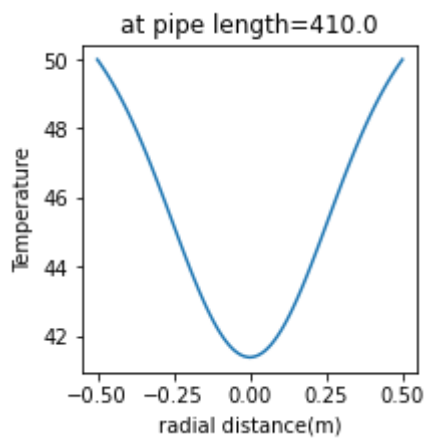
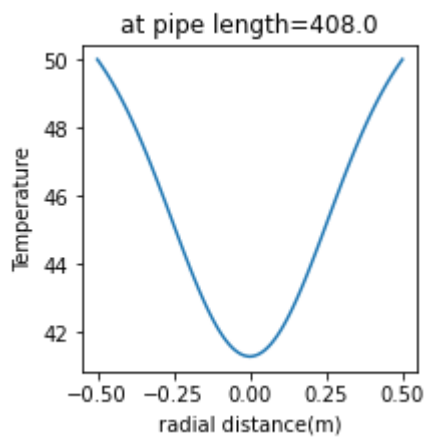


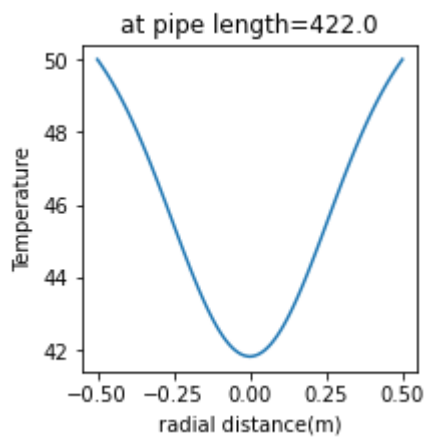
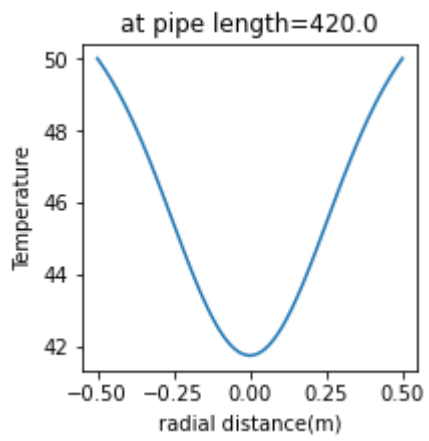
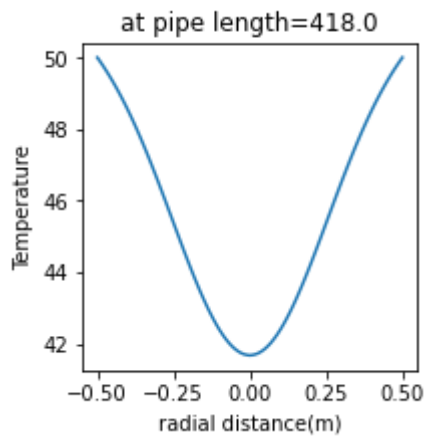
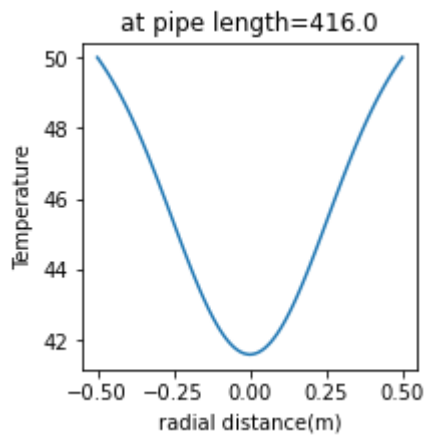


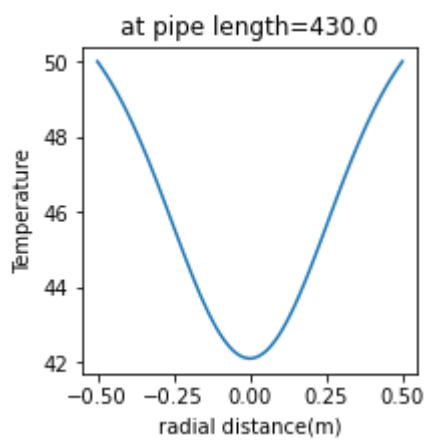
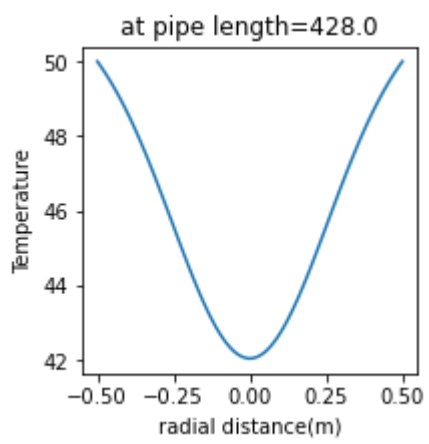
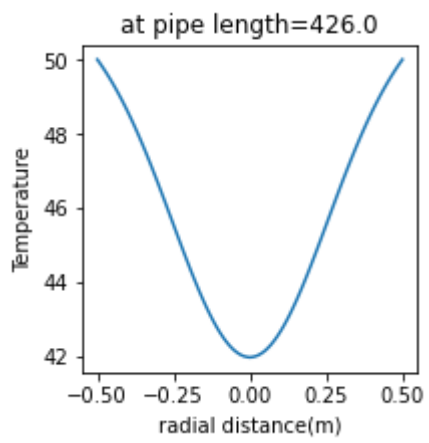
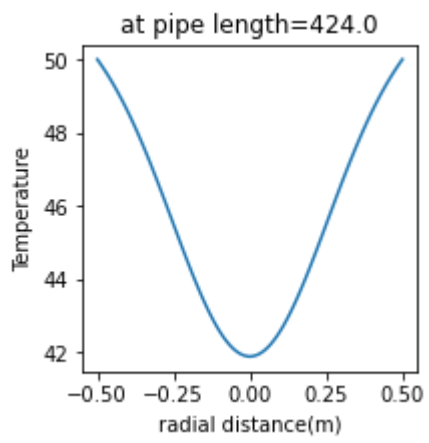


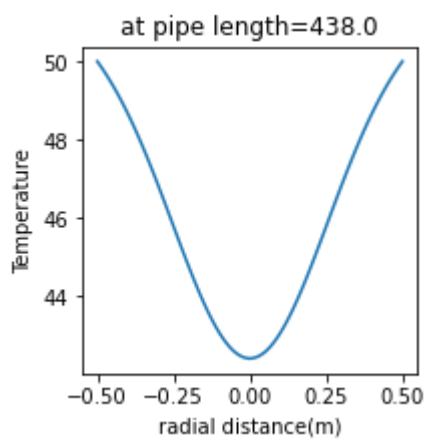
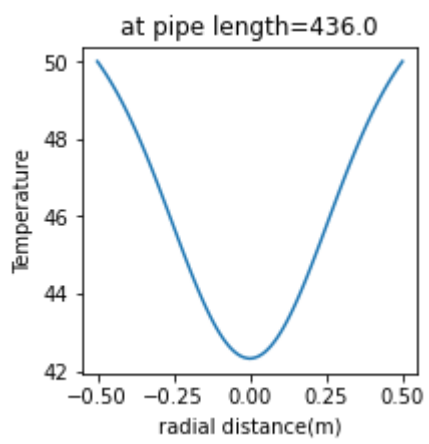
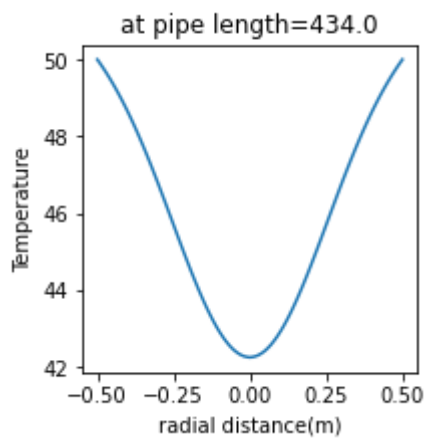
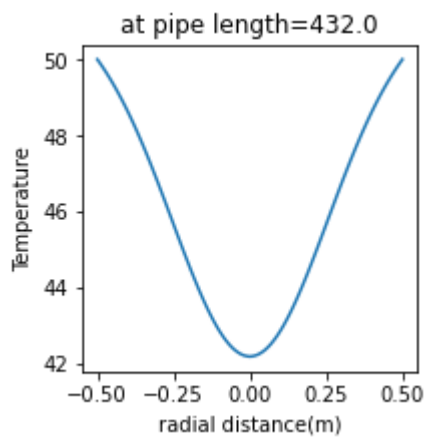


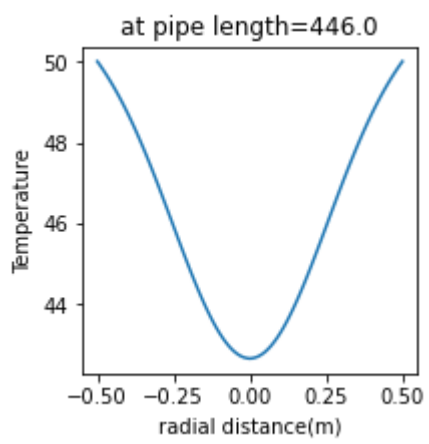
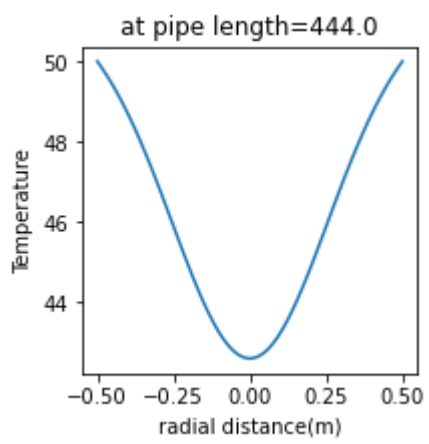
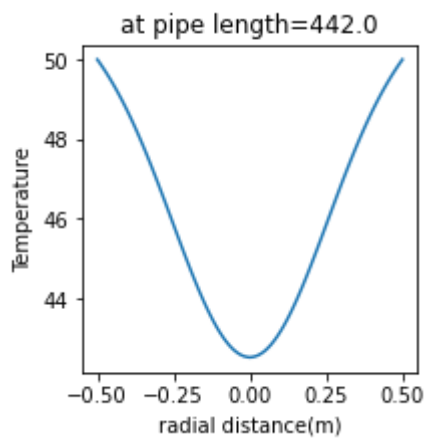
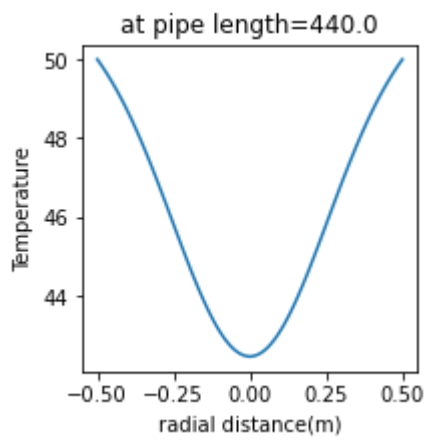


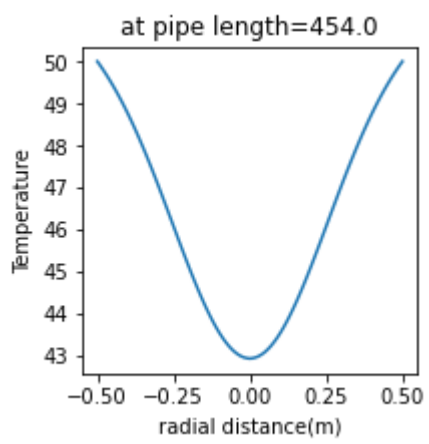
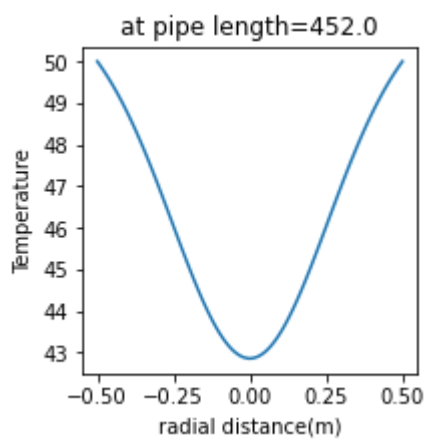
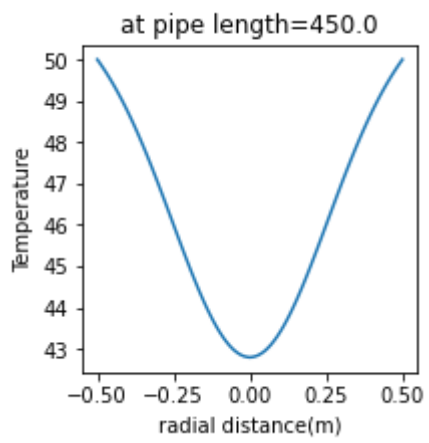
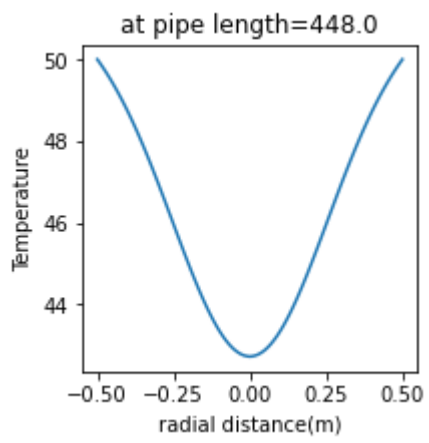


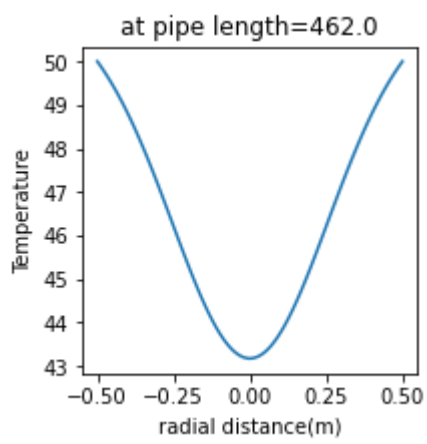
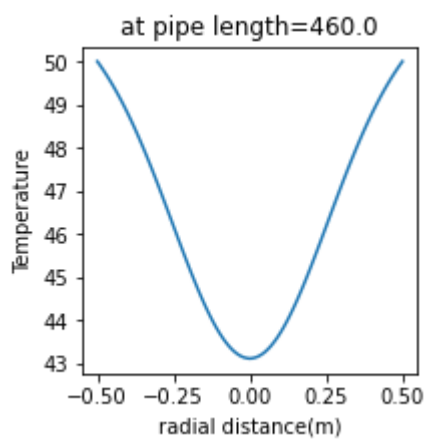
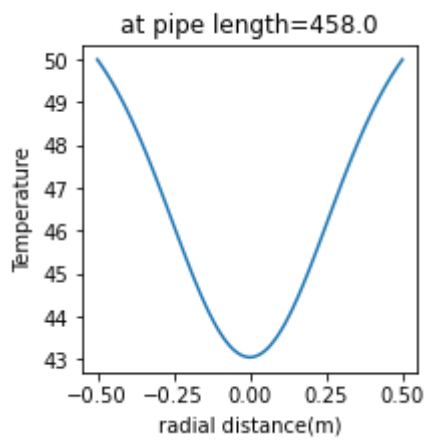
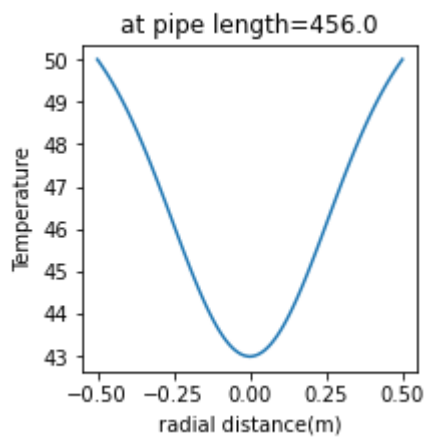


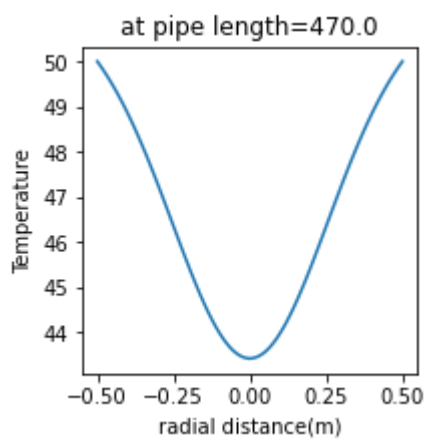
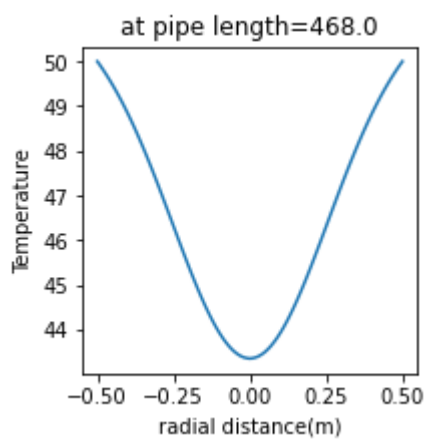
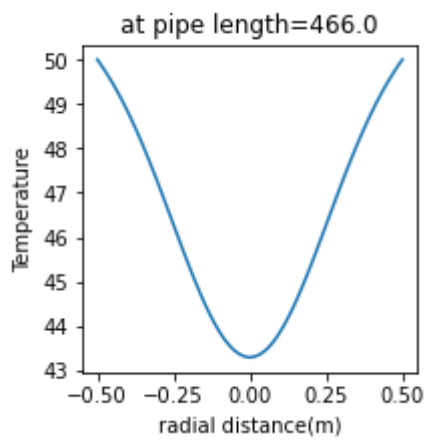
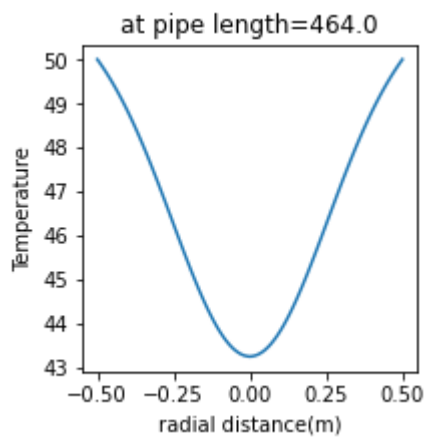


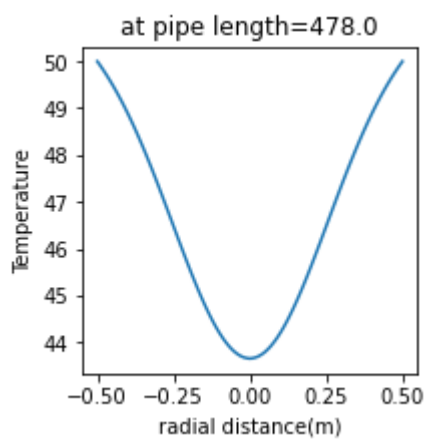
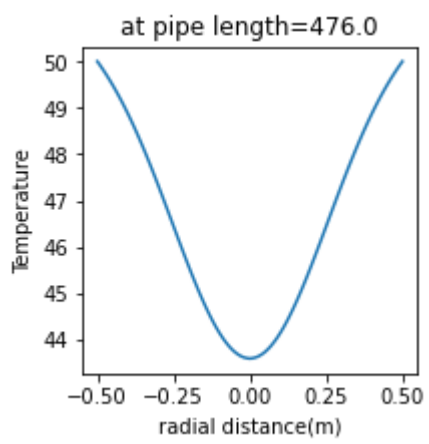
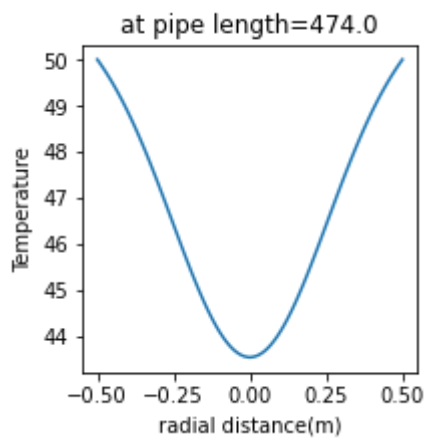
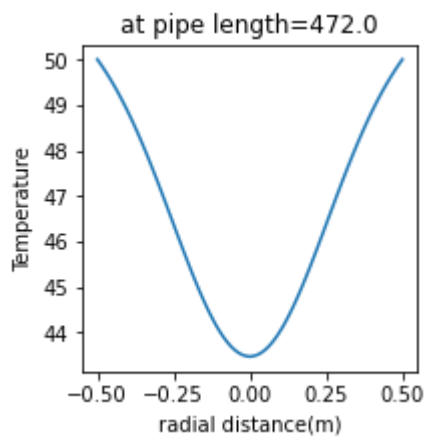


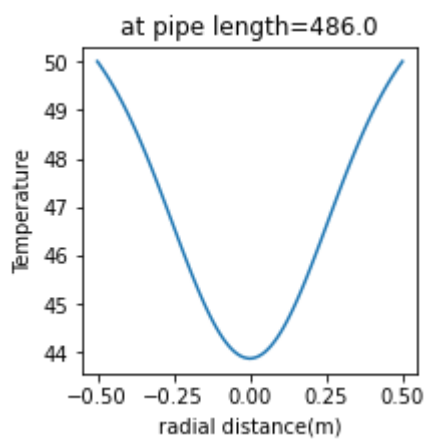
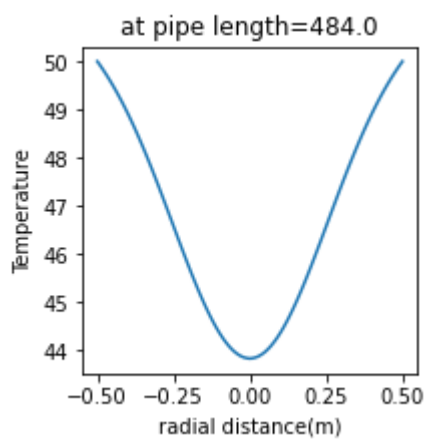
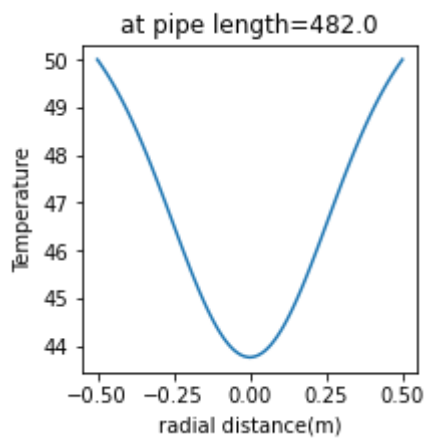
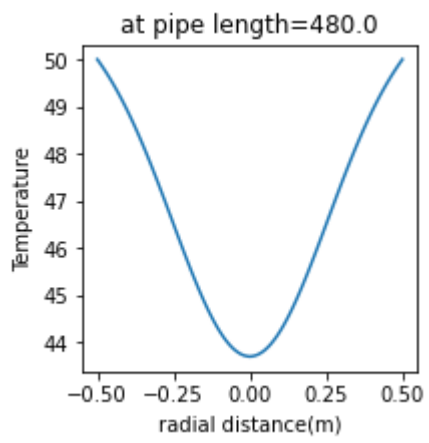


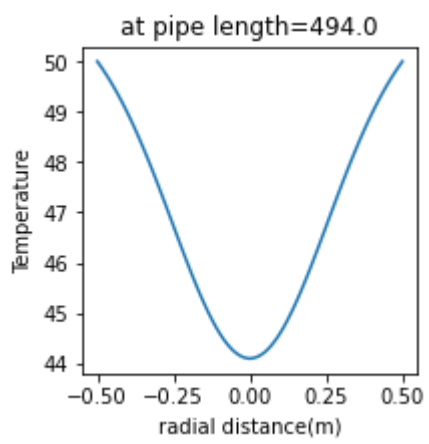
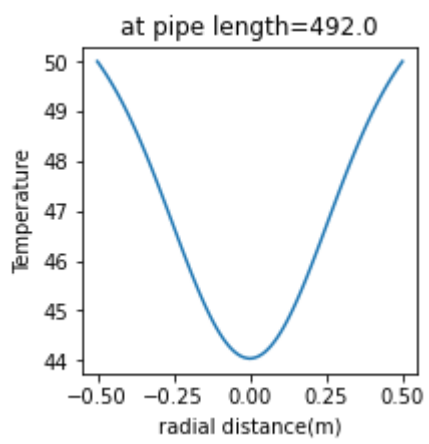
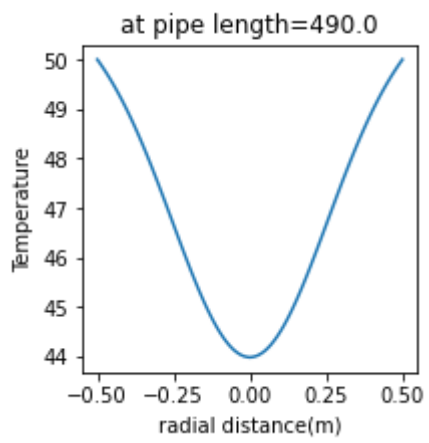
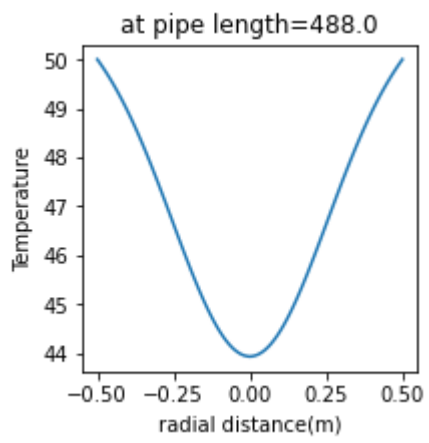


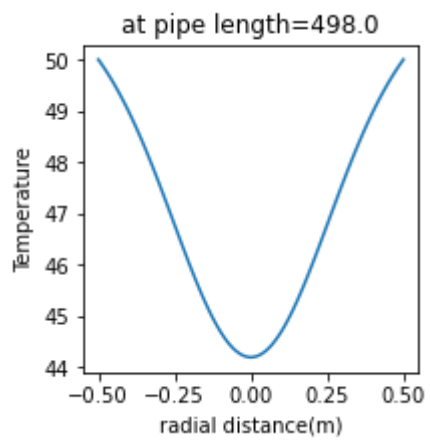
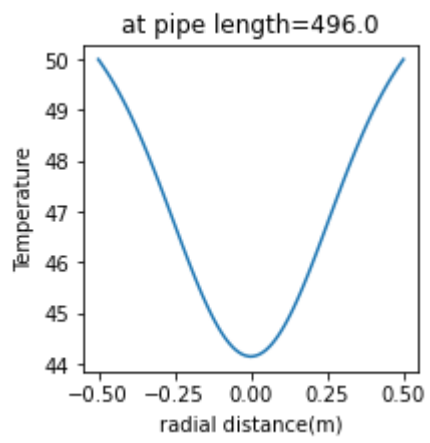












In []: