In [2]:
```
from math import sin, cos, pi
from matplotlib import pyplot as plt
import numpy as np

d_to_r = pi/180
LINE = 6
ANGLE = [0, 9,18,27,36, 45]
SYMMETRY = [(-1, 1), (-1, -1), (1, -1)]

def polar_to_xy(polar):
    coor = []
    for i in range(LINE):
        x = cos(ANGLE[i] * d_to_r) * polar[i]
        y = sin(ANGLE[i] * d_to_r) * polar[i]
        coor.append([x, y])
    for i in range(LINE-1, -1, -1):
        coor.append([coor[i][1], coor[i][0]])
    quarter = 1
    for dx, dy in SYMMETRY:
        if quarter%2 == 1:
            for i in range(LINE*2 - 1, -1, -1):
                coor.append([coor[i][0]*dx, coor[i][1]*dy])
        else:
            for i in range(LINE*2):
                coor.append([coor[i][0]*dx, coor[i][1]*dy])
        quarter += 1
    return coor

def spectrum_generator(shape):
    vertices = [mp.Vector3(shape[0][0], shape[0][1])]
    for i in range(1, len(shape) - 1):
        # eliminate duplicate point
        if abs(shape[i][0] - shape[i-1][0]) < 1e-5 and abs(shape[i][1] - shape
[i-1][1]) < 1e-5:
            continue
        vertices.append(mp.Vector3(shape[i][0], shape[i][1]))
        print(shape[i])
    # calculate transmission
    return get_trans(vertices)
```

In [3]:
```
from matplotlib import pyplot as plt
import numpy as np
import math
import meep as mp
import cmath

shape_size = 48

sx, sy, sz = 1, 1, 4
h = 1.25
dpml = 0.5
b_m, c_m = 1.4, 3.54
res = 15
echo = 1000
cell_size = mp.Vector3(sx,sy,sz)
fcen = 0.5
df = 0.2
theta = math.radians(0)
nfreq = 200

# k with correct length (plane of incidence: XZ)
k = mp.Vector3(math.sin(theta),0,math.cos(theta)).scale(fcen)
def pw_amp(k, x0):
    def _pw_amp(x):
        return cmath.exp(1j * 2 * math.pi * k.dot(x + x0))
    return _pw_amp

def get_trans(vertices):
    geometry = [mp.Block(size = cell_size, material=mp.Medium(index=b_m)),
                mp.Prism(vertices,
                         height=h,
                         material=mp.Medium(index=c_m),
                         center=mp.Vector3()
                        )]
    pml_layers = [mp.PML(thickness=1, direction = mp.Z, side=mp.High),
                  mp.Absorber(thickness=1,direction = mp.Z, side=mp.Low)]
    src_pos = -(sz/2 - dpml - 0.5)
    src = [mp.Source(src = mp.GaussianSource(fcen, fwidth=df),
                     component = mp.Ey,
                     center = mp.Vector3(0,0,src_pos),
                     size = mp.Vector3(sx,sy,0),
                     amp_func=pw_amp(k,mp.Vector3(0,0,src_pos)))]
    sim = mp.Simulation(resolution=res,
                        cell_size=cell_size,
                        boundary_layers=pml_layers,
                        sources=src,
                        geometry=geometry,
                        k_point=k)
    freg = mp.FluxRegion(center=mp.Vector3(0,0,-src_pos),
                         size = mp.Vector3(sx,sy,0))
    trans = sim.add_flux(fcen, df, nfreq, freg)
    sim.run(until = echo)
    bend = mp.get_fluxes(trans)

    #get straight
    sim.reset_meep()
```

```
    geometry = [mp.Block(size = cell_size, material=mp.Medium(index=b_m))]
    pml_layers = [mp.PML(thickness= 1, direction = mp.Z, side=mp.High),
                  mp.Absorber(thickness=1,direction = mp.Z, side=mp.Low)]
    src = [mp.Source(src = mp.GaussianSource(fcen, fwidth=df),
                     component = mp.Ey,
                     center = mp.Vector3(0,0,src_pos),
                     size = mp.Vector3(sx,sy,0),
                     amp_func=pw_amp(k,mp.Vector3(0,0,src_pos)))]
    sim = mp.Simulation(resolution=res,
                        cell_size=cell_size,
                        boundary_layers=pml_layers,
                        sources=src,
                        geometry=geometry,
                        k_point=k)
    freg = mp.FluxRegion(center=mp.Vector3(0,0,-src_pos),
                         size = mp.Vector3(sx,sy,0))
    trans = sim.add_flux(fcen, df, nfreq, freg)
    sim.run(until = echo)
    straight = mp.get_fluxes(trans)
    flux_freqs = mp.get_flux_freqs(trans)
    sim.reset_meep()
    c = 300
    p = 0.6
    Ts = []
    for i in range(nfreq):
        Ts = np.append(Ts, bend[i]/straight[i])
    return np.multiply(flux_freqs, c/p),Ts
```

In [28]:
```
T_shape = [0.19753767, 0.2,        0.19507534, 0.19507534, 0.2,        0.19753
767        ]
P_shape = [0.24440351, 0.24591094, 0.24532092, 0.23044282, 0.22185904, 0.22493
172]
```

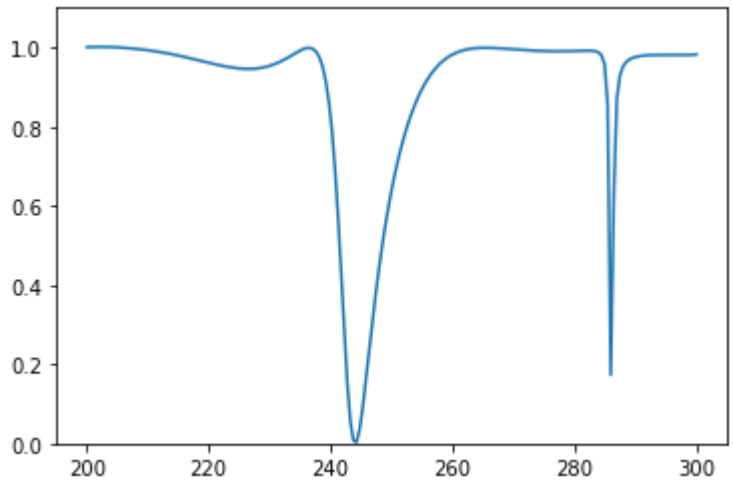
In [29]:
```
freq, Ts = spectrum_generator(polar_to_xy(P_shape))
```

```
[0.24288336826279047, 0.03846894634644031]
[0.23331405954952206, 0.07580833335569692]
[0.2053260560723657, 0.10461885101319042]
[0.17948773371571125, 0.1304054717997659]
[0.1590507445159538, 0.15905074451595377]
[0.1304054717997659, 0.17948773371571125]
[0.10461885101319042, 0.2053260560723657]
[0.07580833335569692, 0.23331405954952206]
[0.03846894634644031, 0.24288336826279047]
[0.0, 0.24440351]
[-0.03846894634644031, 0.24288336826279047]
[-0.07580833335569692, 0.23331405954952206]
[-0.10461885101319042, 0.2053260560723657]
[-0.1304054717997659, 0.17948773371571125]
[-0.15905074451595377, 0.1590507445159538]
[-0.17948773371571125, 0.1304054717997659]
[-0.2053260560723657, 0.10461885101319042]
[-0.23331405954952206, 0.07580833335569692]
[-0.24288336826279047, 0.03846894634644031]
[-0.24440351, 0.0]
[-0.24288336826279047, -0.03846894634644031]
[-0.23331405954952206, -0.07580833335569692]
[-0.2053260560723657, -0.10461885101319042]
[-0.17948773371571125, -0.1304054717997659]
[-0.1590507445159538, -0.15905074451595377]
[-0.1304054717997659, -0.17948773371571125]
[-0.10461885101319042, -0.2053260560723657]
[-0.07580833335569692, -0.23331405954952206]
[-0.03846894634644031, -0.24288336826279047]
[-0.0, -0.24440351]
[0.03846894634644031, -0.24288336826279047]
[0.07580833335569692, -0.23331405954952206]
[0.10461885101319042, -0.2053260560723657]
[0.1304054717997659, -0.17948773371571125]
[0.15905074451595377, -0.1590507445159538]
[0.17948773371571125, -0.1304054717997659]
[0.2053260560723657, -0.10461885101319042]
[0.23331405954952206, -0.07580833335569692]
[0.24288336826279047, -0.03846894634644031]
-----------
Initializing structure...
Meep: using complex fields.
Meep progress: 17.066666666666666/1000.0 = 1.7% done in 4.0s, 230.6s to go
Meep progress: 34.333333333333336/1000.0 = 3.4% done in 8.0s, 225.3s to go
Meep progress: 51.46666666666667/1000.0 = 5.1% done in 12.0s, 221.3s to go
Meep progress: 69.36666666666666/1000.0 = 6.9% done in 16.0s, 214.9s to go
Meep progress: 87.76666666666667/1000.0 = 8.8% done in 20.0s, 208.1s to go
Meep progress: 106.89999999999999/1000.0 = 10.7% done in 24.0s, 200.7s to go
Meep progress: 125.89999999999999/1000.0 = 12.6% done in 28.0s, 194.6s to go
Meep progress: 143.16666666666666/1000.0 = 14.3% done in 32.0s, 191.7s to go
Meep progress: 161.23333333333332/1000.0 = 16.1% done in 36.0s, 187.5s to go
Meep progress: 180.63333333333333/1000.0 = 18.1% done in 40.0s, 181.6s to go
Meep progress: 200.26666666666665/1000.0 = 20.0% done in 44.0s, 175.9s to go
Meep progress: 220.03333333333333/1000.0 = 22.0% done in 48.0s, 170.3s to go
Meep progress: 239.86666666666667/1000.0 = 24.0% done in 52.1s, 165.0s to go
Meep progress: 259.2/1000.0 = 25.9% done in 56.1s, 160.2s to go
Meep progress: 278.96666666666664/1000.0 = 27.9% done in 60.1s, 155.2s to go
```

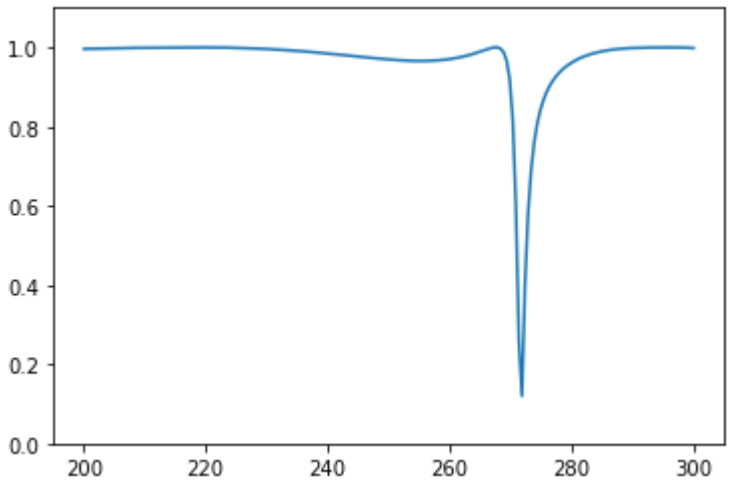
```
Meep progress: 297.56666666666666/1000.0 = 29.8% done in 64.1s, 151.2s to go
Meep progress: 315.93333333333334/1000.0 = 31.6% done in 68.1s, 147.4s to go
Meep progress: 335.6333333333333/1000.0 = 33.6% done in 72.1s, 142.7s to go
Meep progress: 355.0/1000.0 = 35.5% done in 76.1s, 138.2s to go
Meep progress: 374.8333333333333/1000.0 = 37.5% done in 80.1s, 133.6s to go
Meep progress: 394.6666666666667/1000.0 = 39.5% done in 84.1s, 129.0s to go
Meep progress: 414.59999999999997/1000.0 = 41.5% done in 88.1s, 124.4s to go
Meep progress: 434.56666666666666/1000.0 = 43.5% done in 92.1s, 119.8s to go
Meep progress: 454.26666666666665/1000.0 = 45.4% done in 96.1s, 115.4s to go
Meep progress: 472.6333333333333/1000.0 = 47.3% done in 100.1s, 111.7s to go
Meep progress: 490.96666666666664/1000.0 = 49.1% done in 104.1s, 107.9s to go
Meep progress: 510.43333333333334/1000.0 = 51.0% done in 108.1s, 103.7s to go
Meep progress: 529.7333333333333/1000.0 = 53.0% done in 112.1s, 99.5s to go
Meep progress: 549.5333333333333/1000.0 = 55.0% done in 116.1s, 95.2s to go
Meep progress: 569.2333333333333/1000.0 = 56.9% done in 120.1s, 90.9s to go
Meep progress: 588.8666666666667/1000.0 = 58.9% done in 124.1s, 86.7s to go
Meep progress: 608.1666666666666/1000.0 = 60.8% done in 128.1s, 82.6s to go
Meep progress: 627.7/1000.0 = 62.8% done in 132.1s, 78.4s to go
Meep progress: 647.1/1000.0 = 64.7% done in 136.1s, 74.2s to go
Meep progress: 666.6666666666666/1000.0 = 66.7% done in 140.1s, 70.1s to go
Meep progress: 686.3/1000.0 = 68.6% done in 144.1s, 65.9s to go
Meep progress: 705.8/1000.0 = 70.6% done in 148.1s, 61.8s to go
Meep progress: 724.8666666666667/1000.0 = 72.5% done in 152.1s, 57.7s to go
Meep progress: 741.4666666666667/1000.0 = 74.1% done in 156.1s, 54.4s to go
Meep progress: 760.0666666666666/1000.0 = 76.0% done in 160.2s, 50.6s to go
Meep progress: 778.7666666666667/1000.0 = 77.9% done in 164.2s, 46.6s to go
Meep progress: 798.3666666666667/1000.0 = 79.8% done in 168.2s, 42.5s to go
Meep progress: 817.7/1000.0 = 81.8% done in 172.2s, 38.4s to go
Meep progress: 835.2333333333333/1000.0 = 83.5% done in 176.2s, 34.8s to go
Meep progress: 854.3/1000.0 = 85.4% done in 180.2s, 30.7s to go
Meep progress: 872.7333333333333/1000.0 = 87.3% done in 184.2s, 26.9s to go
Meep progress: 892.1999999999999/1000.0 = 89.2% done in 188.2s, 22.7s to go
Meep progress: 911.7666666666667/1000.0 = 91.2% done in 192.2s, 18.6s to go
Meep progress: 931.0333333333333/1000.0 = 93.1% done in 196.2s, 14.5s to go
Meep progress: 950.4666666666667/1000.0 = 95.0% done in 200.2s, 10.4s to go
Meep progress: 970.0666666666666/1000.0 = 97.0% done in 204.2s, 6.3s to go
Meep progress: 989.8/1000.0 = 99.0% done in 208.2s, 2.1s to go
run 0 finished at t = 1000.0 (30000 timesteps)
-----------
Initializing structure...
Meep: using complex fields.
Meep progress: 19.03333333333333/1000.0 = 1.9% done in 4.0s, 206.3s to go
Meep progress: 38.56666666666666/1000.0 = 3.9% done in 8.0s, 199.5s to go
Meep progress: 57.9/1000.0 = 5.8% done in 12.0s, 195.4s to go
Meep progress: 76.7/1000.0 = 7.7% done in 16.0s, 192.7s to go
Meep progress: 96.13333333333333/1000.0 = 9.6% done in 20.0s, 188.2s to go
Meep progress: 114.03333333333333/1000.0 = 11.4% done in 24.0s, 186.6s to go
Meep progress: 133.36666666666667/1000.0 = 13.3% done in 28.0s, 182.1s to go
Meep progress: 152.96666666666667/1000.0 = 15.3% done in 32.0s, 177.3s to go
Meep progress: 171.83333333333334/1000.0 = 17.2% done in 36.0s, 173.7s to go
Meep progress: 190.6/1000.0 = 19.1% done in 40.0s, 170.0s to go
Meep progress: 210.6/1000.0 = 21.1% done in 44.0s, 165.1s to go
Meep progress: 230.03333333333333/1000.0 = 23.0% done in 48.0s, 160.8s to go
Meep progress: 249.56666666666666/1000.0 = 25.0% done in 52.0s, 156.5s to go
Meep progress: 269.5333333333333/1000.0 = 27.0% done in 56.0s, 151.9s to go
Meep progress: 289.1333333333333/1000.0 = 28.9% done in 60.1s, 147.6s to go
Meep progress: 307.8/1000.0 = 30.8% done in 64.1s, 144.1s to go
```

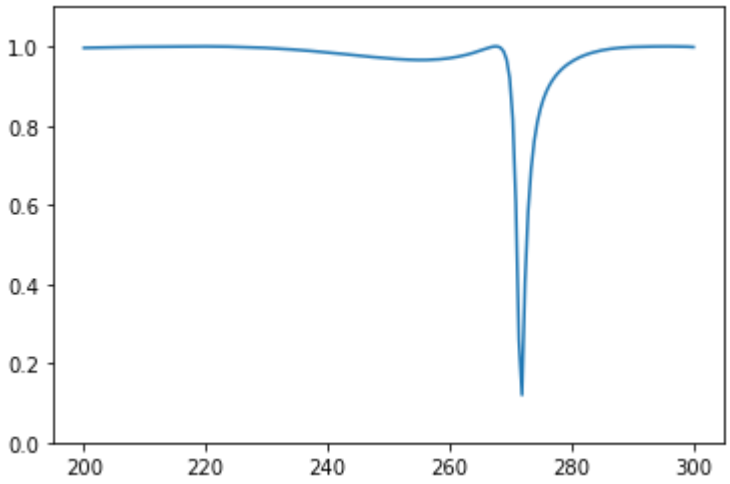
```
Meep progress: 326.6333333333333/1000.0 = 32.7% done in 68.1s, 140.3s to go
Meep progress: 345.3666666666667/1000.0 = 34.5% done in 72.1s, 136.6s to go
Meep progress: 365.1333333333333/1000.0 = 36.5% done in 76.1s, 132.3s to go
Meep progress: 384.8/1000.0 = 38.5% done in 80.1s, 128.0s to go
Meep progress: 404.73333333333335/1000.0 = 40.5% done in 84.1s, 123.7s to go
Meep progress: 424.0/1000.0 = 42.4% done in 88.1s, 119.7s to go
Meep progress: 443.8333333333333/1000.0 = 44.4% done in 92.1s, 115.4s to go
Meep progress: 463.9/1000.0 = 46.4% done in 96.1s, 111.0s to go
Meep progress: 483.3666666666667/1000.0 = 48.3% done in 100.1s, 107.0s to go
Meep progress: 503.1666666666667/1000.0 = 50.3% done in 104.1s, 102.8s to go
Meep progress: 522.6666666666666/1000.0 = 52.3% done in 108.1s, 98.7s to go
Meep progress: 542.1333333333333/1000.0 = 54.2% done in 112.1s, 94.7s to go
Meep progress: 561.7333333333333/1000.0 = 56.2% done in 116.1s, 90.6s to go
Meep progress: 581.6/1000.0 = 58.2% done in 120.1s, 86.4s to go
Meep progress: 601.3666666666667/1000.0 = 60.1% done in 124.1s, 82.3s to go
Meep progress: 620.7666666666667/1000.0 = 62.1% done in 128.1s, 78.3s to go
Meep progress: 639.0/1000.0 = 63.9% done in 132.1s, 74.6s to go
Meep progress: 658.5/1000.0 = 65.8% done in 136.1s, 70.6s to go
Meep progress: 677.8333333333334/1000.0 = 67.8% done in 140.1s, 66.6s to go
Meep progress: 697.3333333333334/1000.0 = 69.7% done in 144.1s, 62.6s to go
Meep progress: 716.6/1000.0 = 71.7% done in 148.1s, 58.6s to go
Meep progress: 736.4666666666667/1000.0 = 73.6% done in 152.1s, 54.4s to go
Meep progress: 755.2666666666667/1000.0 = 75.5% done in 156.2s, 50.6s to go
Meep progress: 772.4/1000.0 = 77.2% done in 160.2s, 47.2s to go
Meep progress: 791.8333333333334/1000.0 = 79.2% done in 164.2s, 43.2s to go
Meep progress: 810.7/1000.0 = 81.1% done in 168.2s, 39.3s to go
Meep progress: 827.2666666666667/1000.0 = 82.7% done in 172.2s, 35.9s to go
Meep progress: 845.6666666666666/1000.0 = 84.6% done in 176.2s, 32.2s to go
Meep progress: 865.3/1000.0 = 86.5% done in 180.2s, 28.0s to go
Meep progress: 885.1/1000.0 = 88.5% done in 184.2s, 23.9s to go
Meep progress: 904.9/1000.0 = 90.5% done in 188.2s, 19.8s to go
Meep progress: 924.7666666666667/1000.0 = 92.5% done in 192.2s, 15.6s to go
Meep progress: 943.4333333333333/1000.0 = 94.3% done in 196.2s, 11.8s to go
Meep progress: 962.4/1000.0 = 96.2% done in 200.2s, 7.8s to go
Meep progress: 982.5333333333333/1000.0 = 98.3% done in 204.2s, 3.6s to go
run 0 finished at t = 1000.0 (30000 timesteps)
```

In [30]:
```
plt.ylim(0, 1.1)
plt.plot(freq, Ts)
plt.show()
```

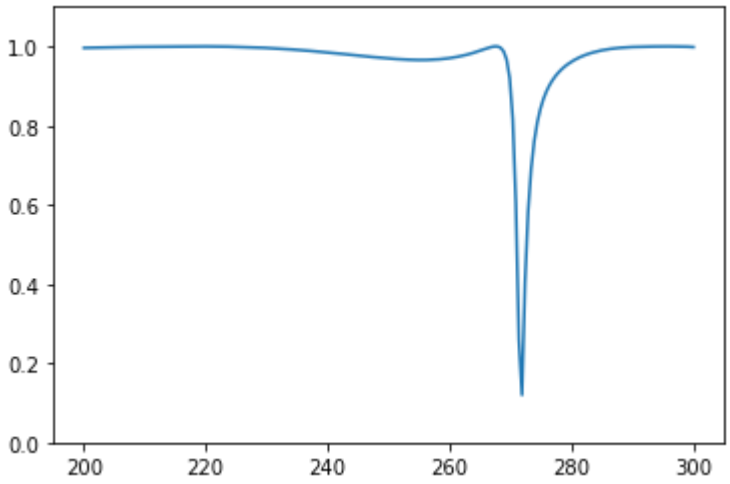


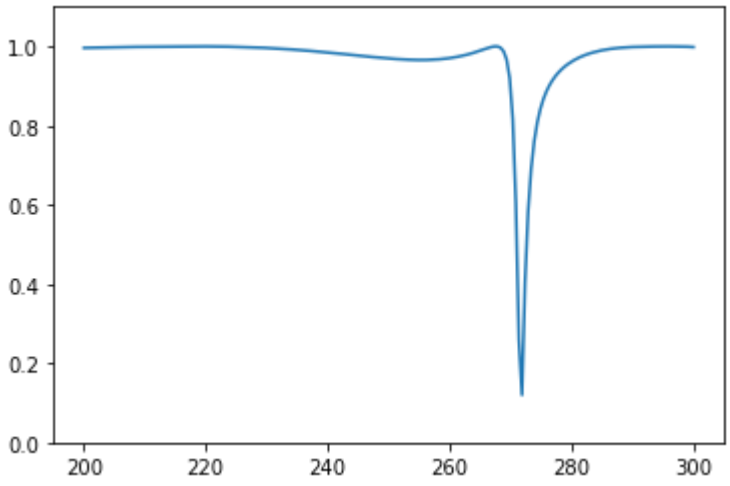
T_shape = [0.19753767, 0.2, 0.19507534, 0.19507534, 0.2, 0.19753767]
P_shape = [0.24440351, 0.24591094, 0.24532092, 0.23044282, 0.22185904, 0.22493172]



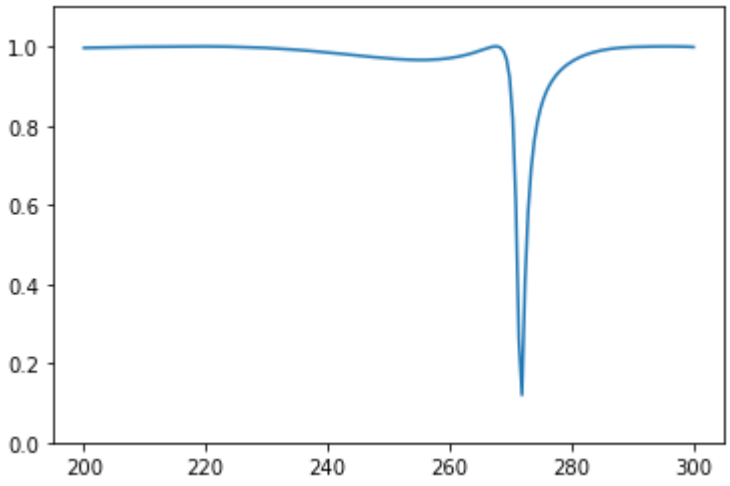


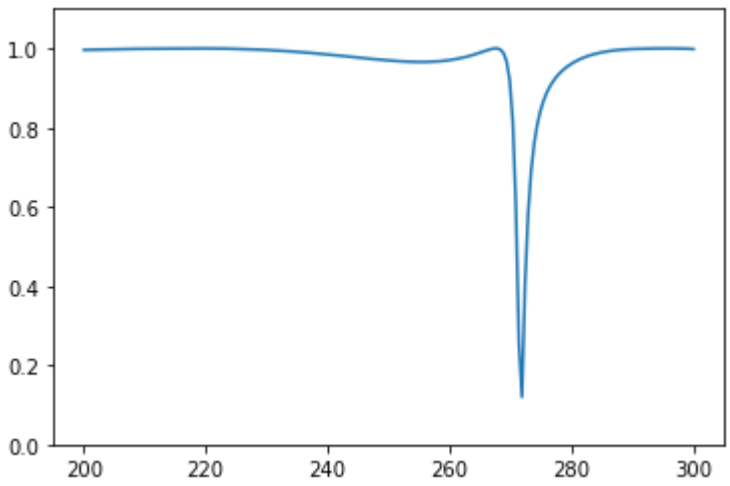
T_shape = [0.3, 0.2370452, 0.2, 0.19507534, 0.19507534, 0.2]
P_shape = [0.27488104, 0.27382213, 0.2732715, 0.25773698, 0.249807, 0.25401998]



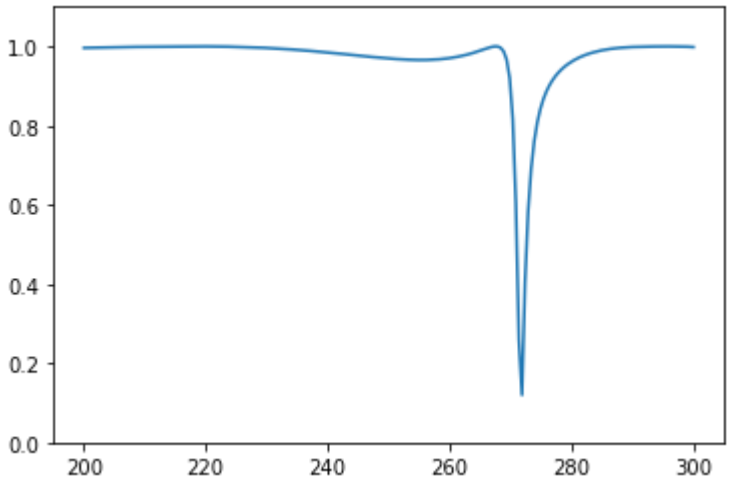


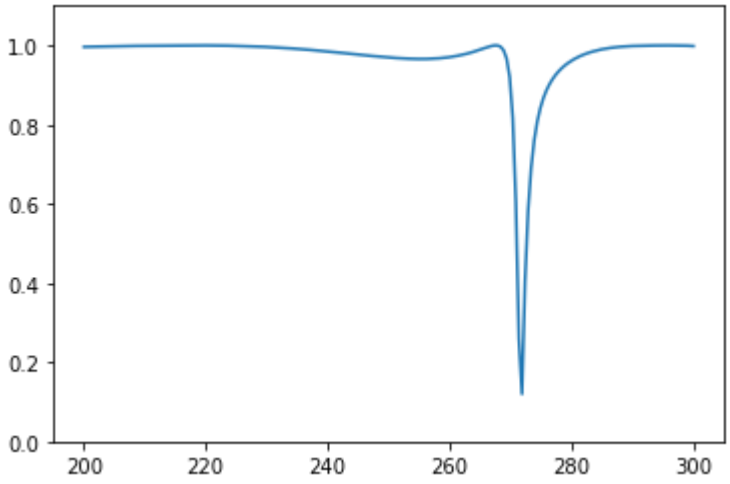
T_shape = [0.3, 0.28887347, 0.28531695, 0.28887347, 0.3, 0.2963065,]
P_shape = [0.28252465, 0.28447065, 0.27900666, 0.2868997, 0.28774616, 0.29724693]



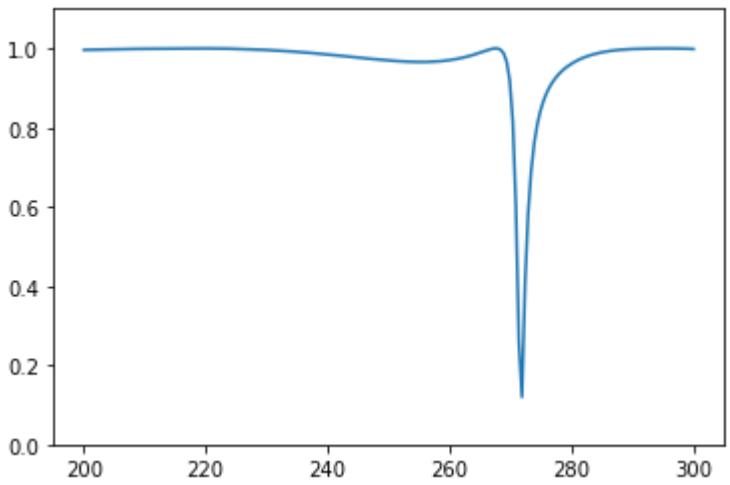


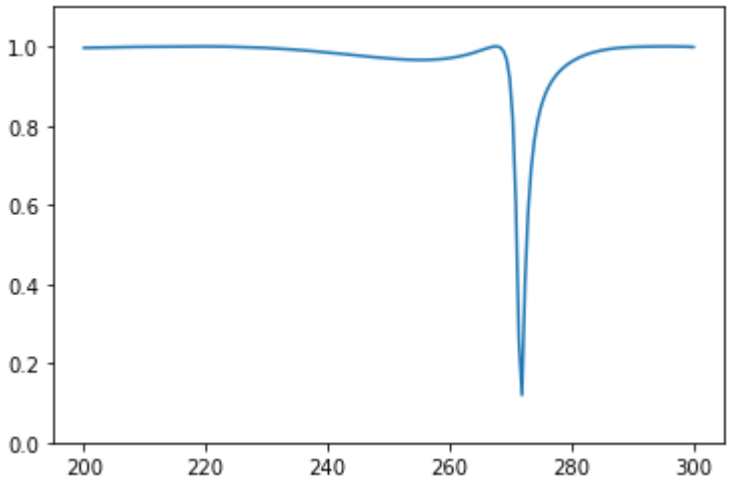
T_shape = [0.2, 0.19753767, 0.2, 0.18737194, 0.18042261, 0.1782013] P_shape = [0.20520595, 0.20827824, 0.20905438, 0.19598675, 0.18641497, 0.18946438]



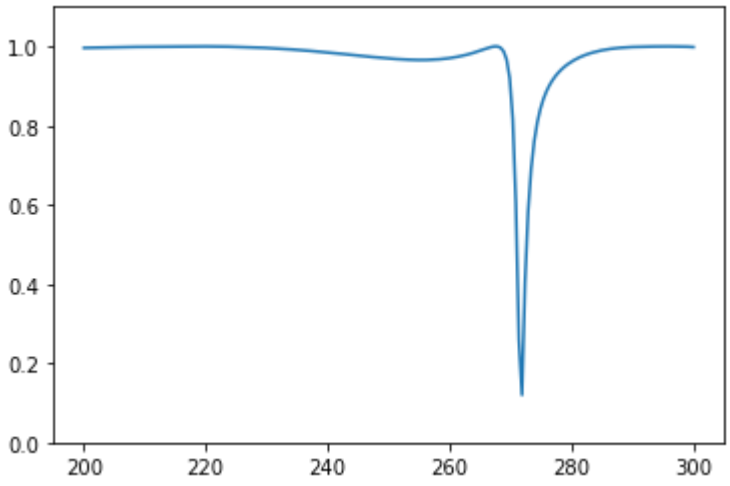


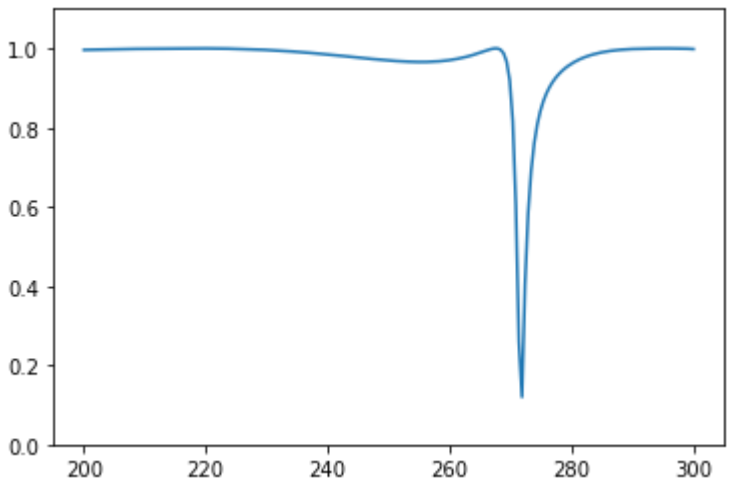
T_shape = [0.2, 0.21968701, 0.25051498, 0.3, 0.28887347, 0.28531695]
P_shape = [0.25500047, 0.25664952, 0.25505495, 0.23924059, 0.23147322, 0.23404978]



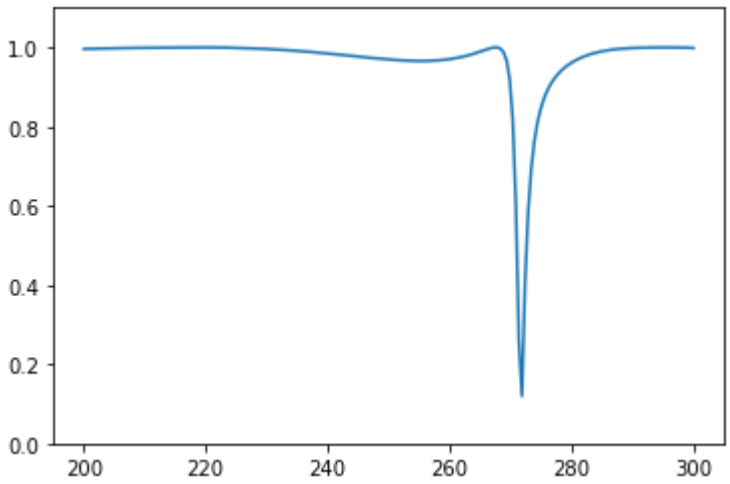


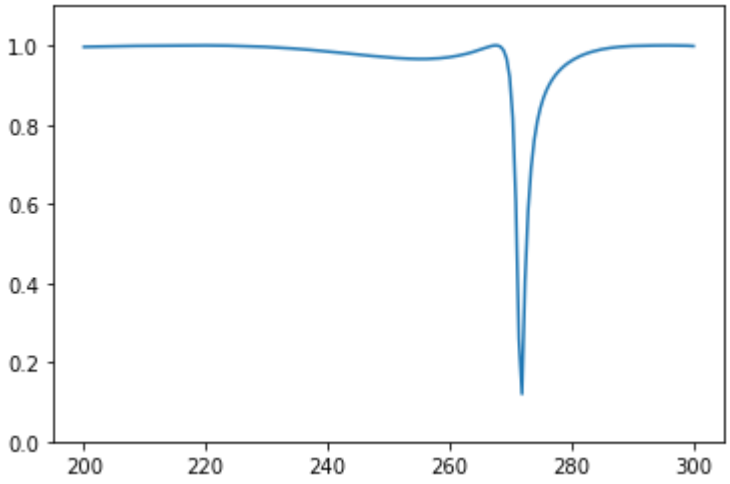
T_shape = [0.3, 0.2963065, 0.3, 0.2370452, 0.2, 0.19753767]
P_shape = [0.2752146, 0.2757306, 0.27225614, 0.2607578, 0.25705594, 0.2554644]



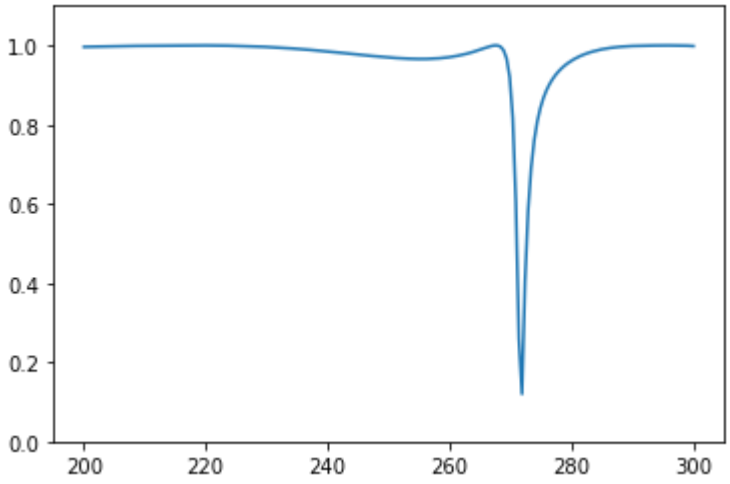


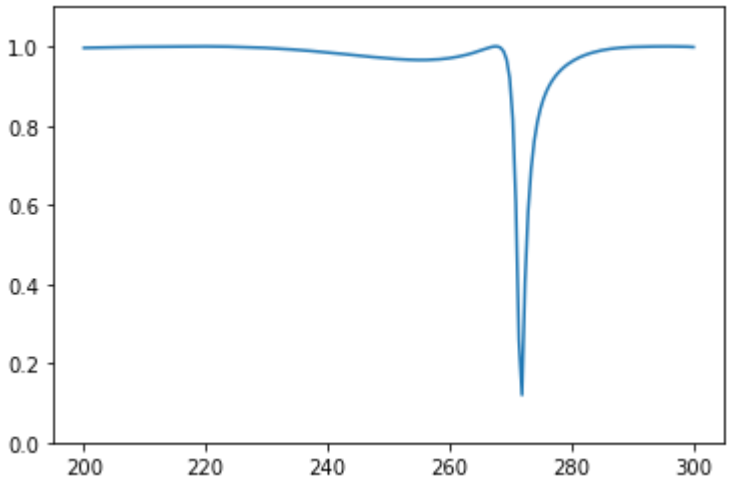
T_shape = [0.1, 0.2, 0.1815962, 0.17013016, 0.1638203, 0.1618034]
P_shape = [0.14724818, 0.1535455, 0.15903279, 0.15645951, 0.14163078, 0.13833539]



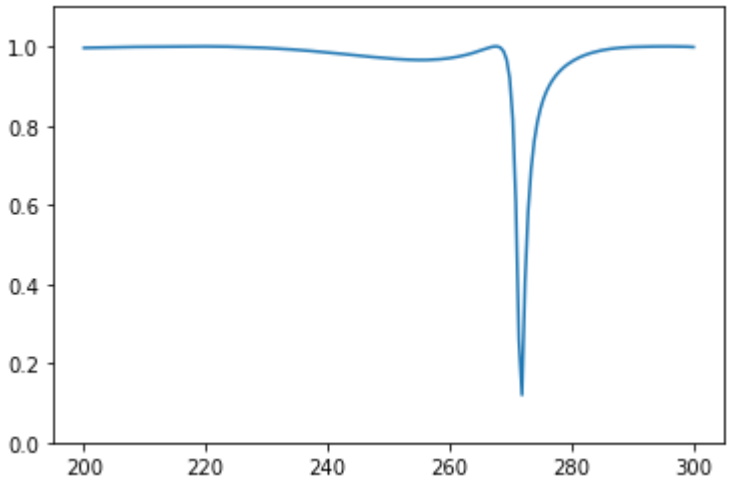


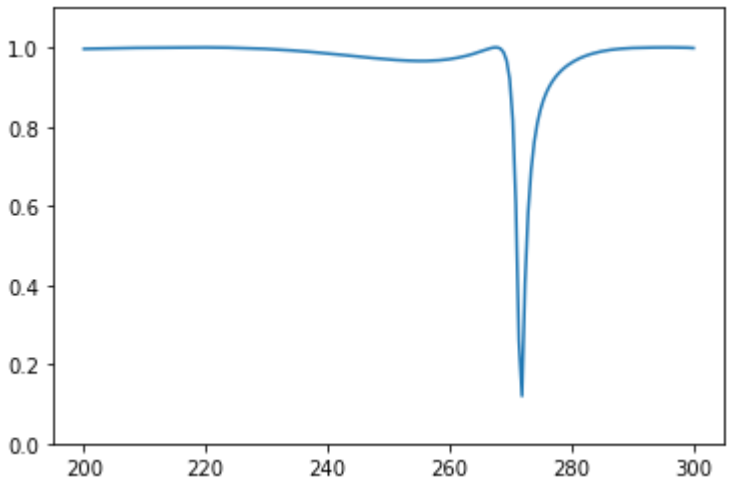
T_shape = [0.39507534, 0.4, 0.338636, 0.3, 0.338636, 0.4]
P_shape = [0.3770977, 0.3605369, 0.354459, 0.3433456, 0.33134732, 0.3258838]





P_shape = [0.14291796, 0.13878718, 0.14108998, 0.14678332, 0.14327656, 0.14059259]
T_shape = [0.09876883, 0.1 , 0.13169178, 0.2 , 0.19258231, 0.1902113]





T_shape = [0.5, 0.45246718, 0.42269179, 0.40597245, 0.4, 0.39507534]
P_shape = [0.41662487, 0.42575783, 0.43479764, 0.47176093, 0.4824425, 0.49359637]