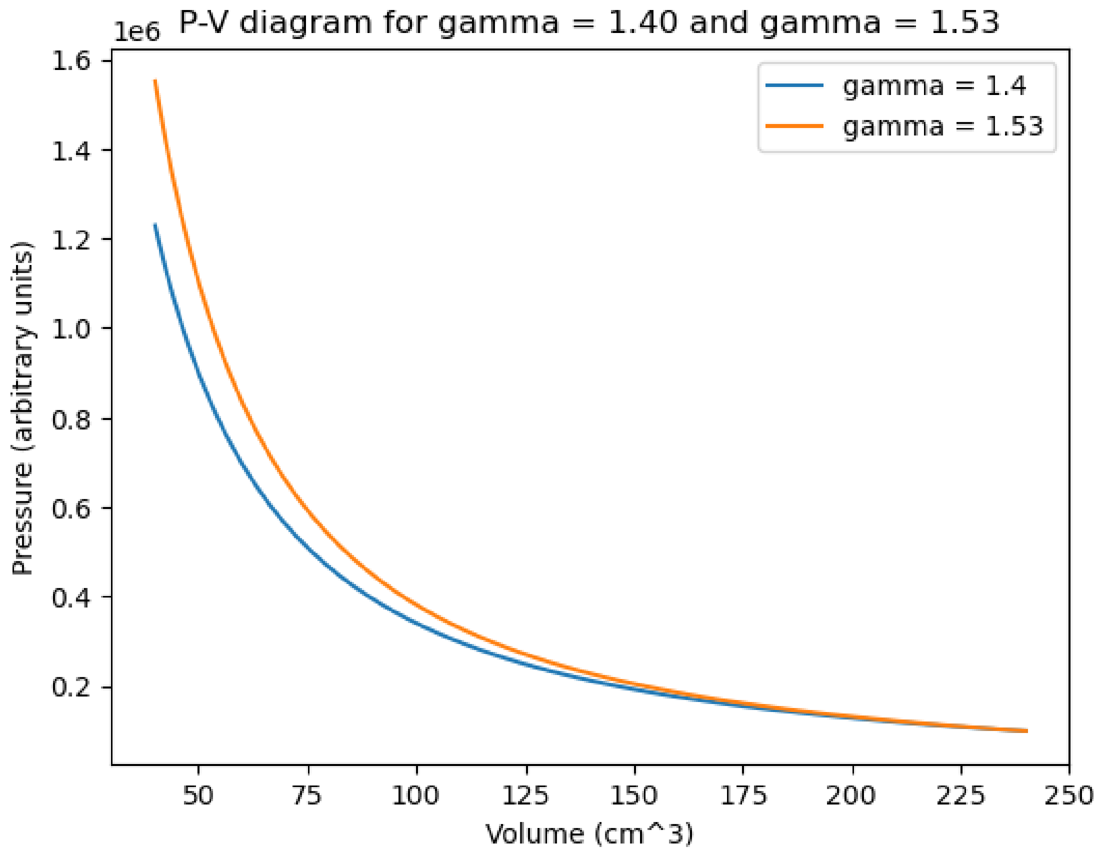
$$P_1 V_1^{\gamma} = P_2 V_2^{\gamma} = constant$$

$$T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1} = constant$$

In [3]:

```
import numpy as np
import matplotlib.pyplot as plt

gamma_1 = 1.4  # Calculated from degrees of freedom
gamma_2 = 1.53 # From paper
V_initial = 240  # initial volume cm^3
P_initial = 1e5  # initial pressure in Pa

V = np.linspace(V_initial, 40, 100)

P_1 = (V_initial/V)**(gamma_1) * P_initial
P_2 = (V_initial/V)**(gamma_2) * P_initial

T_initial = 293 # Kelvin
T_final_1 = T_initial * (V_initial/V)**(gamma_1 - 1)
T_final_2 = T_initial * (V_initial/V)**(gamma_2 - 1)

plt.plot(V, P_1, label=f"gamma = {gamma_1}")
plt.plot(V, P_2, label=f"gamma = {gamma_2}")

plt.xlabel('Volume (cm^3)')
plt.ylabel('Pressure (arbitrary units)')
plt.title('P-V diagram for gamma = 1.40 and gamma = 1.53')

#P_final_1 = P_initial * (V_initial/V_final)**gamma_1
#P_final_2 = P_initial * (V_initial/V_final)**gamma_2

print(f'{"Final Pressure (gamma=1.4):":<40} {P_1[-1]:<15.0f} Pa (N m^[-2])
print(f'{"Final Pressure (gamma=1.53):":<40} {P_2[-1]:<15.0f} Pa (N m^[-2]
print(f'{"Absolute error for pressure:":<40} {abs((P_1[-1] - P_2[-1])/P_2[
print('-' * 70)
print(f'{"Final Temperature (gamma=1.4):":<40} {T_final_1[-1]:<15.0f} K')
print(f'{"Final Temperature (gamma=1.53):":<40} {T_final_2[-1]:<15.0f} K')
print(f'{"Absolute error for temperature:":<40} {abs((T_final_1[-1] - T_fi

plt.legend()
plt.show()
```

```
Final Pressure (gamma=1.4):              1228604         Pa (N m^[-2])
Final Pressure (gamma=1.53):             1550856         Pa (N m^[-2])
Absolute error for pressure:             20.8            %
----------------------------------------------------------------------
Final Temperature (gamma=1.4):           600             K
Final Temperature (gamma=1.53):          757             K
Absolute error for temperature:          20.8            %
```


P-V diagram for gamma = 1.40 and gamma = 1.53
1e6
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
Pressure (arbitrary units)
gamma = 1.4
gamma = 1.53
50
75
100
125
150
175
200
225
250
Volume (cm^3)

In [12]:

```
print('V (cm^3) | P (gamma=1.4) (Pa) |  P (gamma=1.53) (Pa) | P_Err (%) |
print('-'*120)
for V_val in np.linspace(V_initial, 40, 10):
    P_1 = (V_initial/V_val)**(gamma_1) * P_initial
    P_2 = (V_initial/V_val)**(gamma_2) * P_initial

    T_initial = 293
    T_final_1 = T_initial * (V_initial/V_val)**(gamma_1 - 1)
    T_final_2 = T_initial * (V_initial/V_val)**(gamma_2 - 1)

    P_abs_err = abs((P_2 - P_1) / P_2) * 100
    T_abs_err = abs((T_final_2 - T_final_1) / T_final_2) * 100

    print('{0: 8.0f} | {1: 18.0f} | {2: 20.0f} | {3: 9.2f} | {4: 17.0f} |
print()
```

```
V (cm^3) | P (gamma=1.4) (Pa) |  P (gamma=1.53) (Pa) | P_Err (%) | T (ga
mma=1.4) (K) | T (gamma=1.53) (K) | T_Err (%)
------------------------------------------------------------------------
------------------------------------------------
     240 |             100000 |               100000 |      0.00 |
293 |                293 |      0.00
     218 |             114572 |               116028 |      1.26 |
305 |                308 |      1.26
     196 |             133204 |               136798 |      2.63 |
318 |                327 |      2.63
     173 |             157711 |               164526 |      4.14 |
334 |                348 |      4.14
     151 |             191109 |               202955 |      5.84 |
353 |                374 |      5.84
     129 |             238778 |               258877 |      7.76 |
376 |                407 |      7.76
     107 |             311211 |               345811 |     10.01 |
405 |                450 |     10.01
      84 |             431615 |               494390 |     12.70 |
445 |                510 |     12.70
      62 |             661869 |               788836 |     16.10 |
503 |                599 |     16.10
      40 |            1228604 |              1550856 |     20.78 |
600 |                757 |     20.78
```

In [ ]:

In [ ]: