Linear Interpolation

between two points

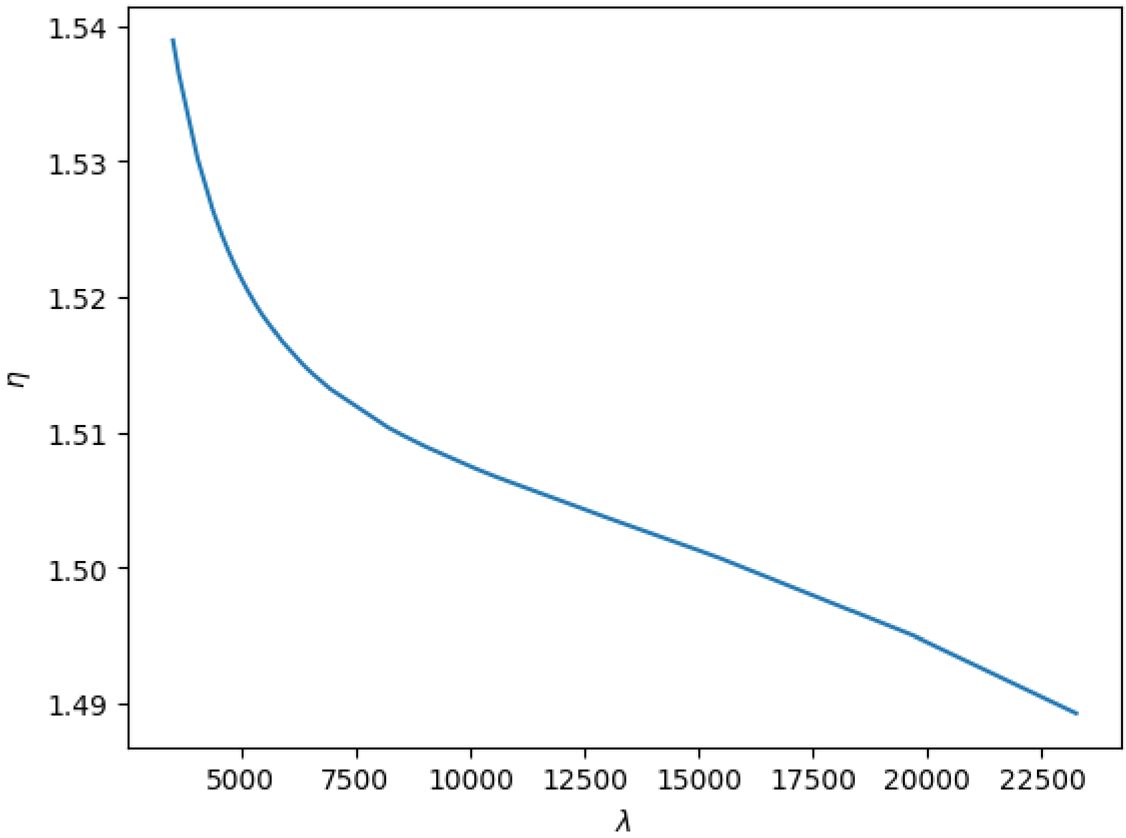
$$y = y_1 + \frac{y_2 - y_1}{x_2 - x_1}(x - x_1)$$

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

In [28]:
```
data = np.loadtxt('data.txt', skiprows = 1 )
l = data[: , 0] # wavelength
r = data[: , 1] # refractive index
print( f' l = {l} \n and \n r = {r}')
```

```
 l = [ 3511.  3638.  4047.  4358.  4416.  4579.  4658.  4727.  4765.  4800.
  4861.  4880.  4965.  5017.  5145.  5320.  5461.  5876.  5893.  6328.
  6438.  6563.  6943.  8210.  8300.  8521.  9040. 10140. 10600. 13000.
 15000. 15500. 19701. 23254.]
 and
 r = [1.53894 1.53648 1.53024 1.52669 1.52611 1.52462 1.52395 1.52339 1.5231
 1.52283 1.52238 1.52224 1.52165 1.5213  1.52049 1.51947 1.51872 1.5168
 1.51673 1.51509 1.51472 1.51432 1.51322 1.51037 1.51021 1.50981 1.50894
 1.50731 1.50669 1.50371 1.5013  1.50068 1.495   1.48929]
```

In [29]:
```
# plt.figure( figsize = ( 17   , 8 ))
plt.plot( l , r )
plt.xlabel(r'$\lambda$')
plt.ylabel(r'$\eta$')
plt.show()
```

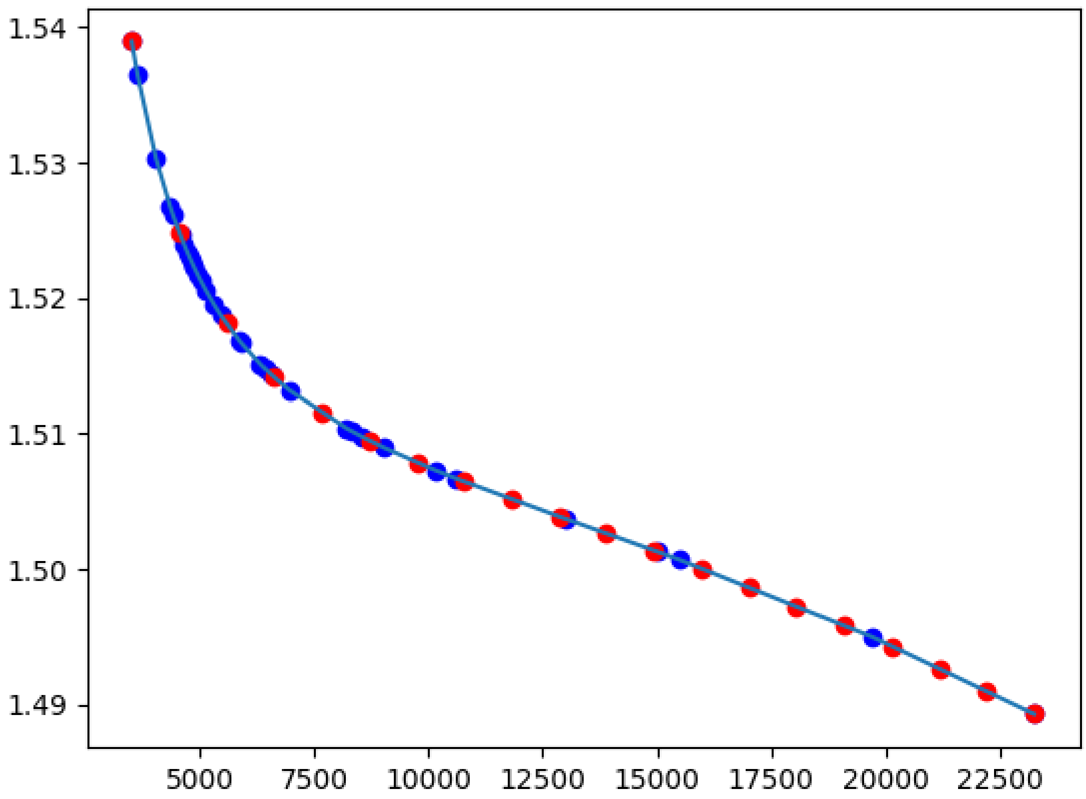


In [30]:
```
print( 'Shortes wavelength in the data = ' , np.min( l ))
print( 'Longest wavelength in the data = ' , np.max( l ))
```

```
Shortes wavelength in the data =  3511.0
Longest wavelength in the data =  23254.0
```

In [54]:
```
def linear_interpolate_vector( l , r , n ): # n = number of points
    l_li = np.linspace( l[0] , l[-1] , n )
    r_li = np.zeros( l_li.size )
    for i in range( l_li.size ):
        index = np.sum( np.array( l < l_li[i] , dtype = int )) - 1
        r_li[i] = r[index] + ( r[index + 1] - r[index] )*( l_li[i] - l[index
    return l_li , r_li  # wavelenght and refractive index
```

In [61]:
```
lnew , rnew = linear_interpolate_vector( l , r, 20  )
plt.plot( l , r )
plt.scatter( l , r , color = 'b')
plt.scatter( lnew , rnew , color = 'r')
plt.show()
```



Question 2

$$p_L(x) = \sum_{k=0}^{n} y_k L_k(x)$$

$$L_k(x) = \prod_{i \neq k}^{n} \frac{x - x_i}{x_k - x_i}$$

In [115…
```
def L( x , k , xp ):
    xk = xp[k]
    temp = np.delete( xp , k)
    return np.prod(np.divide( x - temp , xk - temp ))
# L = np.vectorize(L)
```

```python
def P( x , xp , yp ):
    ans = 0.0
    for k in range( xp.size ):
        ans += yp[k]*L( x , k , xp )
    return ans
def interpol( x , xp , yp ):
    y = np.zeros( x.size )
    for i in range( x.size ):
        y[i] = P( x[i] , xp , yp )
    return y
```

In [108…

```python
# def L2( x , k , xp ):
#     xk = xp[k]
#     temp = np.delete( xp , k)
#     return np.prod(np.divide( x - temp , xk - temp ))
# L2 = np.vectorize(L2 , excluded=['x' , 'xp'])
# def P2( x , xp , yp ):
#     ans = 0.0
#     k = np.arange( xp.size )
#     l = L( x , k , xp )
#     return np.sum( yp*l )
# P2 = np.vectorize( P2 , excluded=['xp' , 'yp'])
```

In [110…

```python
def testP( xp , yp ):
    result = np.zeros( xp.size )
    for i in range( xp.size ):
        result[i] = P( xp[i] , xp , yp ) - yp[i]
    return result
def testP2( xp , yp ):
    return P( xp , xp , yp ) - yp
```

In [116…

```python
x = np.linspace( 0 , np.pi , 5 )
print( 'size of x = '  , x.size )
y = np.sin( x )
print( testP( x , y ))
```

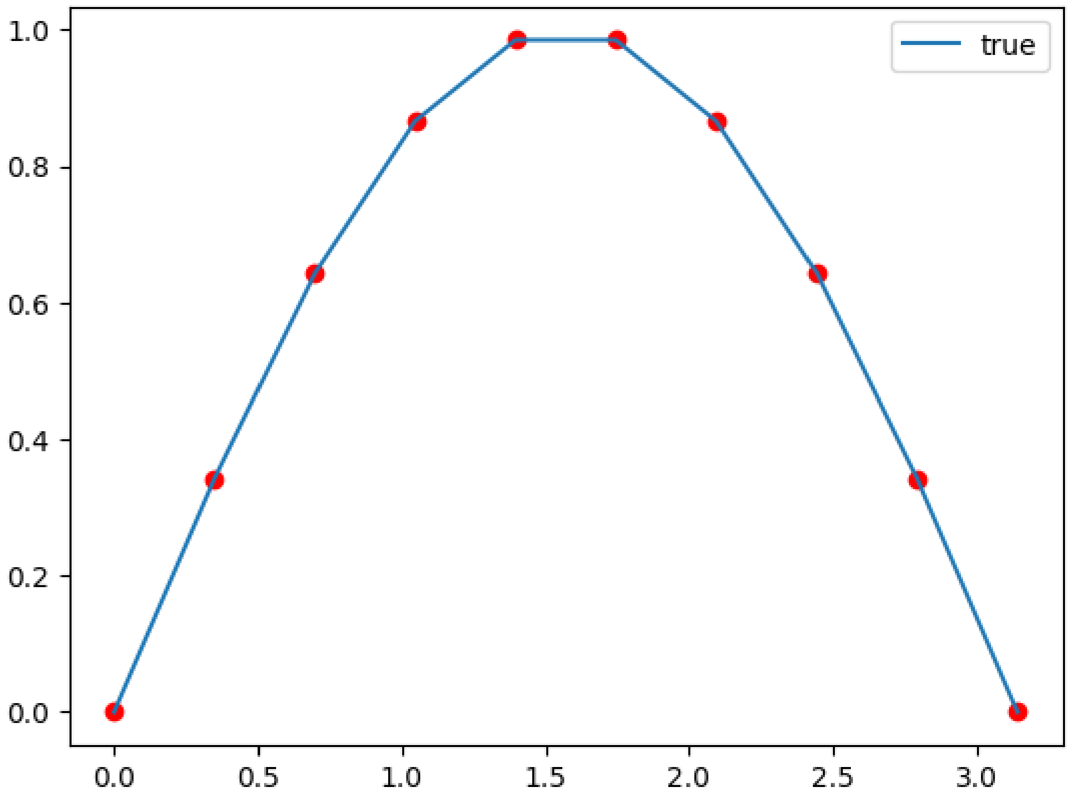
```
size of x =  5
[0. 0. 0. 0. 0.]
```

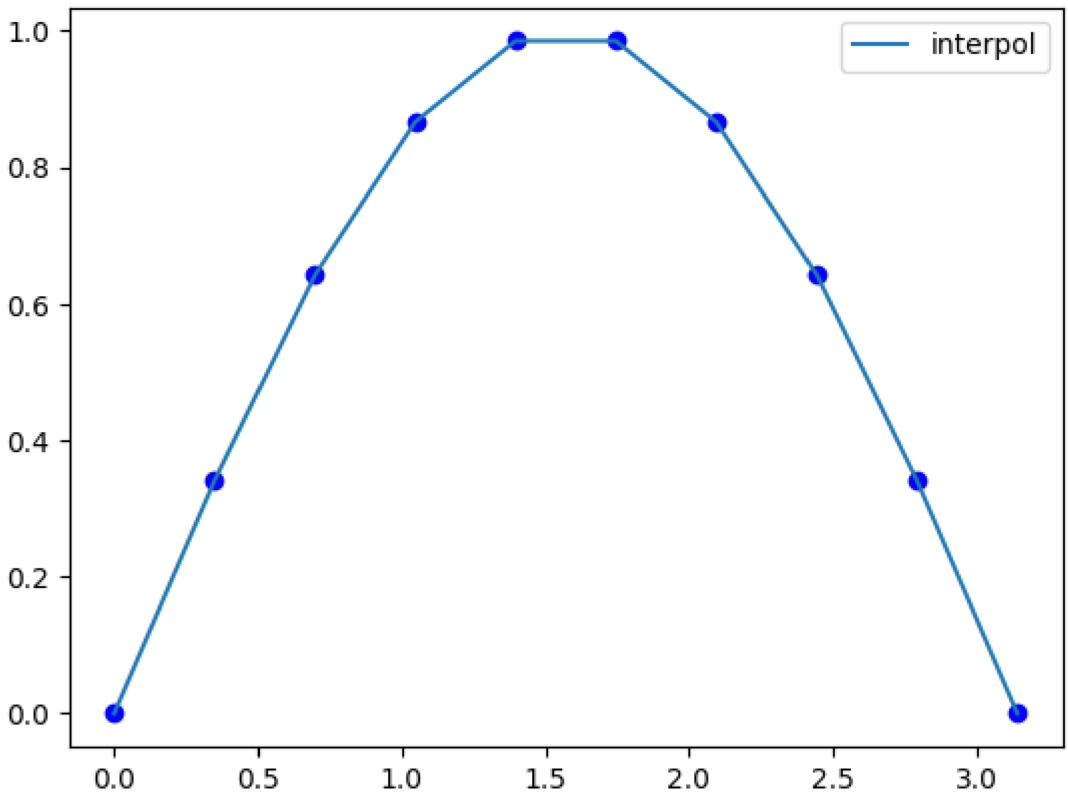
In [123…

```python
test_size = 10
test_x = np.linspace( 0 , np.pi , test_size )
true_y = np.sin( test_x )
inter_y = interpol( test_x , x , y )

plt.plot( test_x , true_y , label = r'true')
plt.scatter( test_x , true_y , color = 'red')
plt.legend()
plt.show()

plt.plot( test_x , inter_y , label = 'interpol')
plt.scatter( test_x , inter_y , color = 'b')
plt.legend()
plt.show()
```





In [124…

```
print( inter_y - true_y )
```

```
[ 0.00000000e+00 -1.63021667e-03 -2.43693689e-04  2.69526223e-04
  5.71903358e-05  5.71903358e-05  2.69526223e-04 -2.43693689e-04
 -1.63021667e-03  0.00000000e+00]
```

test

In [96]:

```
x = np.arange( 4 , 10 )
y = np.array( x < 6.5  , dtype = int  )
print( x )
```

```
print( y )
print( 'index = ' , np.sum( y ) - 1 )
for i in range( x.size ):
    print( x[i])
    print( x )
```

```
[4 5 6 7 8 9]
[1 1 1 0 0 0]
index =  2
4
[4 5 6 7 8 9]
5
[4 5 6 7 8 9]
6
[4 5 6 7 8 9]
7
[4 5 6 7 8 9]
8
[4 5 6 7 8 9]
9
[4 5 6 7 8 9]
```

In [97]:

```
print( np.prod( x ))
```

```
60480
```

In [94]:

```
print( x )
y = np.delete( x , 1 )
print(  y )
print( x )
```

```
[0.         0.78539816 1.57079633 2.35619449 3.14159265]
[0.         1.57079633 2.35619449 3.14159265]
[0.         0.78539816 1.57079633 2.35619449 3.14159265]
```

In [93]:

```
xp = [ 0 , 1 , 2 , 3 ]
xp = np.array( xp )

k = np.arange( 0 , xp.size  )

print( L( 2 ,  3 , xp ))
print( x )
```

```
0.0
[0.         0.78539816 1.57079633 2.35619449 3.14159265]
```