1. Plot Planck's law for blackbody at temperature a) 300K b) 400K c) 500K

Planck's Law is given by the formula:

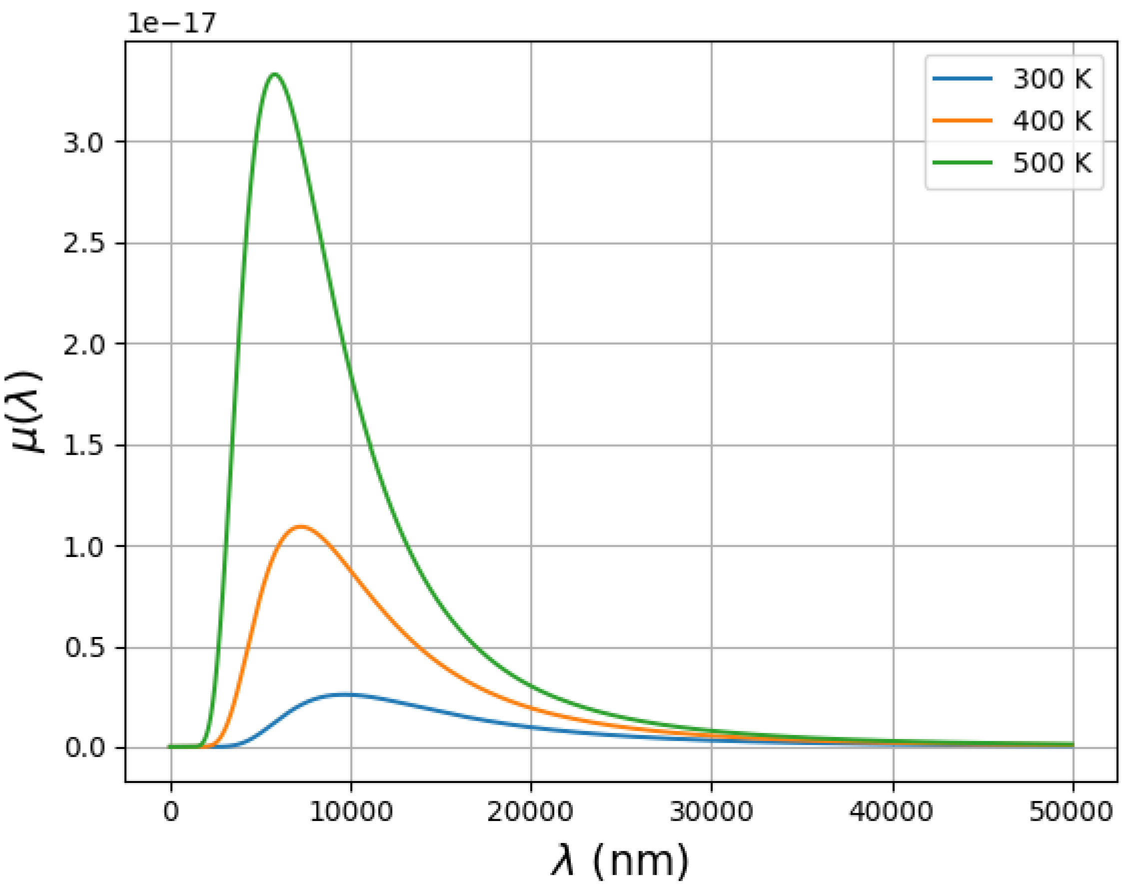
$$\mu(\lambda) = \frac{8\pi hc}{\lambda^5 \left(e^{\frac{hc}{\lambda kT}} - 1\right)}$$

Where:

- $\mu(\lambda)$ is the spectral radiance,In the context of Planck's law, $\mu(\lambda)$ provides the radiant flux per unit wavelength interval, which indicates how much radiant energy is emitted per unit time per unit wavelength range at a given temperature.In other words $\mu(\lambda)$ is radiant flux per unit wavelength. Radiance is the radiant flux emitted, reflected, transmitted or received by a given surface,
- λ is the wavelength of light,
- h is Planck's constant,
- c is the speed of light in vacuum,
- k is the Boltzmann constant, and
- T is the temperature.

In [6]:

```
import matplotlib.pyplot as plt
import numpy as np
%matplotlib inline
T=[300,400,500]
hc=1240
k=8.61*(10**(-5))
np.seterr(over='ignore') # to remove error message
x=np.linspace(0.0001,50000,100000)
for t in T:
 y=(8*np.pi*hc)/((x**5) * (np.exp(hc/(x*k*t))-1))
 plt.plot(x,y)
 plt.ylabel("$\mu(\lambda)$", fontsize=15)  # Spectral radiance
 plt.xlabel("$\lambda$ (nm)", fontsize=15)  # Wavelength
 plt.grid(True)
 plt.legend(['300 K','400 K','500 K'])
```



2.1 Verify Wein's displacement law for all three temperatures

$\lambda_{max} T = a$

where $a = 2.898 \times 10^{-3}$m.K

In [2]:
```
T=[300,400,500]
lambda_max=[9668.59,7251.5,5801.05]
for i in range(len(T)):
    print(f'lambda_max{i+1}*T{i+1} is {T[i]*lambda_max[i]*1e-9}')
```

```
lambda_max1*T1 is 0.002900577
lambda_max2*T2 is 0.0029006
lambda_max3*T3 is 0.002900525
```

2.2 Verify Stephan's law for all three temperatures

Stefan's Law, also known as the Stefan-Boltzmann Law, states that the total energy radiated per unit surface area of a black body per unit time ((P)) is directly proportional to the fourth power of the black body's temperature T :

$$u = \sigma T^4$$

Where:

- P is the total power radiated per unit area (in watts per square meter),
- T is the absolute temperature of the black body (in kelvin), and
- σ is the Stefan-Boltzmann constant, approximately equal to 5.67×10^{-8} watt per square meter per kelvin to the fourth $(\mathrm{W\ m^{-2}K^{-4}})$.

In [3]:
```
from scipy.integrate import quad

# Define constants
hc = 1240
k = 8.61e-5
t1=300
t2=400
t3=500

def f(x,t):
    return (8 * np.pi * hc) / (x**5 * (np.exp(hc / (x * k * t)) - 1))

# Integrate the function from 0 to 200
u1,err = quad(f, 0,50000,t1)
u2,err=quad(f,0,50000,t2)
u3,err=quad(f,0,50000,t3)

print(f'u1/u2 ={u1/u2} and  t1^4/t2^4  is {(t1**4)/(t2**4)}')
print(f'u2/u3 ={u2/u3} and  t2^4/t3^4  is {(t2**4)/(t3**4)}')
print(f'u1/u3 ={u1/u3} and  t1^4/t3^4  is {(t1**4)/(t3**4)}')
```

```
u1/u2 =0.31105892791083967 and  t1^4/t2^4  is 0.31640625
u2/u3 =0.4068577981513973 and  t2^4/t3^4  is 0.4096
u1/u3 =0.12655675050513843 and  t1^4/t3^4  is 0.1296
```

3. For a blackbody plot a) Plank's law b) Wein's law c) Rayleigh-Jeans law

The Wien's distribution law describes the spectral radiance of blackbody radiation as a function of wavelength at a given temperature (T). It is given by the formula:

- Plank's law

$$\mu(\lambda) = \frac{8\pi hc}{\lambda^5 \left(e^{\frac{hc}{\lambda kT}} - 1\right)}$$

- Wein's law

$$\mu(\lambda) = \frac{8\pi hc}{\lambda^5} \cdot e^{\left(-\frac{hc}{\lambda kT}\right)}$$

- Rayleigh-Jeans law

$$\mu(\lambda) = \frac{8\pi kT}{\lambda^4}$$

In [5]:

```
t=300
hc=1240
k=8.61*(10**(-5))

x=np.linspace(0.0001,50000,1000)
x1=np.linspace(20000,50000,1000)

y=(8*np.pi*hc)/((x**5)  * (np.exp(hc/(x*k*t))-1))
y1=(8*np.pi*k*t)/(x1**4)
y3=(8*np.pi*hc*np.exp(-hc/(x*k*t)))/((x**5))

plt.plot(x,y)
plt.plot(x1,y1)
plt.plot(x,y3,'--')
plt.ylabel("$\mu(\lambda)$", fontsize=15)  # spectral radiance
plt.xlabel("$\lambda$ (nm)", fontsize=15)  # Wavelength
plt.legend(["Planks law","Rayleigh-Jeans","Wien's law"])
plt.grid(True)
```