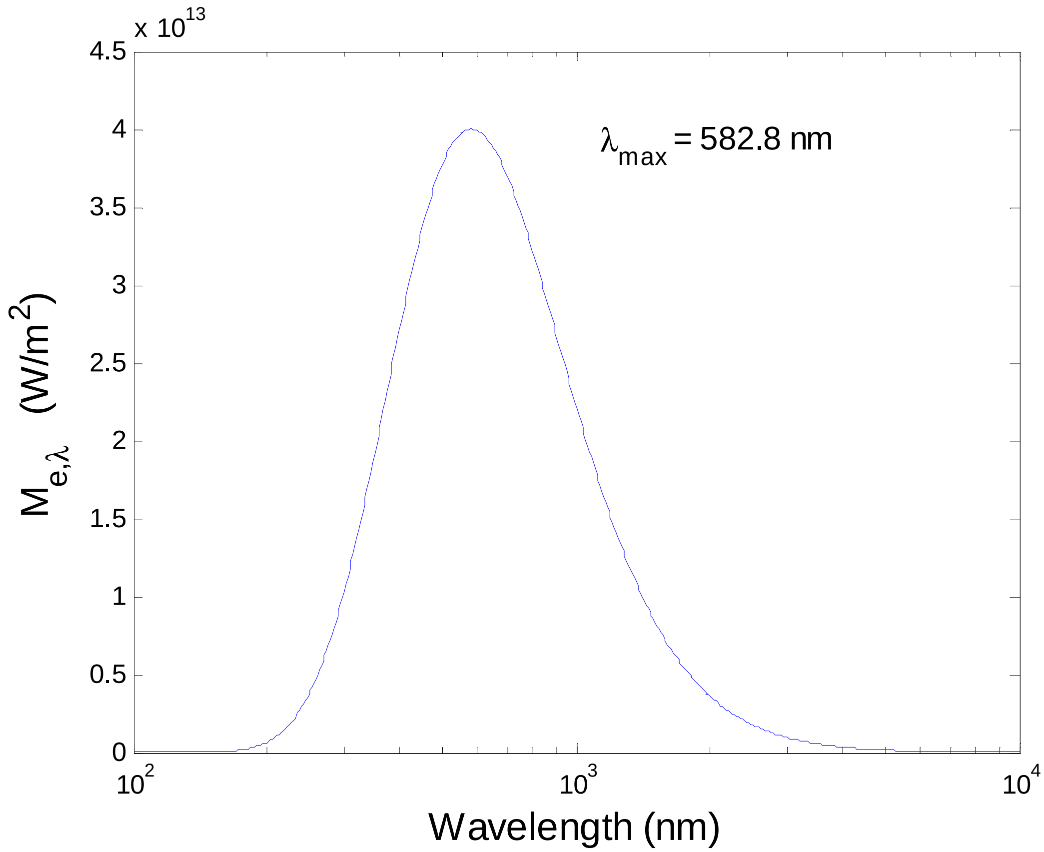
ECE G287 Homework 1 Solution

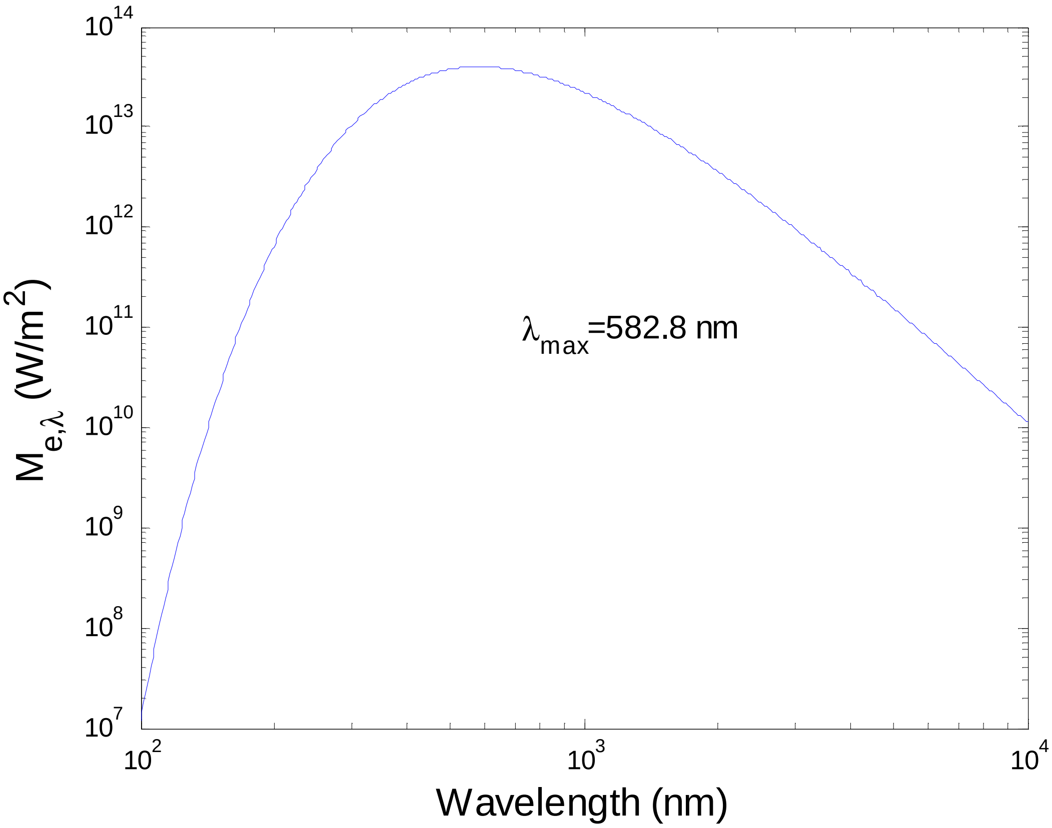
```
>> h=6.63e-34;
>> c=2.998e8;
>> k=1.38e-23;

>> yl=logspace(2, 4, 500);
>> ylm=yl*1e-9;
```

Part a

```
>> M_eyl=2*pi*h*c^2 ./ (ylm.^5  .*(exp(h*c ./ (ylm*k*5000)) -1));
>> semilogx(yl, M_eyl)
>> xlabel('Wavelength (nm)'); ylabel( 'M_{e,\lambda}')
```




```
>> figure(2)
>> loglog(yl, M_eyl)
>> xlabel('Wavelength (nm)'); ylabel( 'M_{e,\lambda}   (W/m^2)')
```



Part b

```
>> [Max,i]=max(M_eyl)
Max =
  4.0015e+013
i =
   192
>> yl(i)
ans =
  582.8155
```

Part c

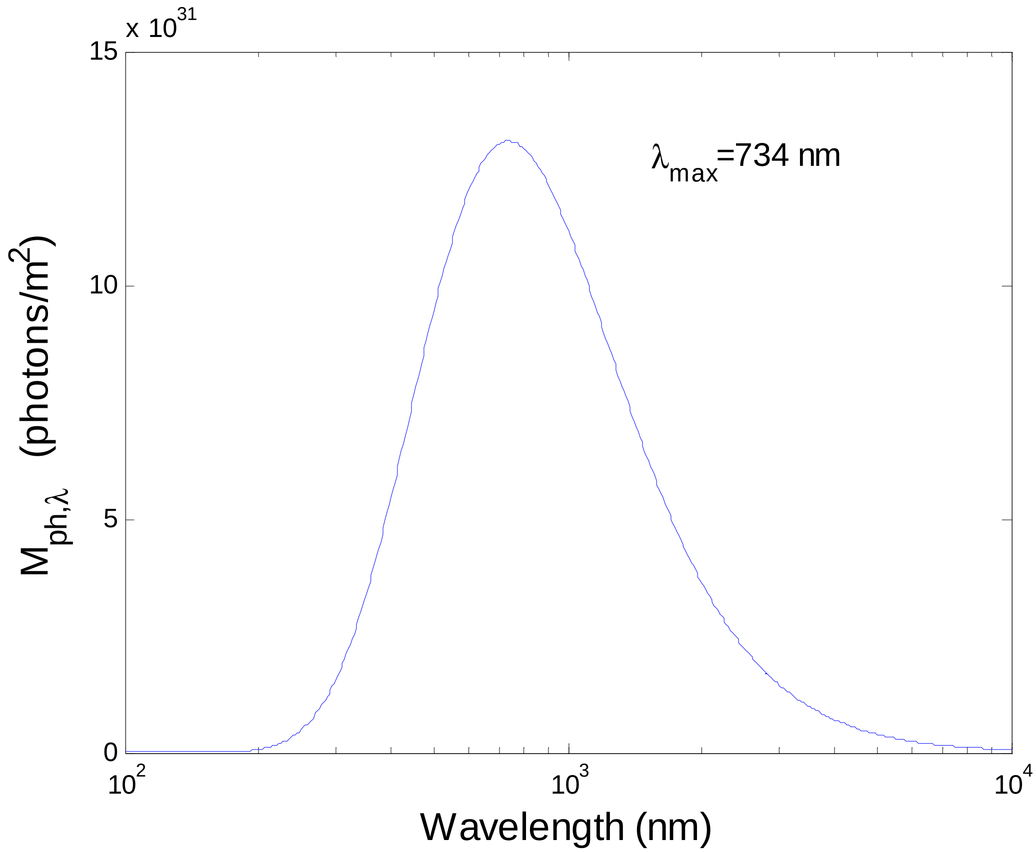
```
>> yl1=550e-9;
>> yl2=560e-9;
>> M_eyl_1=2*pi*h*c^2 ./ (yl1.^5  .*(exp(h*c ./ (yl1*k*5000)) -1));
>> M_eyl_2=2*pi*h*c^2 ./ (yl2.^5  .*(exp(h*c ./ (yl2*k*5000)) -1));
>> P1=0.5*(M_eyl_1+M_eyl_2)*10e-9*(0.01)^2
P1 =
   39.8154 %Watts
```

Part d

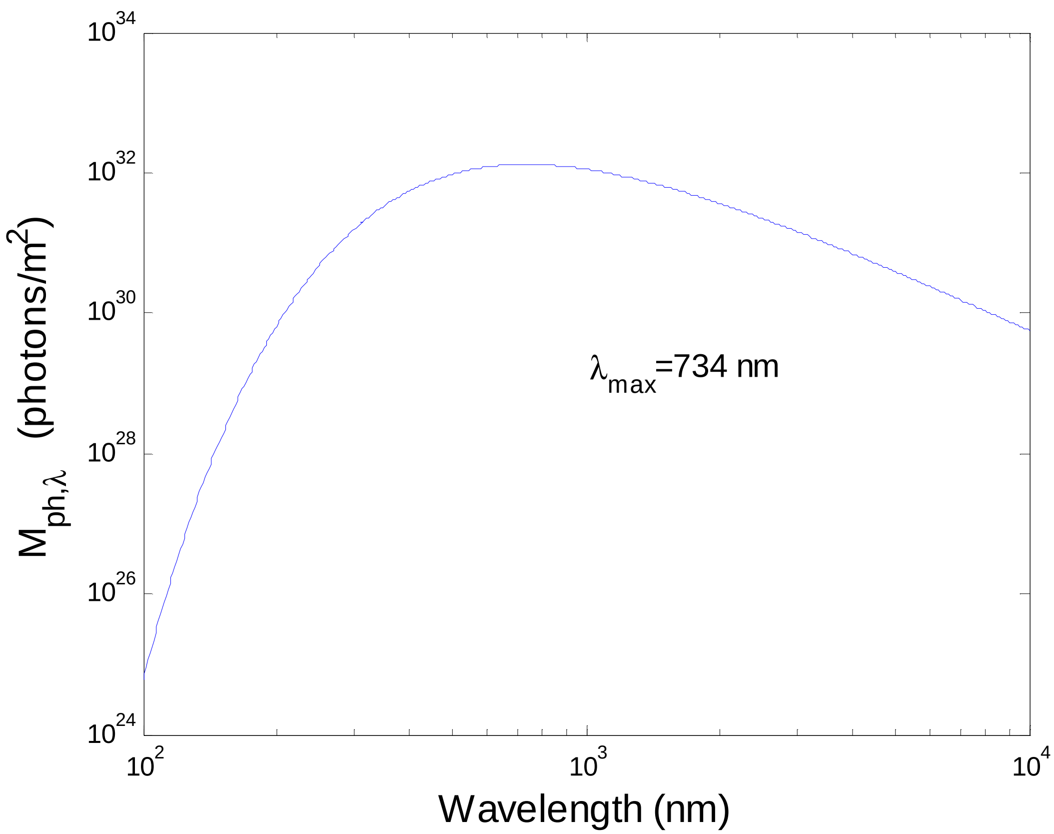
```
>>
>>
>> M_phyl=M_eyl ./ (h * c ./ ylm);
>>
```

Part e

```
>>
>> figure(3)
>> semilogx(yl, M_phyl)
>> xlabel('Wavelength (nm)'); ylabel( 'M_{ph,\lambda}   (photons/m^2)')
```




```
>> figure(4)
>> loglog(yl, M_phyl)
>> xlabel('Wavelength (nm)'); ylabel( 'M_{ph,\lambda}   (photons/m^2)')
```



Part f

```
>> [Max_p,i2]=max(M_phyl)
Max_p =
  1.3075e+032
i2 =
   217
>> yl(217)
ans =
  734.0598
>>
```

Part g

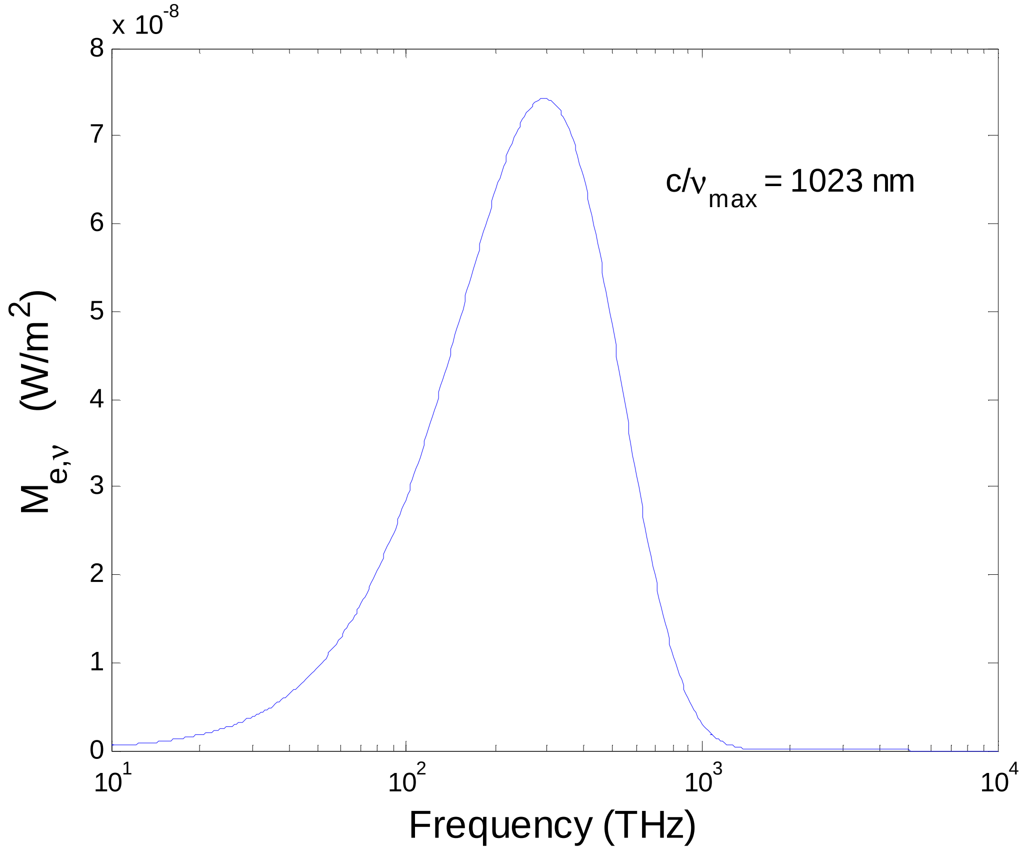
```
>> M_phyl_1=M_eyl_1  ./ (h * c ./ yl1);
>> M_phyl_2=M_eyl_2  ./ (h * c ./ yl2);
>> N1=0.5*(M_phyl_1+M_phyl_2)*10e-9*(0.01)^2
N1 =
  1.1117e+020 %photons

>>
```

Part h

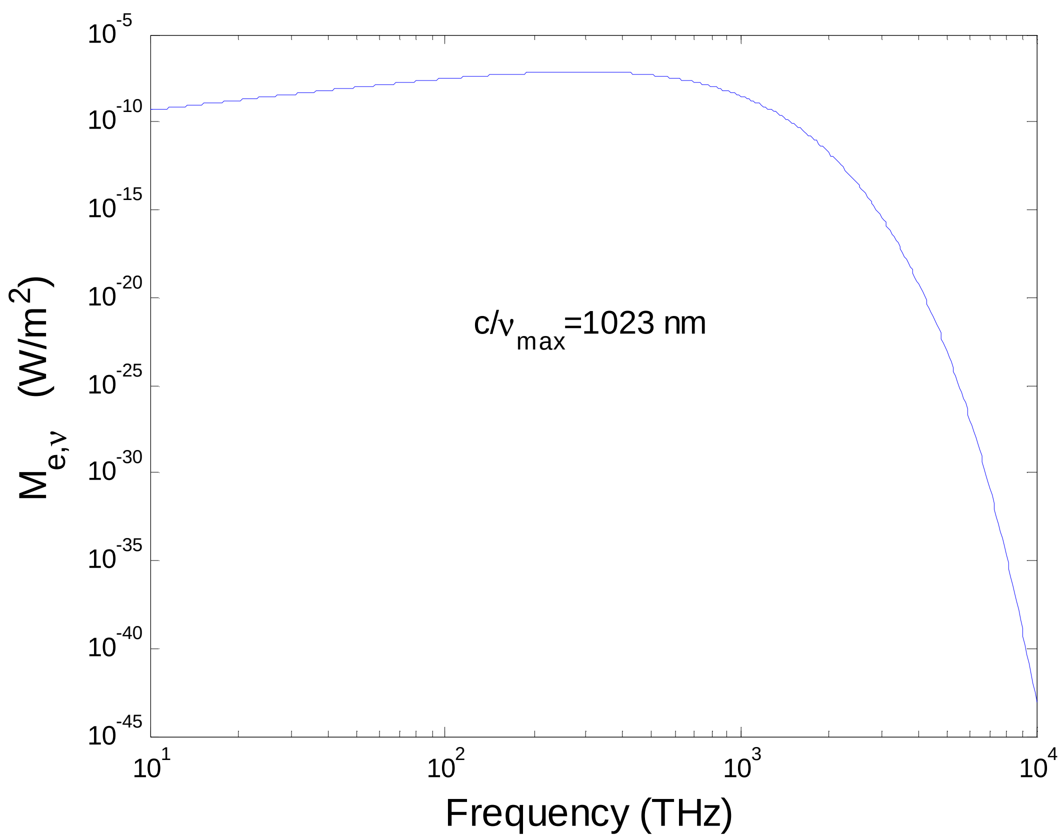
```
>> nu1=c/10000
nu1 =
       29980
>> nu1=c/10000e-9
nu1 =
  2.9980e+013
>> nu2=c/100e-9
nu2 =
  2.9980e+015
>> nu=logspace(13,16,500);
>> nu_THz=nu / 1e12;
>>
>> M_enu=(2*pi*h*nu.^3/c^2) ./ (exp(h*nu/(k*5000)) -1);
>>
```

Part i

```
>> figure(5)
>> semilogx(nu_THz, M_enu)
>> xlabel('Frequency (THz)'); ylabel( 'M_{e,\nu}   (W/m^2)')
```




```
>> figure(6)
>> loglog(nu_THz, M_enu)
>> xlabel('Frequency (THz)'); ylabel( 'M_{e,\nu}   (W/m^2)')
```



Part j

```
>> [Max_en,i3]=max(M_enu)
Max_en =
  7.4261e-008
i3 =
   245
>> nu(245)
ans =
  2.9304e+014
>>
>> (c / nu(245))/1e-9
ans =
  1.0231e+003
>>
```

Part k

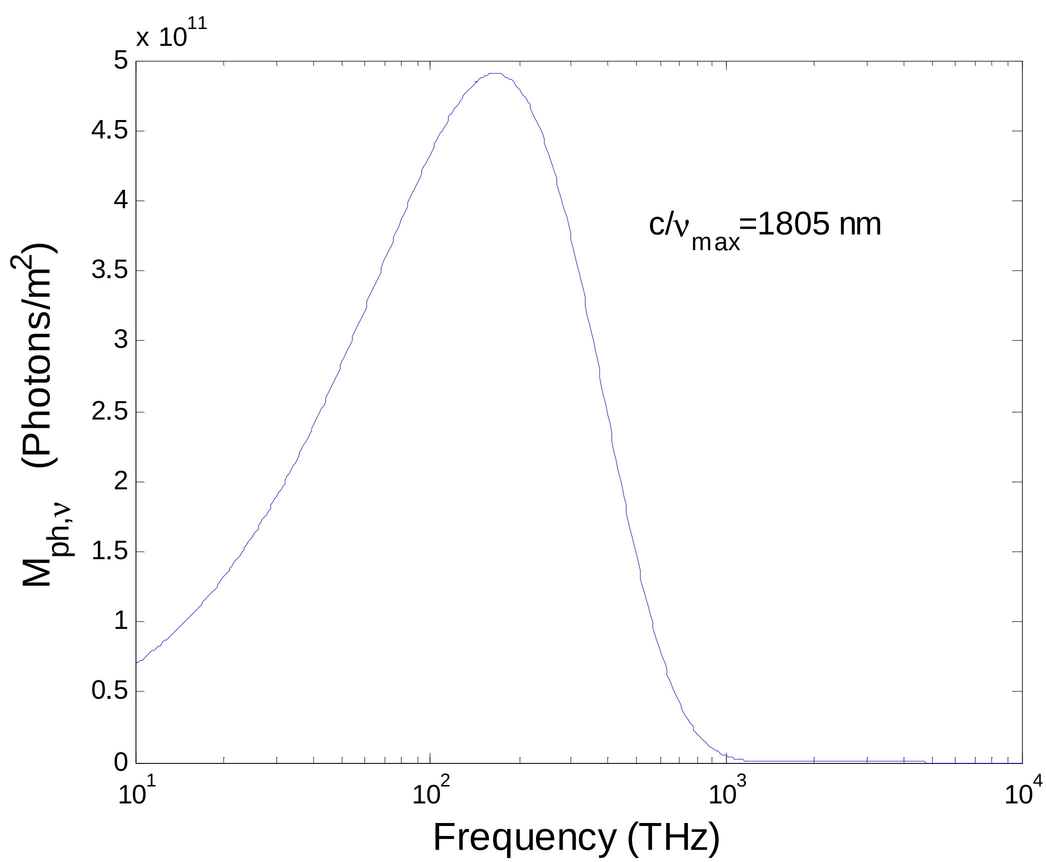
```
>> nu_1=c/560e-9;
>> nu_2=c/560e-9;
>> M_enu_1=(2*pi*h*nu_1.^3/c^2) ./ (exp(h*nu_1/(k*5000)) -1);
>> M_enu_2=(2*pi*h*nu_2.^3/c^2) ./ (exp(h*nu_2/(k*5000)) -1);
>> P2=0.5*(M_enu_2+M_enu_1)*(nu_2-nu_1)*0.01^2
P2 =
   39.8233 %Watts
>>
>>
```

Part l

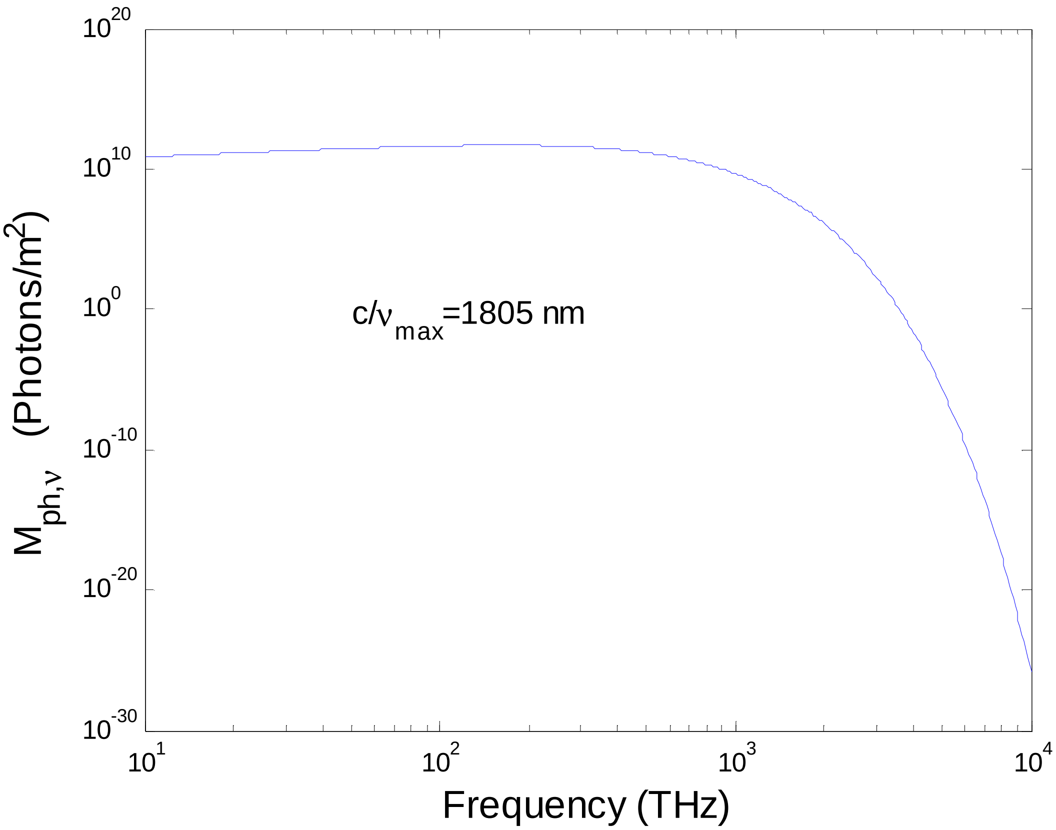
```
>> M_phnu=M_enu ./ (h*nu);
>>
```

Part m

```
>> figure(7)
>> semilogx(nu_THz, M_phnu)
>> xlabel('Frequency (THz)'); ylabel( 'M_{ph,\nu}   (Photons/m^2)')
```



```
>> figure(8)
>> loglog(nu_THz, M_phnu)
>> xlabel('Frequency (THz)'); ylabel( 'M_{ph,\nu}   (Photons/m^2)')
```



Part n

```
>> [Max3,i3]=max(M_phnu)
Max3 =
  4.9034e+011
i3 =
   204
>>
>> nu(204)
ans =
  1.6613e+014
>>
>> c /(ans *1e-9)
ans =

  1.8046e+003
```

Part o

```
>>
>>
>> M_phnu_1=( (2*pi*h*nu_1.^3/c^2) ./ (exp(h*nu_1/(k*5000)) -1) ) ./ (h*nu_1);
>> M_phnu_2=( (2*pi*h*nu_2.^3/c^2) ./ (exp(h*nu_2/(k*5000)) -1) ) ./ (h*nu_2);
>>
>> N2=0.5*(M_phnu_1+M_phnu_2)*(nu_2-nu_1)*(0.01)^2
N2 =
  1.1121e+020 %photons
>>
>>
```

Part p

The wavelength maximum is around 550nm only when one expresses the black-body emission function as $M_{e,\lambda}$ (as power per unit area in terms of wavelength). When you express the black-body function as number of photons or in terms of frequency, the black-body emission peak is not near 550nm. Considering that the rods and cones of the eye are most likely photon counting sensors as a function of energy, $M_{e,\lambda}$ is probably the least appropriate way to describe the spectra with relation to the sensitivity of the eye. The more reasonable evolutionary explanation is that the human eye developed to be sensitive in a region of maximum atmospheric transparency at a wavelength that balanced solar illumination, resolution (favoring small wavelengths), and biological advantages of the sensing mechanism.