Special Assigment
ZCE 111

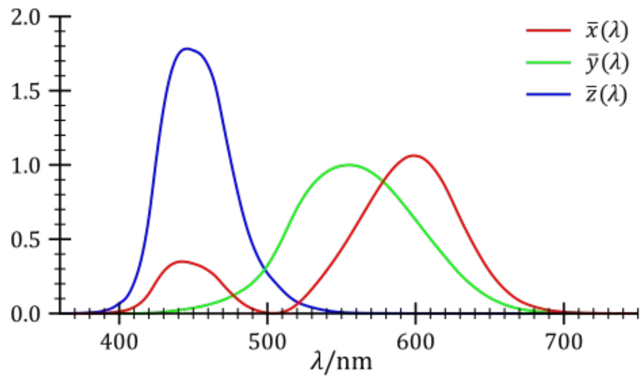
First Part: Planckian locus
Read Planckian locus on https://en.wikipedia.org/wiki/Planckian_locus

In the CIE XYZ color space, the three coordinates defining a electromagnetic spectrum are given by X_T, Y_T, Z_T :

$$X_T = \int \bar{x}(\lambda) M(\lambda, T) d\lambda, Y_T = \int \bar{y}(\lambda) M(\lambda, T) d\lambda, Z_T = \int \bar{z}(\lambda) M(\lambda, T) d\lambda,$$

where *M(λ,T)* is the spectral radiant exitance of the light being viewed, and $\bar{x}(\lambda), \bar{y}(\lambda), \bar{z}(\lambda)$ are the color matching functions of the CIE standard colorimetric observer, shown in the diagram illustration 1, and *λ* is the wavelength.

Illustration



The Planckian locus is determined by substituting into the above equations the black body spectral radiant exitance, which is given by Planck's law:

$$M(\lambda, T) = \frac{c_1}{\lambda^5} \frac{1}{\exp\left(\frac{c_2}{\lambda T}\right) - 1}$$

where:

$c_1 = 2\pi hc^2$ is the first radiation constant
$c_2 = hc/k$ is the second radiation constant

and

M is the black body spectral radiant exitance (power per unit area per unit wavelength: watt per square meter per meter (W/m3))
T is the temperature of the black body
h is Planck's constant
c is the speed of light
k is Boltzmann's constant

This will give the Planckian locus in CIE XYZ color space. If these coordinates are X_T, Y_T, Z_T where *T* is the temperature, then the CIE chromaticity coordinates will be

$$x_T = \frac{X_T}{X_T + Y_T + Z_T}$$

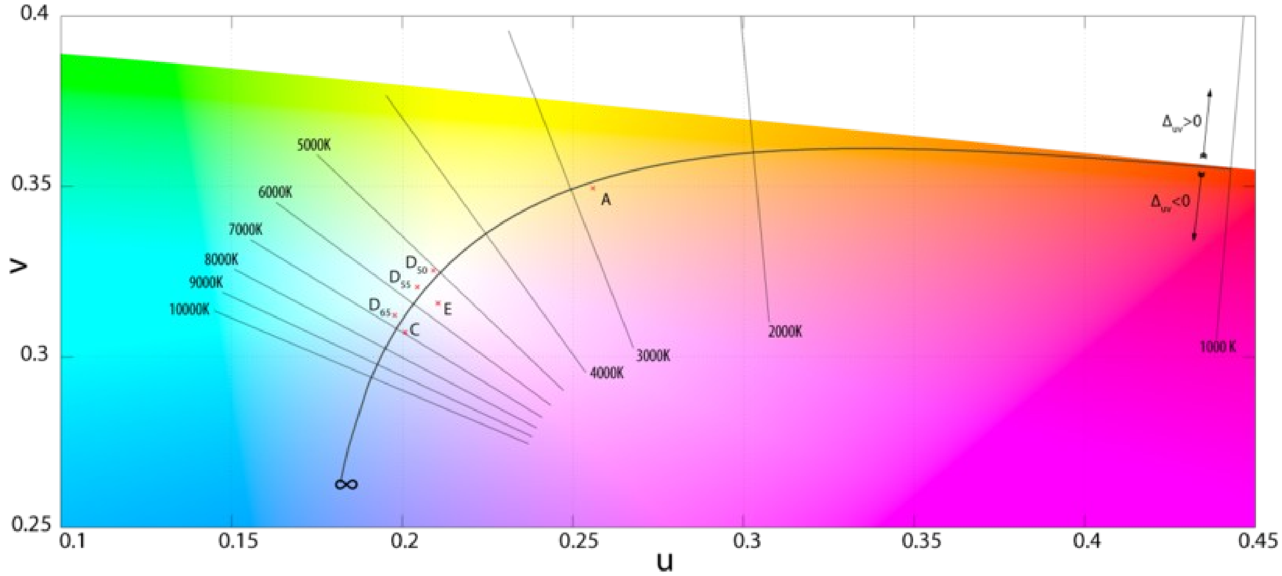
$$y_T = \frac{Y_T}{X_T + Y_T + Z_T}$$

A pair of crhomatocity coordinates (*x*,*y*) can be exprssed in MacAdam's chromaticity scale (*u*, *v*) as

$$u = \frac{4x}{-2x + 12y + 3}, \quad v = \frac{6y}{-2x + 12y + 3}.$$

A Planckian locus can be mapped out in the (*u*,*v*) chromaticity space, see Illustration 2.

Illustration



Task No.1 to perform: Given the CIE color matching functions data, write a code to automatically generate the Plackian locus in (*u*,*v*) space as shown in Illustration 2. The numerical data file for the color matching functions $\bar{x}(\lambda), \bar{y}(\lambda), \bar{z}(\lambda)$ can be downloaded from http://comsics.usm.my/tlyoon/teaching/ZCE111_1516SEM2/data/StdObsFuncs.xls (as an Excel file).

Second Part: Correlated Color temperature (CCT)

Read CCT on https://en.wikipedia.org/wiki/Color_temperature

The tristimulus values (X,Y,Z) for a colour with a spectral power distribution $S(\lambda)$

are given in terms of:

$$X = \int S(\lambda) \bar{x}(\lambda) d\lambda, Y = \int S(\lambda) \bar{y}(\lambda) d\lambda, Z = \int S(\lambda) \bar{z}(\lambda) d\lambda,$$

where λ is the wavelength of the equivalent monochromatic light (measured in nanometers). In practice, $S(\lambda)$ is a spectrum measured experimentally, e.g., that emitted from a LED light bulb.

Task No. 2 to perform: Download the numerical data of a spectrum $S(\lambda)$ from http://comsics.usm.my/tlyoon/teaching/ZCE111_1516SEM2/data/spectral_power_distribution.dat. Note that the numerical data for $S(\lambda)$ is expressed in SI unit (in particular the wavelength values (in the first column) is in unit of meter).

Modify your code from **Task No. 1** to obtain the chromatocity coordinates for the spectrum $S(\lambda)$. Call it $C_s(u_s, v_s)$.

Answer: $(u_s, v_s) = (0.210696, 0.321492)$

Task No. 3 to perform: Extent your code to do the following: Identify a point on the Planckian locus $P_N(u_N, v_N)$ at which the normal line at that point pass through $C_s(u_s, v_s)$. Identify the temperature corresponds to the Planckian locus point $P_N(u_N, v_N)$. This temperature is the CCT of the spectrum $S(\lambda)$.

Answer:

$P_N(u_N, v_N)$ =(0.212529, 0.323398)

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Task No. 4 to perform: Output a diagram displaying (i) the Planckian curve, (ii) the point $C_s(u_s, v_s)$, (iii) $P_N(u_N, v_N)$,(iii) the normal line that passes through both $C_s(u_s, v_s)$ and $P_N(u_N, v_N)$, see the sample output below.

Note:

1. Make sure that your code must output explicitely (a) the values of the CCT for $S(\lambda)$, (b) the $C_s(u_s, v_s)$ dot, (c) the $P_N(u_N, v_N)$ dot, (d) the Planckian locus and (e) the normal line.

2. Your code should be fully automatic and should produce all the required output at a press of a button wihtout any manual intervention (except the act of pressing the shift+enter burron keys).

Illustration