

**Homework 4: Color Vision**  
**10 Points: Due at beginning of class, Thursday, 4 October 2007**

There are two parts to this homework assignment. Each part counts 5 points. Late homework will receive a grade of zero.

**Part 1:** Three colors are each matched by the following three color-equations using the C.I.E. Tristimulus primaries:

$$C_1 \equiv 0.45X + 1.05Y + 0.50Z$$

$$C_2 \equiv 1.35X + 3.15Y + 1.50Z$$

$$C_3 \equiv 3.20X + 1.85Y + 0.95Z$$

The C.I.E. chromaticity coordinates  $x$ ,  $y$ ,  $z$ , are computed from the Tristimulus values:

$$x = \frac{X}{X+Y+Z}, \quad y = \frac{Y}{X+Y+Z}, \quad z = \frac{Z}{X+Y+Z}$$

Compute the chromaticity coordinates of each color (small  $x$ ,  $y$ , and  $z$ ). Construct a chromaticity graph by plotting  $x$ -chromaticity against  $y$ -chromaticity (make the axis scales go from 0.0 to 1.0). Compare the chromaticity of the three colors: are they the same or different? Will these colors exactly match each other in appearance? If not, how do they differ? Finally, what C.I.E. primaries  $X$ ,  $Y$ , and  $Z$ , will match the color  $C_4$  produced when  $C_2$  is added to  $C_3$ ? Plot  $C_4$  on your chromaticity graph.

**Part 2:** There are three processes in color vision: two chromatic channels and one achromatic channel. These three processes receive input from the three types of cones according to these three equations:

$$(+r - g) = 1.89L - 2.79M + 0.45S \quad \text{Red - Green}$$

$$(+y - b) = 0.85L + 0.22M - 1.72S \quad \text{Yellow - Blue}$$

$$L = 0.85L + 0.15M + 0.015S \quad \text{Luminance}$$

where  $S$ ,  $M$ , and  $L$  are the short, medium, and long wavelength cone types. Assume that two colors activate the cones by the following amounts:

	L	M	S
$C_5$	22.0	8.8	2.2
$C_6$	5.0	20.0	5.0

Make a graph of the opponent process color space with the  $x$ -axis representing  $(+r-g)$  and the  $y$ -axis representing  $(+y-b)$ . The scales should run from -50.0 to +50.0. Compute the activation of the three channels to  $C_5$ , to  $C_6$ , and to a mixture of  $C_5$  and  $C_6$  ( $C_5 + C_6$ ). Plot each of the three colors as points on the graph ( $C_5$ ,  $C_6$ , and  $C_5+C_6$ ). What is the color appearance of  $C_5$  and of  $C_6$ ? What is the color **appearance** of the mixture of  $C_5$  and of  $C_6$ ?