

Weber-Fechner law in CIE 230:2019 for threshold colour differences of surface colours; relations between tristimulus value, lightness and luminance

The *Weber-Fechner* law describes the lightness L_r^* as *logarithmic* function of L_r . The *Stevens* law describes the lightness L_{CIELAB}^* as *potential* function of $L_r=Y/5$. IEC 61966-2-1 uses a similar potential function $L_{\text{IEC}}^* = m L_r^{1/2,4}$.

The *Weber-Fechner* law is equivalent to the equation: $\Delta L_r = c L_r$ [1]

Integration leads to the logarithmic equation: $L_r^* = k \log(L_r)$. [2]

Derivation leads for $\Delta L_r^* = 1$ to the linear equation: $L_r / \Delta L_r = k = 57$. [3]

For *Adjacent* colours in offices the standard contrast range is 25:1=90:3,6.

Table 1: CIE tristimulus value Y , luminance L , and lightness L^*

Colour (matte)	Tristimulus value	office luminance	relative luminance	CIELAB lightness	TUBJND lightness
(contrast)	Y	L	L_r	L_{CIELAB}^*	L_{TUBJND}^*
(25:1=90:3,6)		[cd/m^2]	$=L/L_u$	$\sim m L_r^{1/2,4}$	$=k \log(L_r)$
White W (paper)	90 =18*5	142 =28,2*5	5	94 =50+44	40 = $k \log(5)$
Grey Z (paper)	18	28,2	1	50 =50	0 = $k \log(1)$
Black N (paper)	3,6 =18/5	5,6 28,2/5	0,2	18 =50-32	-40 = $k \log(0,2)$

For the lightness range between $L_r^* = -40$ and 40 the constant is: $k = 40 / \log(5) = 57$