

# Equations: colorimetric transfer from CIELAB hue angle $h_{ab}$ to elementary hue number $e^*$

Given: CIELAB hue angle  $h_{ab}$  ( $0 \leq h_{ab} \leq 360$ )  
CIELAB hue angles  $h_{ab,eX}$  of four elementary colours  $eX = RJGB$   
Aim: Elementary hue number  $e^*$  of the given colour ( $0 \leq e^* \leq 1$ )  
Calculate elementary hue angle  $h_{ab,e}$  in one of five possible cases for  $h_{ab}$  ( $0 \leq h_{ab} \leq 360$ ):  
If  $0 \leq h_{ab} < h_{ab,eR}$   $h_{ab,e} = 270 + 90 [360 + h_{ab} - h_{ab,eB}] / [360 + h_{ab,eR} - h_{ab,eB}]$  (1)  
If  $h_{ab,eR} \leq h_{ab} < h_{ab,eG}$   $h_{ab,e} = 0 + 90 [h_{ab} - h_{ab,eR}] / [h_{ab,eG} - h_{ab,eR}]$  (2)  
If  $h_{ab,eG} \leq h_{ab} < h_{ab,eB}$   $h_{ab,e} = 90 + 90 [h_{ab} - h_{ab,eG}] / [h_{ab,eB} - h_{ab,eG}]$  (3)  
If  $h_{ab,eB} \leq h_{ab} < h_{ab,eR}$   $h_{ab,e} = 180 + 90 [h_{ab} - h_{ab,eB}] / [h_{ab,eR} - h_{ab,eB}]$  (4)  
If  $h_{ab,eR} \leq h_{ab} < 360$   $h_{ab,e} = 270 + 90 [h_{ab} - h_{ab,eB}] / [360 + h_{ab,eR} - h_{ab,eB}]$  (5)  
Elementary hue number  $e^* = h_{ab,e} / 360$  ( $0 \leq e^* \leq 1$ ) (6)

## Inverse equations: transfer from elementary hue number $e^*$ to CIELAB hue angle $h_{ab}$

Given: elementary hue number  $e^*$  ( $0 \leq e^* \leq 1$ )  
CIELAB hue angles  $h_{ab,eX}$  of four elementary colours  $eX = RJGB$   
Aim: CIELAB hue angle  $h_{ab}$  of the given colour ( $0 \leq h_{ab} \leq 360$ )  
Elementary hue angle  $h_{ab,e} = 360 e^*$  ( $0 \leq e^* \leq 1$ ) (1)  
Calculate CIELAB hue angle  $h_{ab}$  in one of four possible cases for  $e^*$  ( $0 \leq e^* \leq 1$ ):  
If  $0.00 \leq e^* < 0.25$   $h_{ab} = h_{ab,eR} + [h_{ab,e} / 90] [h_{ab,eG} - h_{ab,eR}]$  (2)  
If  $0.25 \leq e^* < 0.50$   $h_{ab} = h_{ab,eG} + [h_{ab,e} / 90 - 1.00] [h_{ab,eB} - h_{ab,eG}]$  (3)  
If  $0.50 \leq e^* < 0.75$   $h_{ab} = h_{ab,eB} + [h_{ab,e} / 90 - 2.00] [h_{ab,eR} - h_{ab,eB}]$  (4)  
If  $0.75 \leq e^* \leq 1.00$   $h_{ab} = h_{ab,eR} + [h_{ab,e} / 90 - 3.00] [h_{ab,eG} - h_{ab,eR}]$  (5)  
only if  $h_{ab} \geq 360$  then:  $h_{ab} = h_{ab} - 360$  ( $0 \leq h_{ab} \leq 360$ ) (6)

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# Equations: colorimetric data transfer from $LCH^*$ (CIELAB) to $ncc^*$ and $olr^*$

Given: adapted CIELAB data of any colour  $L^*$ ,  $C^*_{ab,a}$ ,  $h_{ab,a} = LCH^*_a = LAB^*LCH^*_a$   
adapted CIELAB data  $L^*$ ,  $C^*_{ab,a}$ ,  $h_{ab,a}$ ,  $a^*_{25}$ ,  $b^*_{25}$  of eight basic colours  $X = OYLVCVMNW$   
Aim:  $ncc^*$  and  $olr^*$  device data  $olr^*_3$  of the given colour  
hue angle of the given colour and of  $M$   $h_{ab,a} = H^*_a$  (1)  
CIELAB  $LCH^*_a$  data of maximum colour  $M$   $L^*_M = \text{function} [h_{ab,a}]$  (with table/equation) (2)  
 $C^*_{ab,a,M} = \text{function} [h_{ab,a}]$  (with table/equation) (3)  
 $h_{ab,a,M} = h_{ab,a}$  (4)  
relative lightness of the given colour  $l^* = (L^* - L^*_N) / [L^*_M - L^*_N]$  (5)  
relative chroma of the given colour  $c^* = C^*_{ab,a} / C^*_{ab,a,M}$  (6)  
relative triangle lightness of the given colour  $l^* = l^* - [L^*_M - L^*_N] / [L^*_M - L^*_N] c^* + 0.5 c^*$  (7)  
relative blackness of the given colour  $n^* = 1 - l^* - 0.5 c^*$  (8)  
relative whiteness of the given colour  $w^* = 1 - n^* - c^*$  (9)  
elementary hue angle of the given colour  $e^* = \text{function} [h_{ab,a}]$  (with table or equation) (10)  
relative  $olr^*_{3,M}$  data of maximum colour  $M$   $o^*_{3,M} = \text{function} [h_{ab,a}]$  (with table/equation) (11)  
 $l^*_{3,M} = \text{function} [h_{ab,a}]$  (with table/equation) (12)  
 $v^*_{3,M} = \text{function} [h_{ab,a}]$  (with table/equation) (13)  
relative  $olr^*_3$  data of the given colour  $o^*_3 = w^* + c^* o^*_{3,M}$  (14)  
 $l^*_3 = w^* + c^* l^*_{3,M}$  (15)  
 $v^*_3 = w^* + c^* v^*_{3,M}$  (16)

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# Inverse equations: transfer from standard hue angle $h_{ab,s}$ to CIELAB hue angle $h_{ab}$

Given: standard hue angle  $h_{ab,s}$  ( $0 \leq h_{ab,s} \leq 360$ )  
CIELAB hue angles  $h_{ab,s,X}$  of six standard colours  $sX = RJGC^*BM^*$   
Aim: CIELAB hue angle  $h_{ab}$  of the given colour ( $0 \leq h_{ab} \leq 360$ )  
Remark:  
The standard hue angle  $h_{ab,s}$  is usually calculated from the data  $rgb^*r_3$   
relative red-green chroma in system  $s$   $a^*_{rs} = r^*_3 \cos(30) + g^*_3 \sin(150)$   
relative yellow-blue chroma in system  $s$   $b^*_{rs} = r^*_3 \sin(30) + g^*_3 \sin(150) + b^*_3 \sin(270)$   
hue angle in standard system  $s$   $h_{ab,s} = \arctan [b^*_{rs} / a^*_{rs}]$   
Calculate CIELAB hue angle  $h_{ab}$  in one of seven possible cases for  $h_{ab,s}$  ( $0 \leq h_{ab,s} \leq 360$ ):

If  $0 \leq h_{ab,s} < 30$   $h_{ab} = h_{ab,s,M^*} + [h_{ab,s} + 360 - h_{ab,s,M^*}] [h_{ab,s,R} + 360 - h_{ab,s,M^*}] / 60$  (11)  
If  $30 \leq h_{ab,s} < 90$   $h_{ab} = h_{ab,s,R} + [h_{ab,s} - h_{ab,s,R}] [h_{ab,s,J} - h_{ab,s,R}] / 60$  (21)  
If  $90 \leq h_{ab,s} < 150$   $h_{ab} = h_{ab,s,J} + [h_{ab,s} - h_{ab,s,J}] [h_{ab,s,G} - h_{ab,s,J}] / 60$  (31)  
If  $150 \leq h_{ab,s} < 210$   $h_{ab} = h_{ab,s,G} + [h_{ab,s} - h_{ab,s,G}] [h_{ab,s,C^*} - h_{ab,s,G}] / 60$  (41)  
If  $210 \leq h_{ab,s} < 270$   $h_{ab} = h_{ab,s,C^*} + [h_{ab,s} - h_{ab,s,C^*}] [h_{ab,s,B} - h_{ab,s,C^*}] / 60$  (51)  
If  $270 \leq h_{ab,s} < 330$   $h_{ab} = h_{ab,s,B} + [h_{ab,s} - h_{ab,s,B}] [h_{ab,s,M^*} - h_{ab,s,B}] / 60$  (61)  
If  $330 \leq h_{ab,s} < 360$   $h_{ab} = h_{ab,s,M^*} + 360 + [h_{ab,s} - h_{ab,s,M^*}] [h_{ab,s,R} + 360 - h_{ab,s,M^*}] / 60$  (71)  
only if  $h_{ab} \geq 360$  then:  $h_{ab} = h_{ab} - 360$  ( $0 \leq h_{ab} \leq 360$ ) (81)

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# Equations: colorimetric data transfer from $olr^*_3$ to $ncc^*$ data and $LCH^*_a$ data

Given:  $rgb$  device data of any colour  $olr^*_3 = lab^*olr^*_3$   
adapted CIELAB data  $L^*$ ,  $C^*_{ab,a}$ ,  $h_{ab,a}$ ,  $a^*_{25}$ ,  $b^*_{25}$  of eight basic colours  $X = OYLVCVMNW$   
Aim:  $ncc^*$  =  $lab^*ncc^*$  (similar to NCS data) and  $LCH^*_a$  data of the given colour ( $0 \leq e^* \leq 1$ )  
relative chroma of the given colour  $c^* = \max [olr^*_3] - \min [olr^*_3]$  (1)  
relative blackness of the given colour  $n^* = 1 - \max [olr^*_3]$  (2)  
relative triangle lightness of the given colour  $l^* = 1 - n^* - 0.5 c^*$  (3)  
relative red-green chroma in 60 degree system  $s$   $a^*_{rs} = o^*_3 \cos(30) + l^*_3 \sin(150)$  (4)  
relative yellow-blue chroma in 60 degree system  $s$   $b^*_{rs} = o^*_3 \sin(30) + l^*_3 \sin(150) + v^*_3 \sin(270)$  (5)  
hue angle in 60 degree system  $s$   $h_{ab,s} = \arctan [b^*_{rs} / a^*_{rs}]$  ( $0 \leq h_{ab,s} \leq 360$ ) (6)  
CIELAB hue angle in device system  $h_{ab,a} = \text{function} [h_{ab,s}]$  (with table/equation) (7)  
elementary hue number of the given colour  $e^* = \text{function} [h_{ab,a}]$  (with table/equation) (8)  
adapted CIELAB  $LCH^*_a$  data of maximum colour  $M$   $L^*_M = \text{function} [h_{ab,a}]$  (with table/equation) (9)  
 $C^*_{ab,a,M} = \text{function} [h_{ab,a}]$  (with table/equation) (10)  
 $h_{ab,a,M} = h_{ab,a}$  (11)  
relative lightness of maximum colour  $M$   $l^*_M = [L^*_M - L^*_N] / [L^*_M - L^*_N]$  (12)  
relative lightness of the given colour  $l^* = l^* + l^*_M c^* + 0.5 c^*$  (13)  
adapted CIELAB  $LCH^*_a$  data of the given colour  $L^* = l^* [L^*_M - L^*_N] + L^*_N$  (14)  
 $C^*_{ab,a} = c^* C^*_{ab,a,M}$  (15)  
 $h_{ab,a} = h_{ab,a,M}$  (16)

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